SCAN TEAM REPORT
NCHRP Project 20-44 (05)

DISSEMINATION OF NCHRP DOMESTIC SCAN 14-01: LEADING MANAGEMENT PRACTICES IN DETERMINING FUNDING LEVELS FOR MAINTENANCE AND PRESERVATION

Supported by the
National Cooperative Highway Research Program

Acknowledgments

The work described in this document was conducted as part of NCHRP Project 20-44, Task 05, Dissemination of NCHRP Domestic Scan 14-01: Leading Management Practices in Determining Funding Levels for Maintenance and Preservation. This task was proposed in support of the dissemination activities developed by the scan team that participated in Domestic Scan 14-01, Leading Management Practices in Determining Funding Levels for Maintenance and Preservation, under NCHRP 20-68A – U.S. Domestic Scan Program. The Domestic Scan Program is intended to accelerate beneficial innovation in transportation by facilitating information sharing and technology exchange among the states and other transportation agencies and identifying actionable items of common interest. Further information on the NCHRP 20-68A U.S. Domestic Scan program is available at: http://144.171.11.40/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=1570.

The NCHRP 20-44 program provides funding to help facilitate the implementation of NCHRP research results. Funding requests are reviewed and approved by a panel. This peer exchange was proposed under the NCHRP 20-44 program to advance the use of maintenance performance data to improving maintenance funding, since the scan found that only three state Departments of Transportation (DOTs) were using maintenance performance data to support the statewide allocation of funding for maintenance activities. Several additional state DOTs use maintenance performance data to allocate funds to districts but the degree to which performance data is used varies widely.

The report was prepared by many of the original members of the scan team (listed below) who volunteered to serve as the steering committee responsible for organizing and conducting the peer exchange. Peer exchange planning and logistics were managed by Arora and Associates, P.C. Harry Capers served as the principal investigator and Melissa Jiang provided valuable support to the team. In addition, Greg Waidley, CTC and Associates, LLC, provided implementation support to the scan team throughout the planning and conduct of the peer exchange. NCHRP Project 20-44 is guided by a technical project panel and managed by Andrew Lemer, PhD, NCHRP Senior Program Officer.

NCHRP Domestic Scan Team Members Involved in the Peer Exchange Activities:

Mark McConnell, PE, Scan Team Chair, Volkert (Mississippi DOT, retired)
Dale Doughty, Maine DOT
Laura Mester, Michigan DOT
Rudy Powell, Florida DOT
Tony Sullivan, Arkansas DOT
Thomas Van, FHWA
Katie Zimmerman, PE, Applied Pavement Technology, Inc., Subject Matter Expert

The peer exchange team is extremely grateful for the support provided by the Tennessee DOT throughout the meeting. In addition to providing the meeting space and furnishing all necessary audiovisual materials, the Tennessee DOT participants also provided shuttle service between the hotel and meeting space each day.

Disclaimer

NCHRP Project 20-44 (05)

Dissemination of NCHRP Domestic Scan 14-01: Leading Management Practices in Determining Funding Levels for Maintenance and Preservation

REQUESTED BY THE
American Association
of State Highway and Transportation Officials

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Abbreviations and Acronyms

ADOT&PF	Alaska Department of Transportation and Public Facilities
AASHTO	American Association of State Highway and Transportation Officials
ADOT	Arizona Department of Transportation
ALDOT	Alabama Department of Transportation
ARDOT	Arkansas Department of Transportation
CDOT	Colorado Department of Transportation
DOT	Department of Transportation
FDOT	Florida Department of Transportation
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FTE	Full-Time Equivalent
GIS	Geographic Information System
HATS	Highway Activity Tracking System (Washington State DOT)
IT	Information Technology
ITS	Intelligent Transportation System
KDOT	Kansas Department of Transportation
LiDAR	Light Detection and Ranging
LOE	Level of Effort
LOM	Level of Maintenance
LOS	Level of Service
MAC	Maintenance Committee (AASHTO)
MDT	Montana Department of Transportation
MLA	Maintenance Leadership Academy (National Highway Institute)
MLOS	Maintenance Level of Service Program (Colorado DOT)
MMQA+	Maintenance Management Quality Assurance (Utah DOT)
MMS	Maintenance Management System
MnDOT	Minnesota Department of Transportation
MPA	Maintenance Program Area
MQA	Maintenance Quality Assurance
MRP	Maintenance Rating Program (Florida DOT)
NCHRP	National Cooperative Highway Research Program
NDOT	Nevada Department of Transportation
NHI	National Highway Institute
NHDOT	New Hampshire Department of Transportation
Pecos	Performance Control Section (Arizona DOT)
QA	Quality Assurance
QC/QA	Quality Control/Quality Assurance
RWIS	Road Weather Information System
TDOT	Tennessee Department of Transportation

TRB	Transportation Research Board
UDOT	Utah Department of Transportation
VTrans	Vermont Agency of Transportation
VDOT	Virginia Department of Transportation
WSDOT	Washington State Department of Transportation

Overview of NCHRP 20-44 Program

The National Cooperative Highway Research Program (NCHRP) manages practical, applied research that addresses problems identified by practitioners and managers in state Departments of Transportation (DOTs). NCHRP publishes the research results and delivers implementable products. The benefits from the project findings, however, begin with implementation by state DOTs and other transportation agencies. To ensure that the research products are viable, NCHRP considers implementation throughout the course of a project – from the development of the problem statement to the awarding of the research contract and beyond to the completion of the research.

The Implementation Support Program, part of *Moving Research into Practice*, has funding of approximately $2 million annually to facilitate implementation of NCHRP research results. Funding requests are reviewed and approved by NCHRP Panel 20-44, which also helps panels coordinate with other implementation funding programs, such as Every Day Counts, Accelerated Innovation Deployment, Transportation Pooled Fund, and others.

Executive Summary

Overview

This report summarizes the findings from a peer exchange that was conducted as part of the NCHRP 20-44 program. The idea for this Peer Exchange, which was conducted as part of NCHRP Project 20-44(005), was one of the recommendations developed from a domestic scan conducted during 2015 to investigate successful practices that have led to reliable and adequate funding levels to support maintenance programs, as well as state Departments of Transportation (DOTs) that are using performance data to set performance targets, to allocate funding to districts/regions, and to establish maintenance priorities.

As one of the recommended dissemination activities for the original 2015 Scan, the Peer Exchange described in this report provided a structured information exchange among state DOTs for sharing leading practices in the use of performance data for maintenance activities and identifying strategies for advancing the use of performance data for maintenance among the participating agencies. This peer exchange, which was hosted by the Tennessee DOT, was held in Nashville in the auditorium of the agency's Region 3 offices during the 2½-day period between September 18 and 20, 2018. A total of 45 individuals participated in the peer exchange, representing 27 state DOTs, industry, and the Transportation Research Board (TRB). The group included individuals who served on the original scan team, meeting organizers and facilitators, and maintenance practitioners.

This summary report outlines the format that was used for this peer exchange and summarizes the presentations, discussions, and key findings from the Tennessee workshop.

Summarized Findings

The key findings from the peer exchange include those listed below.

Data

- There are differences in the performance measures that are being used to support MQA programs but the extent and impact of the differences are not well known. The use of a combination of level-of-service (LOS) and pass/fail approaches appeared to be common among many of the participating agencies. Based on the pre-workshop survey, most of the participating state agencies are collecting maintenance quality assurance (MQA) data at least annually on 1/10-mile sample.
- Most agencies participating in the peer exchange indicated that they did not collect enough asset performance data to confidently report LOS at the state, district, and shop levels. Most report only at the statewide level. According to the pre-workshop survey, only eight of 27 state agencies collect data on 5% or more of their networks.
- Several participating agencies have moved toward central office data collection teams to reduce district maintenance requirements and improve quality.
- A key to ensuring data quality is to make sure the data is used and understood. It is important to leverage the data available, even beyond a Maintenance Division. Data that isn't used is not regarded as important by those collecting the information, so data quality suffers.
- Data dictionaries and other methods of data governance have also become increasingly important for data consistency and ownership.

- An inventory is critical to performance-based budgeting and processes must be established to keep the inventory current. Utah DOT is moving toward a process that facilitates continuous updates to the inventory, which is updated as maintenance supervisors work in the field.
- Several agencies are forming internal partnerships so that data from other data collection efforts, such as pavement and bridge management or traffic safety, can be used to support maintenance data needs.

Processes

- There was tremendous benefit to the participating agencies from hearing about the practices in other state DOTs. In the final session, several of the participants stated that they were re-energized by the successes in peer states, had a better understanding of what it takes to be successful, and had ideas for making improvements to their existing programs.
- Historical budgeting or budgeting allocations based on formulas remain the norm in maintenance; however, these practices are not necessarily addressing performance-driven needs.
- One of the challenges to performance-based budgeting is the lack of knowledge of what resources (e.g., staffing, equipment, and materials) are required to move from one LOS rating to another. Agencies do not have a clear understanding of how to use historical records to prepare these models.
- It may be worthwhile analyzing the cost of moving from one LOS category to another over a three-year period, since agencies don't always have the resources available to make changes in conditions in just one year. Spreading the resources out over a three-year period makes it easier to tackle.
- Agencies do not recognize the benefits associated with a shift toward performance-based budgeting and expressed interest in information that would demonstrate the potential benefits that could be realized.
- Extreme weather events and emergencies impact the availability of funding for other maintenance activities. Several agencies, including the Florida and Colorado DOTs, have contingency funds available to preserve funding for planned activities.
- Several participating agencies, including Washington State DOT, have developed technology that allows them to quickly generate estimates for reimbursement from insurance companies for third-party damage.

Staffing

- There are gaps between the skills needed by maintenance workers today and those that are traditionally required. Training has become increasingly important to familiarize maintenance workers with the technology that is currently being used. One individual stated that maintenance workers will have to be comfortable with an iPad in three years or will have to find a new job. Florida DOT emphasized the importance of linking work to the agency's mission through performance measures. Washington State DOT shared that pairing experienced maintenance personnel with inexperienced but technology-savvy personnel has been a successful method of two-way mentoring.
- With responsibility comes accountability; however, to hold employees accountable, performance targets must be realistic and attainable.

- Involving field personnel in the development of field applications, performance targets, and MQA program changes enabled Washington State DOT to build buy-in and ensure that the products were used.
- Communication with field personnel and ongoing training at all levels are important to the continued success of an MQA program.
- MQA champions are important to building and maintaining support for the program. Once the program is fully ingrained into the way the organization does business, it is difficult for changes in leadership to derail it. Washington State DOT meets with new assistant directors within the first week of their appointment to introduce the MQA program and its benefits.
- Several participants noted that promoting an MQA culture is not at the forefront of the national maintenance community any longer and this is perceived as having negatively impacted the importance of MQA programs.

Technology

- Several agencies have had MQA programs for many years; however, it appears another evolution is underway due to the technology now available to assist with collecting and using data. In particular, the use of data extraction tools to build asset inventories was suggested to reduce manpower requirements and improve efficiency.
- Several examples were provided that illustrated how map-based interfaces and touch-screen applications are being used to simplify maintenance data collection activities. These applications are envisioned as a way to keep inventories updated as work is being performed.
- The increased use of technology has led several agencies to hire data analysts (e.g., Colorado DOT) and place Information Technology (IT) staff in maintenance (Washington State DOT).
- There are numerous examples of available tools, such as Tableau, for data analytics and reporting; however, most agencies have had to customize the off-the-shelf programs they have implemented in some way.
- The use of iPads seemed to be common among the participating agencies; however, the extent to which they are used can vary tremendously. For example, Washington State DOT provides iPads to all maintenance workers but other agencies provide them only to maintenance supervisors.
- Data integration is important. For maintenance programs, integration with the agency's payroll program is especially important and an often-mentioned source of frustration when it is not integrated with the maintenance management system (MMS).

Recommendations

The following recommendations were developed from the key findings.

Improve the Understanding of MQA Programs in the Maintenance Community

- Distribute peer exchange information throughout the state DOT maintenance community.
- Identify a list of experts willing to speak about MQA programs with different DOT audiences.
- Develop a set of webinars tailored to different DOT audiences to promote the use of MQA data for

performance-based budgeting.

- Develop case studies for several of the leading agencies based on the information presented during the peer exchange to promote the benefits of performance-based budgeting.
- Integrate MQA into the American Association of State Highway and Transportation Officials (AASHTO) Maintenance Committee (MAC) structure to address issues common to state DOTs looking for strategies to overcome implementation challenges.
- Incorporate the peer exchange results into the update of the asset management module included in the National Highway Institute's (NHI's) Maintenance Leadership Academy (MLA).

Foster Activities That Improve the Effectiveness of MQA Programs

- Develop data governance guidance on how to collect performance data, how to maintain quality, and how to manage the data effectively.
- Conduct a technology showcase highlighting the use of light detection and ranging (LiDAR) to establish asset inventories, iPads for field data collection, applications for budgeting activities, and other ways that agencies are using technology to improve the effectiveness of their MQA programs.
- Establish and pilot a peer-to-peer mentoring program to promote the use of MQA data to support maintenance budgeting activities.
- Develop case studies showcasing how maintenance business units have partnered with IT to better use available information to maintain assets.
- Scope a research effort to evaluate the benefits associated with the use of technology for MQA data collection activities.

Develop Tools and Resources to Support the Increased Use of MQA Data in DOTs

- Develop a primer on MQA data collection activities, including the level of data needed to support reporting at the state, district, and field office levels.
- Work with the AASHTO MAC to develop standardized terminology and performance measures to be used with MQA programs.
- Develop and document a process for developing condition grading cost models to enable agencies to estimate the costs associated with moving from one LOS grade to another.
- Promote efforts to re-establish the MQA document library.

1 Introduction

Overview

Although maintenance and operations activities are critical to the safety, smoothness, and sustainability of the nation's transportation system, these activities, which are key to keeping the highway system operating in a safe and reliable manner, have traditionally been underfunded. As a result, maintenance activities that are key to preserving existing assets are not performed regularly or on a timely basis. The cost of deferred maintenance is well documented, with studies showing that "repair costs rise to six times maintenance costs after three years of neglect and up to 18 times after five years of neglect.[1]"

In addition to inadequate funding levels, state Departments of Transportation (DOTs) face challenges associated with an aging infrastructure, significant workforce reductions, and ongoing pressure to keep the system operating safely. Within this environment, it is imperative that transportation agencies identify strategies that could lead to a more reliable and sustainable level of maintenance funding to address their needs and that available maintenance funding is used as effectively as possible to address agency priorities.

Although the challenges associated with uncertain and inadequate levels of maintenance funding are recognized, practical and implementable solutions to address the challenges are not widely available. As a result, finding solutions to address these challenges remains a top priority. To address these needs, a domestic scan[2] was conducted in the fall of 2015 to investigate successful practices that have led to reliable and adequate funding levels to support maintenance programs, as well as state DOTs that are using performance data to set performance targets, to allocate funding to districts/regions, and to establish maintenance priorities. The findings and recommendations contained in the report[3] were intended to be used to promote practices that lead to more reliable and sustainable funding for highway maintenance and preservation in the U.S.

Findings from the domestic scan, which focused on the following observations from the state DOTs successfully using performance data to support their maintenance programs, are listed below.

- The culture within Category 1 agencies fully embraces performance-based management at all levels of the organization.
- The Category 1 state DOTs and several Category 2 state DOTs have established a strong relationship with elected officials based on trust in agency decisions.
- Performance measures and targets are needed to link investments with results.
- Performance targets should be achievable with available funding and resources.
- The degree to which data is used to make investment decisions is strongly related to the degree of confidence that managers have in the information available to them.
- Because of the importance of data and the demand on resources associated with these activities, several agencies have initiated efforts to streamline their data collection efforts.

1 Burningham S and N Stankevich, Why Road Maintenance Is Important and How to Get it Done, Transport Note No. TRN-4. World Bank, Washington, D.C., June 2005

2 National Cooperative Highway Research Project 20-68A, Scan 14-01: Leading Management Practices in Determining Funding Levels for Maintenance and Preservation

3 A copy of the domestic scan summary report can be found here: http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-68A_14-01.pdf

- Performance-based organizations have established business processes, implemented software tools, and used available resources creatively to support their programs.

Implementation of the scan findings focused on two types of activities: those that advance the scan's findings through information dissemination and those that advance industry practices through the development of guidelines and other resources. The peer exchange documented in this report was one of the recommended dissemination activities, providing a structured information exchange among state DOTs for sharing leading practices in the use of performance data for maintenance activities and identifying strategies for advancing the use of performance data for maintenance among the participating agencies. This summary report outlines the format that was used for the peer exchange and summarizes the presentations, discussions, and key findings.

Peer Exchange Logistics

The peer exchange was held in Nashville, where Tennessee DOT (TDOT) hosted the meeting in the auditorium of its Region 3 offices during the 2½-day period between September 18 and 20, 2018.

Approximately one month prior to the peer exchange, a web meeting was conducted to familiarize the participants with the planned activities, to address travel and logistical questions, and to introduce a survey of practices that would be distributed to attendees electronically. In addition, Lacy Love (Volkert) discussed efforts by the American Association of State Highway and Transportation Officials (AASHTO) Maintenance Committee and the Maintenance Peer Network to re-establish the Maintenance Quality Assurance (MQA) document library. Mr. Love requested that all participants post MQA documents at the Highway MQA SharePoint site.[4]

Peer Exchange Participants

A total of 45 individuals participated in the peer exchange, representing 27 state DOTs, industry, and the Transportation Research Board (TRB). The group included individuals who served on the original scan team, meeting organizers and facilitators, and maintenance practitioners.

Original Scan 14-01 Team Members and Organizers Involved in the Peer Exchange Activities

Several members of the original NCHRP 14-01 scan team were involved in planning, organizing, and facilitating the peer exchange. As with the original scan, the team was led by Mark McConnell, the former deputy executive director and chief engineer for the Mississippi DOT (and now with Volkert), who served as the peer exchange team chair. Other scan team members involved in the peer exchange include those individuals listed below.

- Dale Doughty, director of the Bureau of Maintenance and Operations for MaineDOT
- Laura Mester, Chief Administrative Officer for Michigan DOT
- Rudy Powell, director of the Office of Maintenance for Florida DOT (FDOT)
- Tony Sullivan, newly retired assistant chief engineer of Operations for Arkansas DOT (ARDOT)
- Thomas Van, Pavement Management engineer, Office of Preconstruction, Construction, and Pavements at the Federal Highway Administration (FHWA)

Katie Zimmerman, Applied Pavement Technology, Inc., served as the team's subject matter expert. Contract

4 Highway MQA, www.highwaymqa.com

administration, scan organization, and travel support were provided by Arora and Associates, P.C. Harry Capers and Melissa Jiang were instrumental to the success of the scan. Greg Waidley, CTC and Associates LLC, also assisted the team with the peer exchange proposal development and planning for the meeting. Contact information for the scan team members is included in Appendix A and short biographies are included in Appendix B.

Other Peer Exchange Participants

Table 1-1 summarizes the state DOT participants who were not members of the original scan team. In addition to the representatives from the states, James Bryant, a senior program officer at the TRB attended the meeting.

Table 1-1 State maintenance participants (not members of the scan team).

State Agency	Participants' Names and Titles
Alabama DOT	Ben Yates, Assistant State Maintenance Engineer Morgan Musick, Maintenance Bureau
Alaska DOT	Dan Adamczak, Northern Region Maintenance & Operations Engineer
Arizona DOT	John Roberts, Maintenance Management Services Manager
Arkansas DOT	Joe Sartini, State Maintenance Engineer
Colorado DOT	Kyle Lester, Director, Division of Highway Maintenance B.J. Jacobs, Analyst VI
Delaware DOT	Matt Schlitter, South District Assistant Maintenance Engineer
Iowa DOT	Bob Younie, State Maintenance Engineer
Kansas DOT	W. Clay Adams, Bureau Chief of Maintenance
Louisiana DOTD	David Miller, Chief Maintenance Engineer
Maryland SHA	Sandi Sauter, Deputy Director, Operations
Michigan DOT	Tim Croze, Maintenance Services Engineer
Minnesota DOT	Jed Falgren, District 7 Maintenance Engineer Todd R. Stevens, Assistant District Engineer – East Operations Tom Zimmerman, Business Process Specialist, Asset Management Office
Mississippi DOT	Heath Patterson, State Maintenance Engineer James Williams, Chief Engineer
Montana DOT	Douglas McBroom, Operations Manager
Nevada DOT	Anita Bush, Chief Maintenance and Asset Management Engineer
New Hampshire DOT	Caleb Dobbins, Administrator, Highway Maintenance
North Dakota DOT	Beise Brandon, Maintenance Division
Ohio DOT	Kacey Young, Highway Management Administrator
Tennessee DOT	Jerry Hatcher, Director, Maintenance Division Chris Harris, Civil Engineering Manager 1 Amos Pulley, Transportation Project Specialist Austin Holliman, Transportation Project Specialist Ashley Pence, Administrative Services Assistant
Texas DOT	Alanna Bettis, Contracts and MMS Support Section Director
Utah DOT	Kevin Griffin, Director of Maintenance
Vermont DOT	Ken Valentine, Maintenance and Operations Bureau Deputy Director
Virginia DOT	Michael Stiles, Assistant Director of Fleet
Washington State DOT	Andrea Fortune, Maintenance Policy Branch Manager
Wyoming DOT	Ralph Tarango, District Maintenance Engineer

Peer Exchange Agenda

The peer exchange was organized over a 2½-day period, with five technical sessions that included both presentations from leading state DOT representatives followed by facilitated discussions. The technical sessions were organized around key findings from the domestic scan, including these areas:

- Collecting and maintaining inventory and condition assessment data
- Selecting performance measures and setting performance targets
- Using data to evaluate funding needs and allocate funding
- Building an organizational culture to support performance-based decisions
- Using technology to support maintenance budgeting
- Next steps – Where do we go from here?

During each of the technical sessions at least three, up to a maximum of six, participating agencies were asked to make 15-minute presentations describing their practices related to the topic area. Most of the speakers were selected from the Category 1 and 2 states identified during the initial scan. However, state DOTs that wanted to share their practices were invited to volunteer for a presentation slot and several agencies took advantage of the opportunity.

For each of the facilitated discussion sessions questions were provided to initiate discussion; however, there was typically enough discussion among the participants to make the prepared questions unnecessary.

A copy of the peer exchange agenda is provided in Appendix C.

Report Organization

This report summarizes the information presented during the peer exchange and suggests next steps for advancing the use of performance-based budgeting tools for maintenance activities in state DOTs. The report organization follows the peer exchange agenda, with each of the next five chapters addressing one of the five topics discussed during the peer exchange:

- Chapter 3: Collecting and Maintaining Inventory and Condition Assessment Data
- Chapter 4: Selecting Performance Measures and Setting Performance Targets
- Chapter 5: Using Data to Evaluate Funding Needs and Allocate Funding
- Chapter 6: Building an Organizational Culture to Support Performance-Based Decisions
- Chapter 7: The Use of Technology to Support Maintenance-Based Planning Activities

These chapters are followed by Chapters 8 and 9, which summarize key findings and recommendations, respectively. The final chapter, Chapter 10, presents an implementation strategy for putting the peer exchange findings into practice. There are also four appendices providing information about the scan team members (Appendix A and Appendix B), a copy of the peer exchange agenda (Appendix C), and a copy of the survey sent to the peer exchange participants prior to the event (Appendix D). Copies of the presentations from the peer exchange are available online[5].

5 Peer Exchange Presentations – Final, Files from Melissa Jiang at Arora and Associates, P.C., https://arorapc.sharefile.com/d-s45f3b9453724c09a

2 Practice Summary

Immediately prior to the peer exchange, a short survey of practice was distributed to participating agencies to summarize current practices so participants could quickly compare their MQA practices to those of the other participating state DOTs.

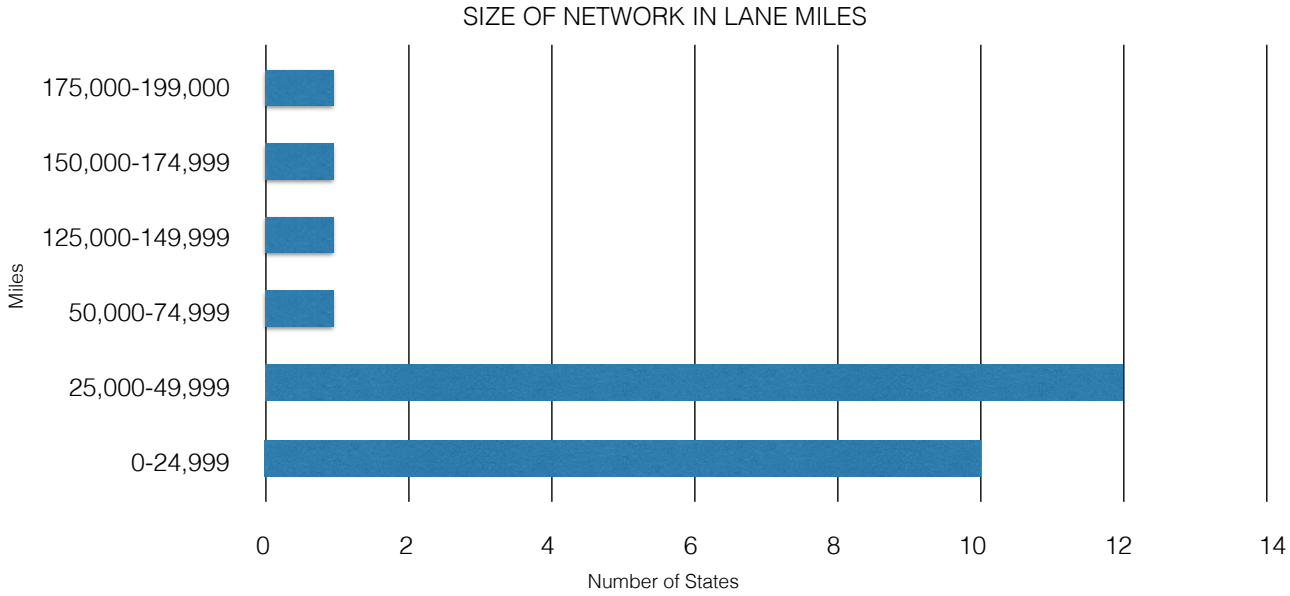
A copy of the survey is provided in Appendix D and the results are summarized here. A total of 27 agencies responded to the survey, although not all agencies answered each question. One of the agencies that responded to the survey, North Carolina DOT, had intended to participate in the peer exchange; however, a hurricane the week prior to the workshop forced it to cancel. Its responses are included in the information provided. The questions that were asked and the responses received from the 27 responding agencies are provided in this chapter.

Several highlights from the survey are summarized below.

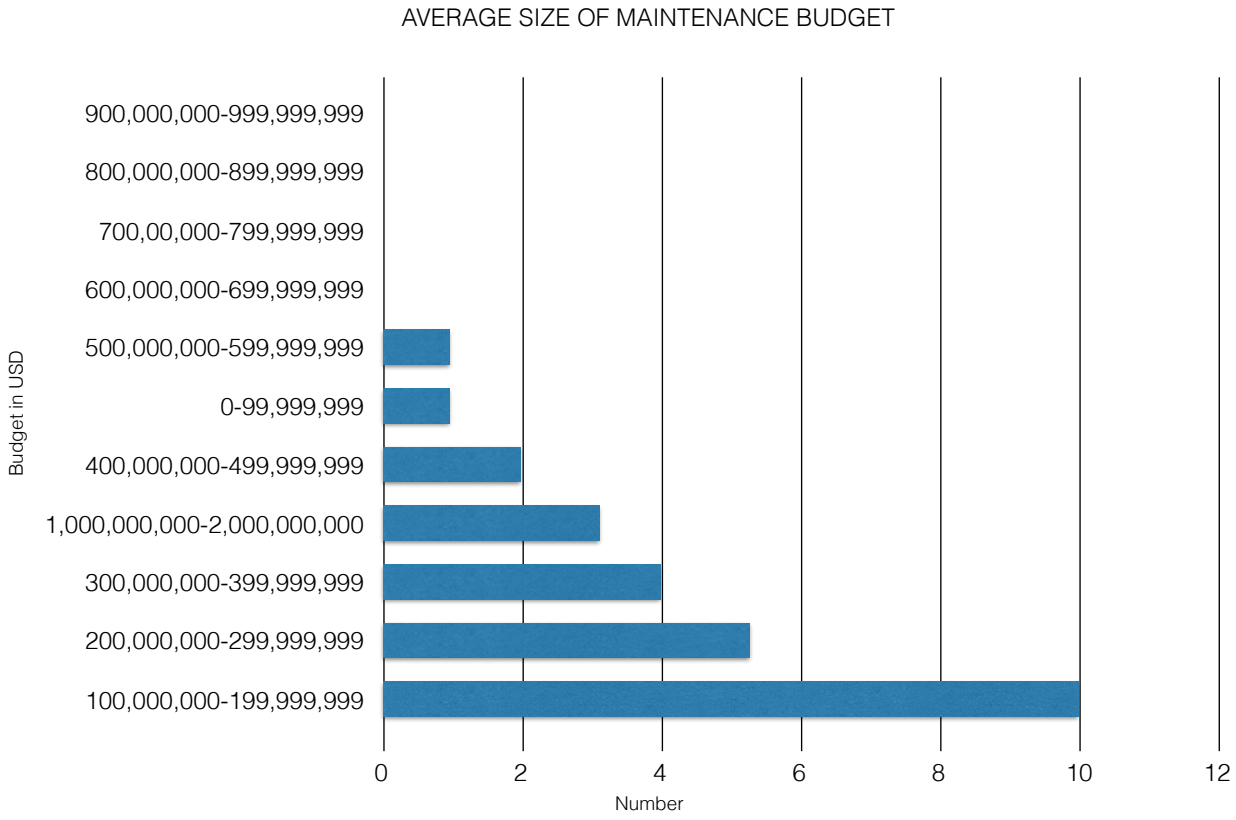
- Fifteen out of 27 agencies reported that they had an MQA program in place and an additional nine agencies indicated that they had parts of a program in place. Most agencies (23) are collecting MQA data annually on 1/10-mile samples (used by 19 agencies). Only eight of the 21 agencies that reported using a sampling process inspect 5% or more of their system as part of their MQA surveys.
- A total of 21 agencies have a computerized MMS in place and three more are in the process of implementing or updating a system.
- Only 10 of the 27 agencies are using the results of their MQA inspections to develop a needs-based budget for their maintenance program. Eight agencies reported that they had used their performance data to increase maintenance funding.
- More than half of the responding agencies have complete, current inventories for the assets listed below. Many agencies have established inventories for other assets, as presented in Appendix D.
  - Intelligent transportation system (ITS) assets (15)
  - Culverts (15)
  - Guardrail end treatments (16)
  - Overhead sign structures (17)
  - Guardrail (17)
  - Rest areas (18)
  - Signs (19)

Survey Response Summary

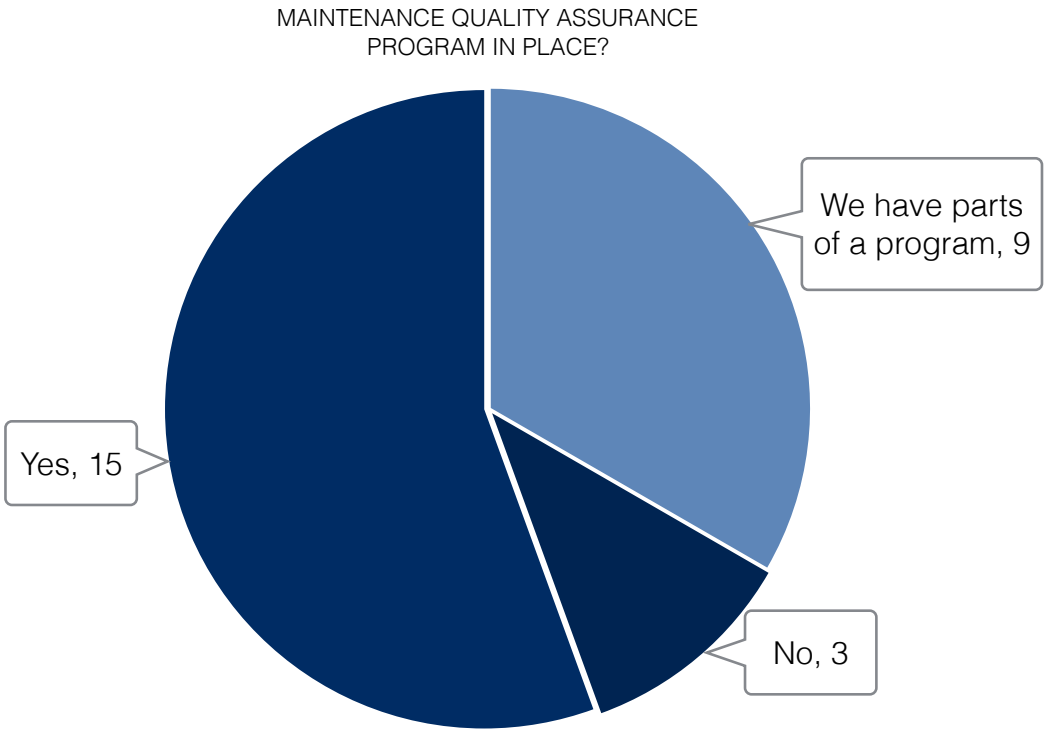
What is the approximately size of your network in lane miles? (26 responses)



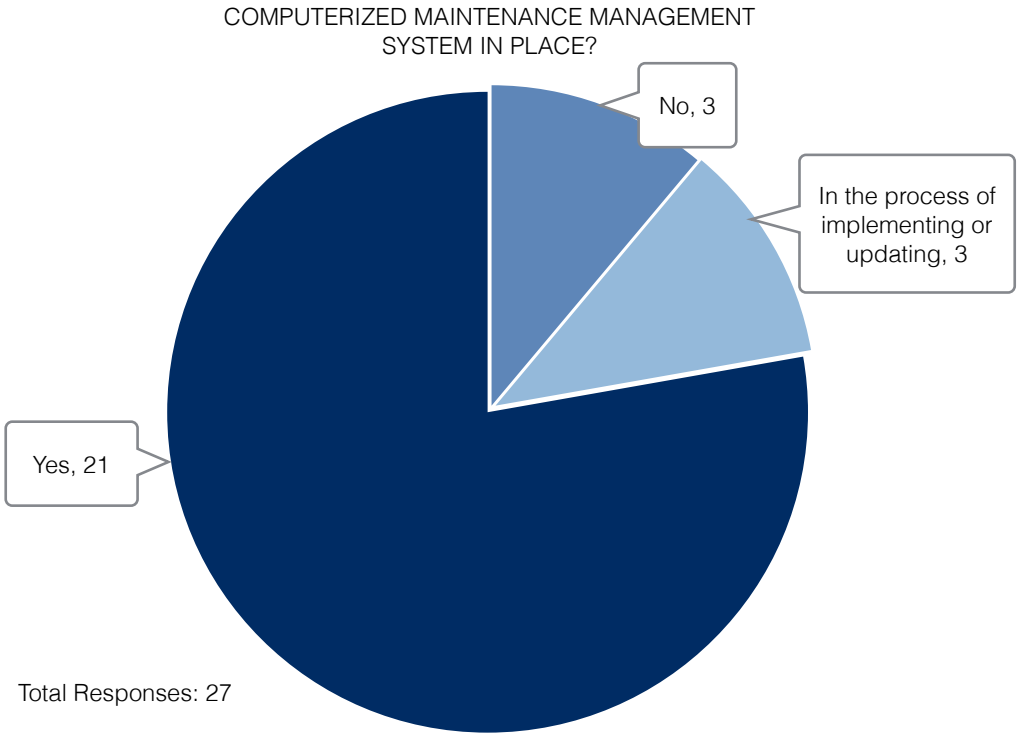
What is the average size of the maintenance budget (in dollars)? (26 responses)

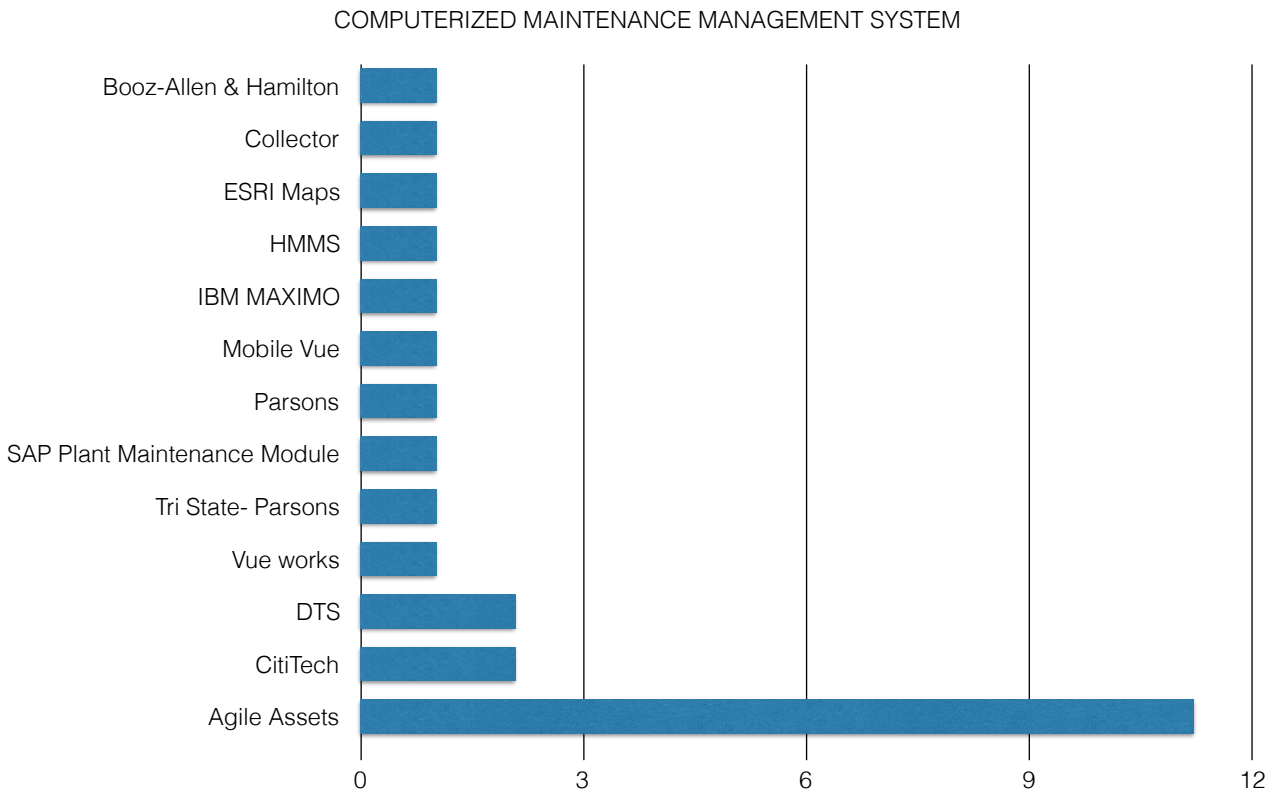


Do you have an MQA program in place? (27 responses)

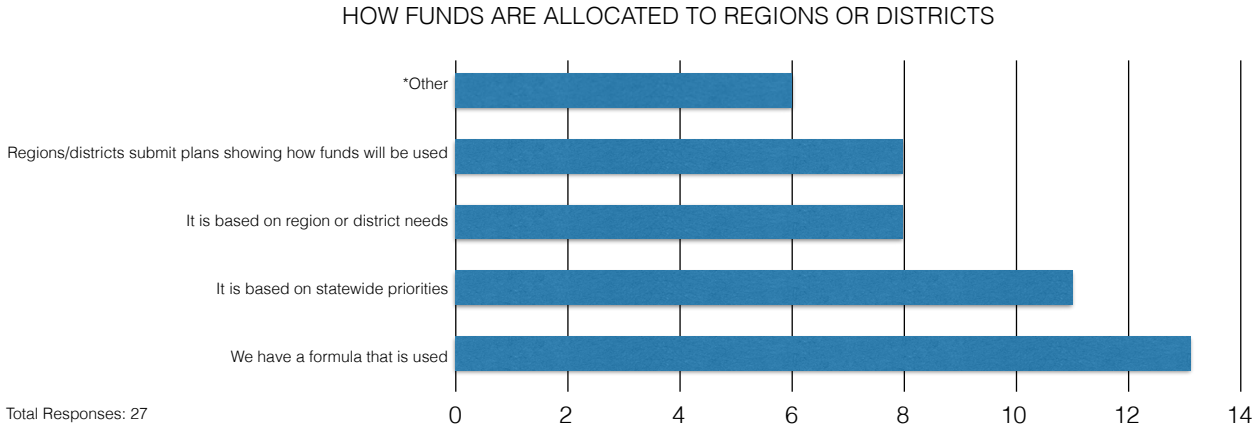


Do you have a computerized MMS in place? (27 responses) If so, please name the provider.





How are funds allocated to regions or districts? (27 responses, multiple answers provided)

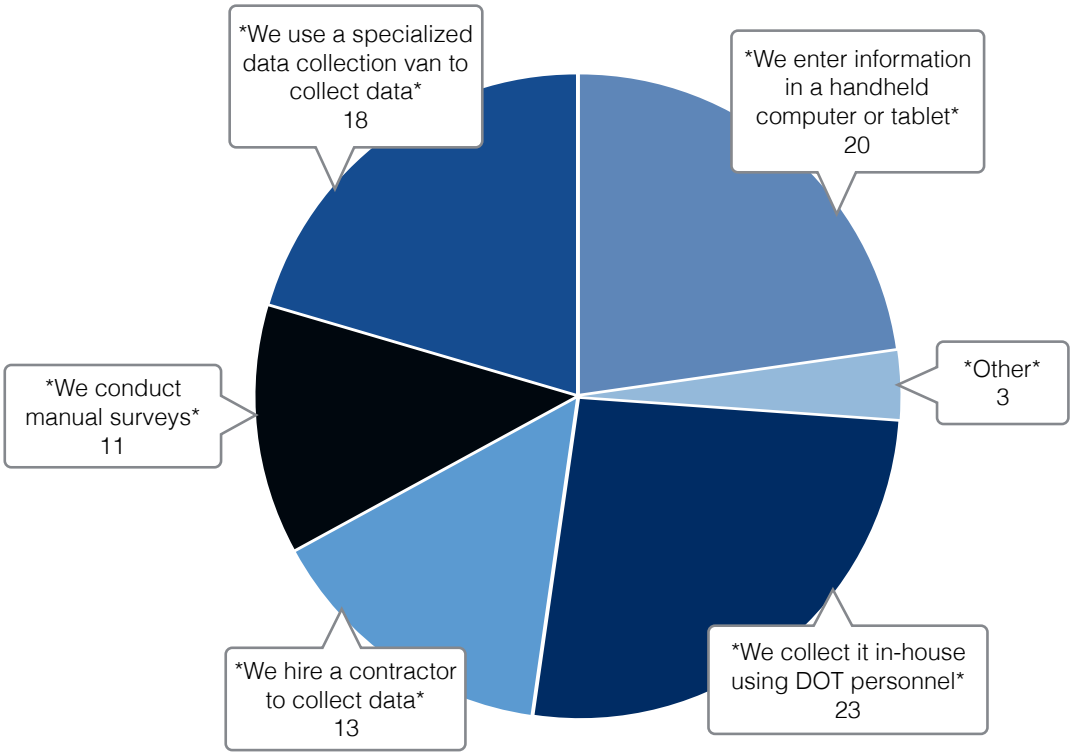


Other responses provided included:

- Historical budget
- Budget based on historical budgets with annual economic increase and adjusted throughout the year based on input from monthly maintenance budget team meeting
- County-level asset inventory by road system
- Historical allocation adjusted based on specific data-supported needs
- Dollar limit caps set by executive staff
- Routine: predominately historical

How are inventory and condition data collected? (27 responses, multiple answers provided)

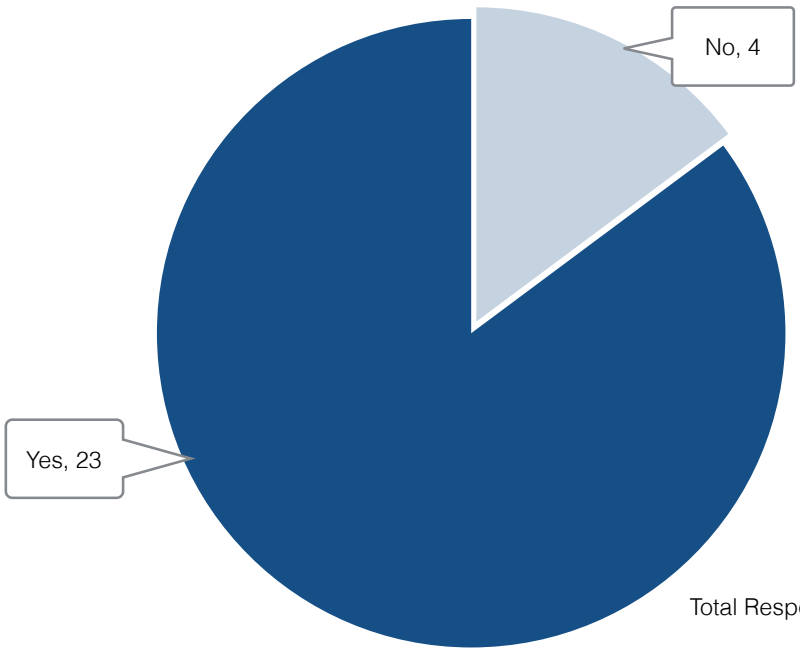
METHODS FOR COLLECTING INVENTORY AND CONDITION DATA



Other responses included, "In past years we have used visual inspection. This year, automated collection."

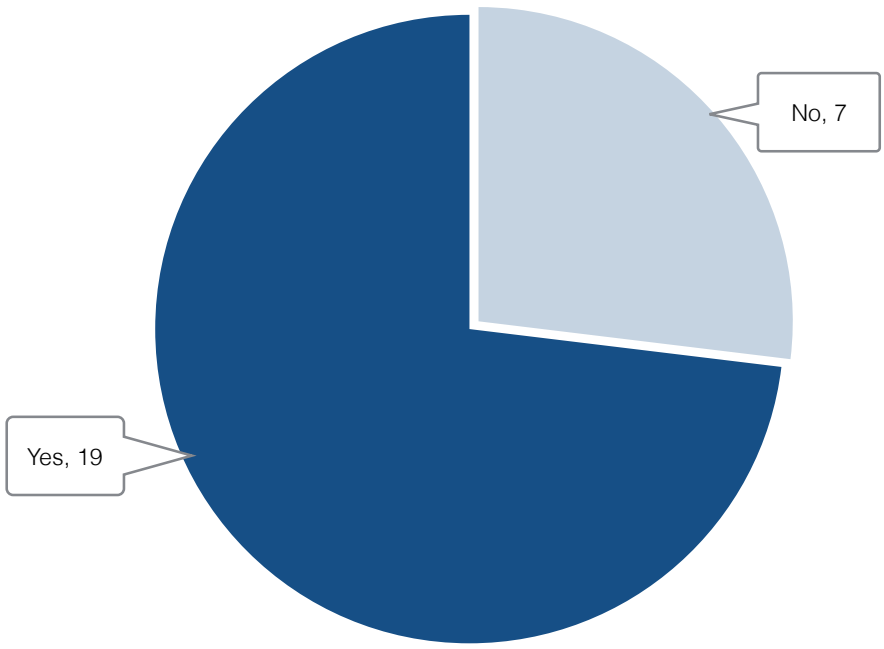
Do you collect asset condition information at least annually? (27 responses)

IS ASSET CONDITION INFORMATION COLLECTED AT LEAST ANNUALLY?



Total Responses: 27

Do you use 1/10-mile samples for inspections? (26 responses)

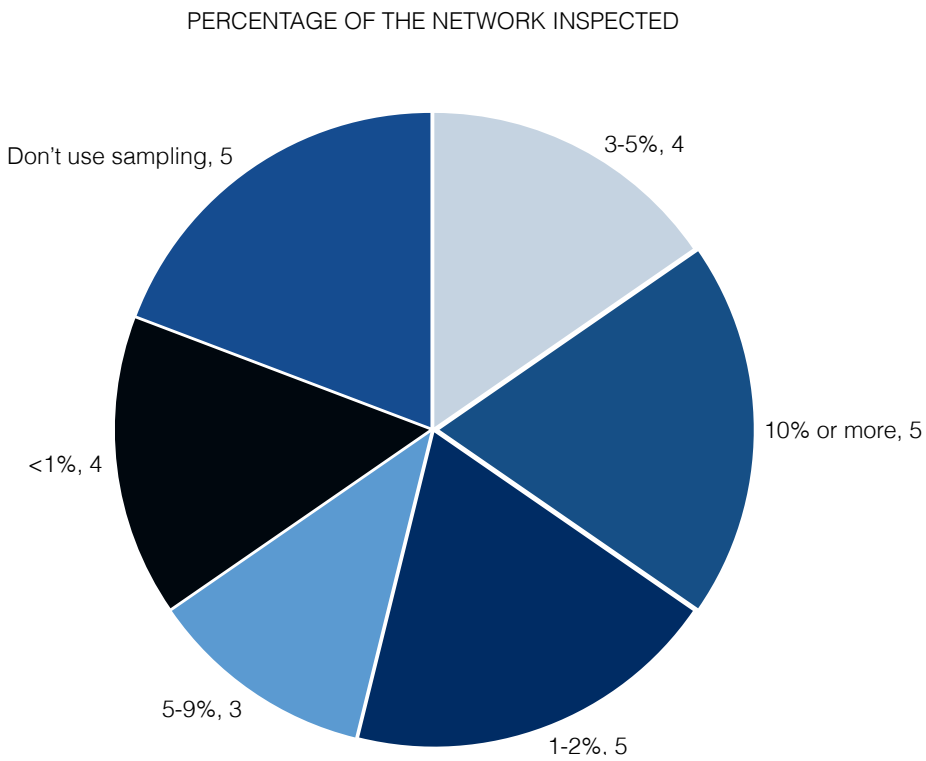


One agency that uses 1/10-mile samples noted that sign and striping reflectivity are inspected using a 1-mile sample.

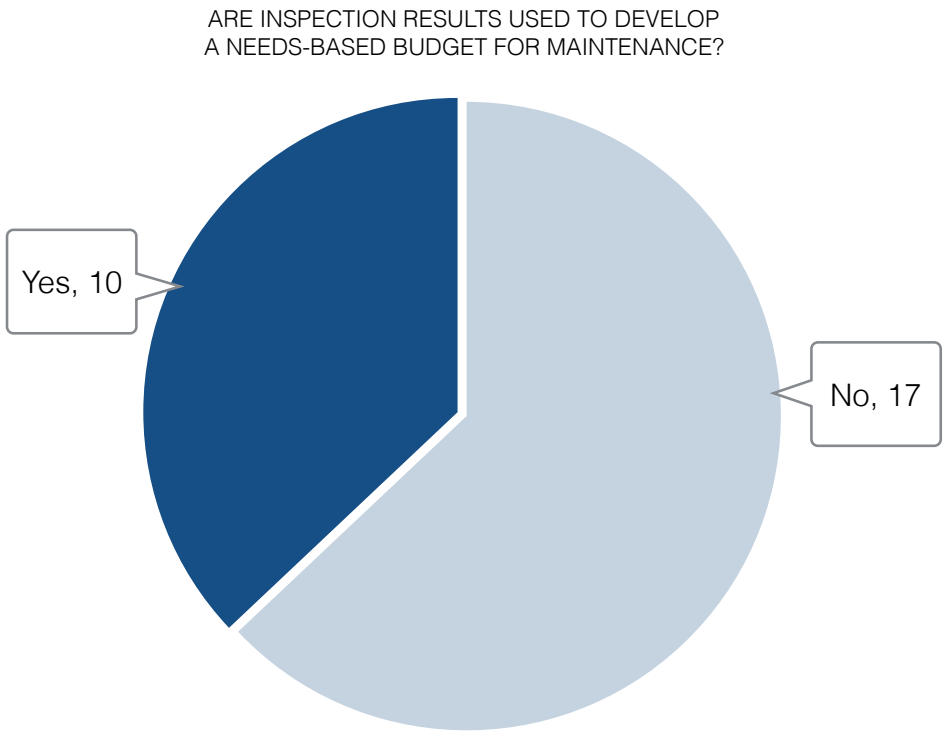
Agencies that do not use 1/10-mile samples use the following sample sizes:

- 0.5-mile (two agencies)
- 0.2-mile (one agency)
- Full roadway length (one agency)
- Did not provide sample size (three agencies)

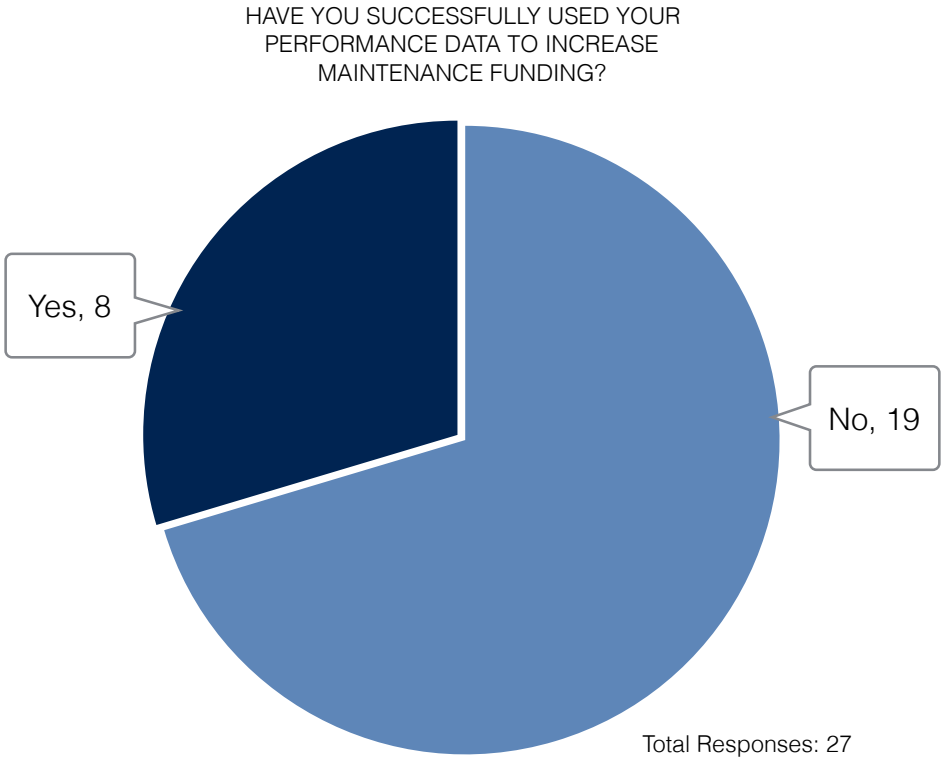
If sampling is used, approximately what percentage of the network do you inspect? (26 responses)



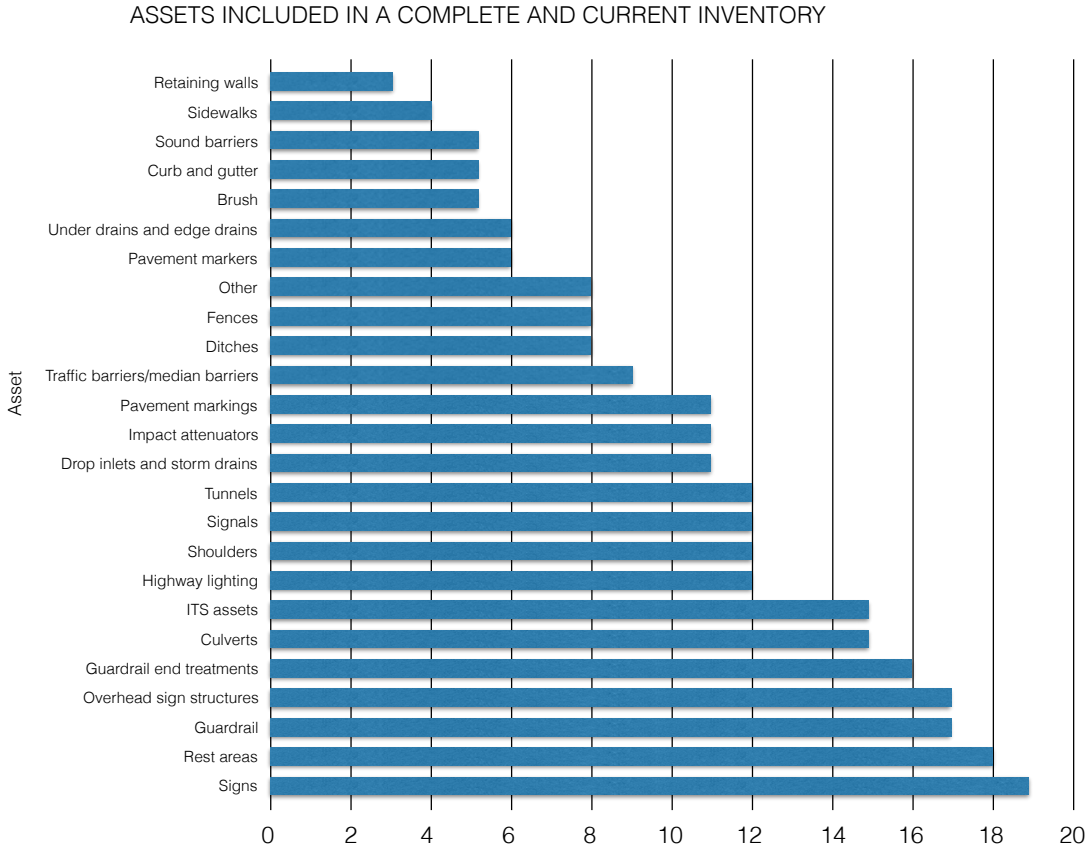
Are inspection results used to develop a needs-based budget for maintenance? (27 responses)



Have you successfully used your performance data to increase maintenance funding? (27 responses)



Which assets are included in a complete and current inventory? (27 responses)



Other responses provided included potholes, rumble strips, rutting, bikeways, blowing snow control features, bridge joints, surface separation, bridges, cattle guards, cracking, delineators, drainage, gravel surfacing, landscape, litter, mowing areas, noise walls, pavement dropoffs, pavements, post-construction best management practices, pump stations, railroad crossings, road weather information system (RWIS) installations, slope stability, snow fence, and travel lane widths.

3 Collecting and Maintaining Inventory and Condition Assessment Data

The availability of a complete, comprehensive, and credible asset inventory, along with reliable asset condition information, is fundamental to being able to conduct performance-based budgeting activities. During this session, representatives from six state DOTs summarized their practices in this area. The presentations reflect a range of approaches to collecting and maintaining asset inventory and condition information. These varied approaches impact the agencies' level of confidence in the data and the way the information is used.

Presentation Summaries

Washington State

Andrea Fortune introduced Washington State DOT's (WSDOT's) Maintenance Accountability Process, which is a comprehensive planning, measuring, and managing process that is used to communicate the impacts of policy and budget on maintenance activities. The agency is actively collecting data on 14 assets and condition information is one of several indicators used to represent a level of service (LOS). Inventories are complete for signals, signs, ITS assets, highway lighting, tunnels, rest areas, stormwater best management practices, cable barriers, bridges, and roadside. Inventories are currently being developed for culverts, catch basins, guardrail, end treatments, impact attenuators, and pavement markings.

Dedicated regional survey teams perform inspections on 420 randomly generated sites each year over a 3-week period. This number is a significant reduction in the number of sites inspected previously (2200 sites) but budget and workforce demands impacted the number of inspections they could perform. As a result of the drop in the number of samples, the information can only be used for statewide reporting since there are not enough samples to report grades at the regional level.

Since 2015, WSDOT has made a commitment to using technology to support maintenance activities. For instance, 1200 of its 1500 full-time equivalents (FTEs) have iPads that allow them to access and report information in the field daily. The DOT developed a map-based application for entering field data collection using touch features, so it is easy to use, and all information is geospatially located.

The agency has collected a lot of information using the iPads and is currently developing ways to use the information effectively. One year, it was able to use the information to reduce tort liabilities associated with snow and ice removal claims from $10 million to $1 million. In addition, the information is used to tell the maintenance story to the legislature, media, internal stakeholders, and other DOTs. The information helps it identify areas of concern where additional funding may be needed, as shown in Figure 3-1. In 2017, the DOT achieved 77% of its maintenance asset condition targets.

The agency faces several challenges with regard to maintaining their asset inventory. For instance, when new assets are added to the system, maintenance does not necessarily receive the information needed. Additionally, there are several inventory systems/databases that are being maintained, so data integration is another challenge that the agency faces.

	Funded level (MAP LOS target)	2015 results	2016 results	2017 results
Special Bridges and Ferry Operations[1]	A	A	A	A
Traffic Signal System Operations	C	B	C	B
Snow and Ice Control Operations	A	A	A	A
Bridge Cleaning	B	B	B	B
Urban Tunnel System Operations	B	B	B	N/A[2]
Regulatory/Warning Sign Maintenance	C	D	C	D
Intelligent Transportation Systems	A	A	B	A
Slope Repairs	A	B	A	B
Catch Basins and Inlets Maintenance	A	A	B	A
Barrier Maintenance	A	B	A	B
Pavement Striping Maintenance	B	A	B	A
Raised/Recessed Pavement Marking Maintenance	C	C	C	C
Vegetation Obstruction Control	C	C	A	C
Rest Area Operations	B	B	B	B
Sweeping and Cleaning	A	A	A	C
Highway Lighting Systems	A	B	B	C
Ditch Maintenance	B	B	A	B
Guidepost Maintenance	D	D	D	D
Stormwater Facility Maintenance	A	A	A	A
Culvert Maintenance	D	D	B	C
Pavement Marking Maintenance	D	D	C	F
Shoulder Maintenance	C	C	C	C
Noxious Weed Control	B	B	B	A
Guide Sign Maintenance	C	C	C	C
Nuisance Vegetation Control	D	C	D	C
Landscape Maintenance	D	D	C	C
Litter Pickup	D	D	D	D

Figure 3-1 Sample maintenance accountability process results from Washington State DOT

Mississippi

Heath Patterson summarized the MQA practices Mississippi DOT uses. He indicated that the agency conducts condition assessments on 50 maintenance elements, which is down slightly from the 54 elements that had been included in the past. Asset owners perform pavement and bridge condition assessments outside of maintenance, and the MQA program rates the condition of the remaining assets using a sampling approach. Grades ranging from A to F are assigned to all assets, including pavements and bridges, using the available condition information. The DOT uses the grades to set LOS targets and to report current conditions.

Central office staff performs inspections on approximately 2700 1/10-mile segments each year, which is statistically significant to report at the district level. Mr. Patterson indicated that he would like to be able to report grades at the county level but recognizes that this would require more samples. During discussions with other participants, it became evident that several states are reducing the number of samples they're

inspecting, which Mr. Patterson found interesting because the trend differed from his intentions.

Field inspections are informed by a data collection manual that explains how to look at each element and what to measure, as shown in Figure 3-2. The inspection data is currently entered on a form and transferred to a laptop computer; the agency plans to transition to a tablet-based approach with a data collection application in the near future.

Asset Group: Unpaved Shoulders	**Date:** June 2007
Maintenance Feature: Drop Off	
Definition: Shoulder drop-off includes deformation or loss of material along the edge of the paved surface, where there is a vertical drop in elevation 2 inches or more below the edge of the paved surface.	
Measurement Unit: Inventory: Lindear feed of unpaved shoulders. Note: All roadways have 2 shoulders, whether it's obviously evident or not, even if they are only a few feet wide. Therefore a divided highway would have 4 shoulders. A shoulder is defined as a "paved shoulder" if it is paved greater than or equal to 4 feet past the edge line. Generally curbs are within 2 feet of the edge line, but if it's not, then you may want to consider saying there is a paved shoulder. This same rule could apply to barrier walls greater than 2 feet from the edge line. Condition: Linear feet of drop-off of unpaved shoulders.	
Inspection Procedure: Shoulder Drop-Off data will be collected at the sample sites in the field. For each sample with unpaved shoulders, measure and record the total linear feet of unpaved shoulder on both sides of the roadway in the sample area. Also, inspect the edges of pavement for drop-offs of 2 inches or more and measure and record the total linear feet of such drop-off along both shoulders. Use the measuring tape or wheel, as appropriate, to measure length and a level or straightedge and emtal tape to measure the drop in elevation.	

Figure 3-2 Excerpt from the Mississippi DOT MQA manual

The MQA data is fed into an MMS that was developed in partnership with Alabama DOT (ALDOT). Mr. Patterson reported that the core system is useful but there are still gaps and challenges that they are dealing with. One of the challenges that Mr. Patterson reported is establishing data governance protocols and maintaining asset inventories. The agency has created an Asset Management Workshop Group to help tackle these issues. The group was formed under a larger, Geographic Information System (GIS) Committee whose responsibilities include defining asset data ownership and developing standard operating procedures for data governance and inventory maintenance. Some of the inventories are stored in older legacy software but the agency envisions moving toward a single platform for all asset data in the future.

Tennessee

TDOT uses an automated data collection van to establish its asset inventory. Chris Harris reported that asset information is extracted from a photolog and light detection and ranging (LiDAR) information for approximately 20 assets. Information on interstates is collected every year and information on other state routes is collected every other year. The van collects data on mainline pavements and ramps with a single pass in each direction. The information is entered into a GIS database at the asset class level. Mr. Harris reported that the DOT spends about $3.5 million annually on data collection and extraction, which represents about $50/mile for collecting the data and about $60/mile for asset extraction. A visual representation of asset extraction is provided in Figure 3-3.

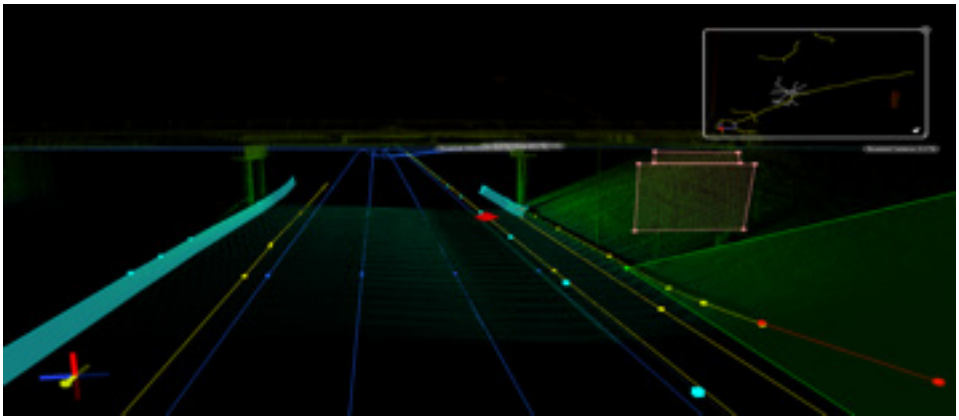


Figure 3-3 Asset extraction example from Tennessee DOT

The inventory data that the vendor provides is used in combination with the past frequency of performing maintenance (the LOS) to determine needed maintenance work quantities. The work quantities are then multiplied by a unit cost to determine the total budget for maintenance activities. Mr. Harris reported that the DOT's LOS is currently based on the amount of work required to maintain the inventory in the past; however, in the future the agency hopes to convert to a LOS that is driven by condition instead.

The inventory is entered into the MMS at a summary level for each county rather than at the asset level. This is an important distinction since it means that the work activity information the DOT has been collecting since the 1970s is not linked to the asset inventory. Work activities currently continue to be reported on paper, although the agency may transition to tables in the future.

District staff conducts condition assessments annually using approximately 7000 1/10-mile samples (i.e., 6% of the network). As part of the DOT's quality assurance activities, consultants re-inspect approximately 10% of the surveys conducted by the districts. The MQA program has undergone some changes in recent year, including a shift from the previous pass/fail approach to a graded approach. The change was made so the agency has a better idea of how close it is to meeting targets.

The inspections evaluate six elements (i.e., pavement, shoulder, roadside, drainage, traffic services, and ramps) and 61 characteristics. Any deficiencies noted during the inspections are used to assign a grade of A to F to an asset. A GIS-based application that runs on a tablet is used to record MQA data in the field. Future efforts are expected to be able help the DOT estimate the cost of moving from one LOS grade to another. This will enable the agency to develop a needs-based budget and to better estimate the LOS that can be achieved for the level of funding that is provided.

Maine

Dale Doughty reported that MaineDOT is only in its second year of its MQA program. He indicated that in the New England area, the New Hampshire, Vermont, and Maine legislatures frequently compare practices and conditions. To facilitate common reporting, the transportation agencies from the three states pooled their resources to develop a shared, home-grown MMS. Under this arrangement, any modules paid for and developed by one state become available to the other two states to use.

A primary focus for the MaineDOT in the past year has been the development of data quality standards. A field inspection manual has been developed so all three states are measuring conditions in the same way. Inspections are conducted each fall during a two-week period and data is entered into a tablet using an application developed by an intern. The number of samples currently inspected represents less than 1/10 of the network, so data is reported at the statewide level. The DOT has not yet established LOS targets but plans to do so in the future.

Nevada

Anita Bush indicated that Nevada DOT (NDOT) began collecting data for its Maintenance Achievement Program in 2012. Initially, consultants collected the data; eventually the DOT was provided funding for two FTEs and one was assigned responsibility for conducting the MQA surveys. This has helped NDOT avoid data quality issues and has ensured that the inspections are done each year. Inspectors are trained by Maintenance and Asset Management staff using a combination of classroom and field activities.

The MQA field surveys are conducted on 1100 randomly selected, 1/10-mile segments. The number of samples was selected to provide a statistically significant sample size for statewide reporting at a 95% confidence level. The inspection results are input using a Survey123[6] application that is accessed in the Collector for ArcGIS[7] application, as shown in Figure 3-4. The use of mobile phones for data entry has eliminated data errors associated with the old paper forms and allows both photographs and text descriptions to be added to the records. The Maintenance and Asset Management headquarters staff performs field reviews on randomly selected sites as part of the agency's quality assurance activities. The results are reviewed for accuracy and precision within acceptable tolerance levels.

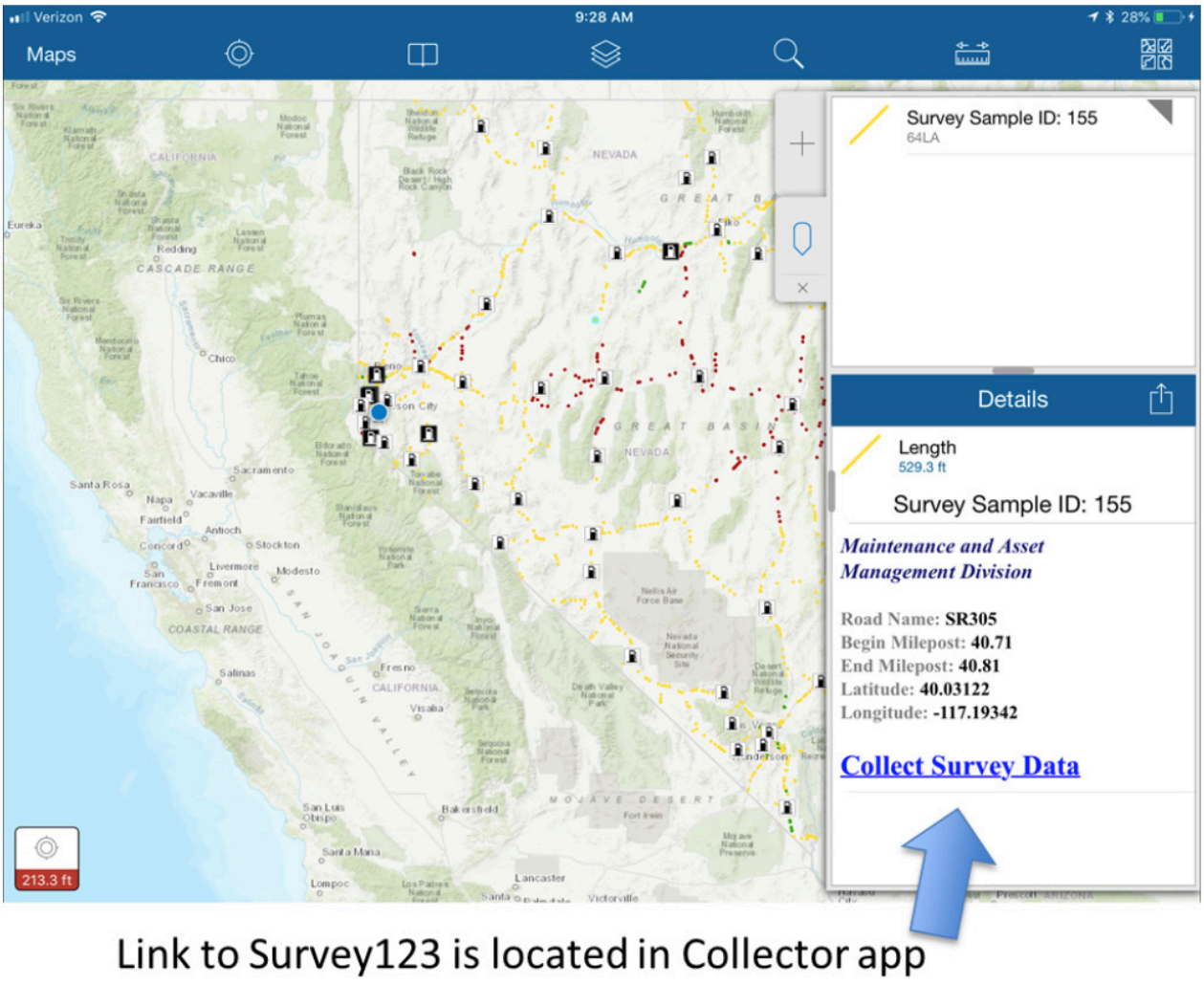


Figure 3-4 Access to the Survey123 application for field data collection from Nevada DOT

6 Survey123 for ArcGIS, https://survey123.arcgis.com/
7 Collector for ArcGIS, https://www.esri.com/en-us/arcgis/products/collector-for-arcgis/overview

The MQA results can be filtered by district or by maintenance task using an online version of ArcGIS. The results are compared to established targets for each maintenance task using scorecards, such as the one shown in Figure 3-5, allowing the DOT to more effectively plan, budget, and manage its highway maintenance work.

Statewide
Nevada DOT Maintenance Assets Level of Service, 2016

Group	Task	Asset Feature	Sum of Deficient Asset	Sum of Total Asset	% Deficient	Level of Service			A	B	C	D	F
						Units	Measure	Grade					
Group 112- Concrete Repair	112.03.01	Curb & Gutter (Lin Ft)	1,342	71,854	1.87	% Deficient	1.87	A-	A-				
	112.05.01	Reinforced Concrete Boxes/Pips (Es)	21	181	11.60	% Deficient	11.60	F					F
	112.06.01	Concrete Barrier Rail (Lin Ft)	808	39,097	2.07	% Deficient	2.07	B		B			
	112.08.01	Repair Drop Inlets (Ea)	2	147	1.36	% Deficient	1.36	B+		B+			
Group 131 - Roadside Maintenance	131.01.01	Clean Drains & Culverts (Ea)	20	171	11.70	% Deficient	11.70	D+				D+	
	131.01.02	Clean Drop Inlets (Ea)	19	152	12.50	% Deficient	12.50	D+				D+	
	131.01.03	Clean Slotted Drains (Ea)	461	596	77.35	% Deficient	77.35	F					F
	131.01.04	Clean Culvert Openings (Ea)	112	734	15.26	% Deficient	15.26	D				D	
	131.01.07	Clean Retention Basins (Ea)	0	1	0.00	% Deficient	0.00	A+	A+				
	131.05.01	Repair Culverts (Ea)	34	648	5.25	% Deficient	5.25	D+				D+	
	131.05.03	Repair Channels/Ditches (Lin Ft)	6,029	421,403	1.43	% Deficient	1.43	A-	A-				
	131.05.05	Clean Ditches (Lin Ft)	10,097	417,922	2.42	% Deficient	2.42	B		B			
	131.06.01	Fill & Cut Slopes (Lin Ft)	17,569	1,055,566	1.66	% Deficient	1.66	B+		B+			
	131.07.01	Blade Shoulders (Lin Ft)	19,566	259,363	7.54	% Deficient	7.54	D				D	
Group 133 - Roadside Cleanup	133.01.01	Debris Litter (Ea)	0	13,633	373.51	No. / Mile	373.51	C			C		
	133.01.03	Litter Barrels (Ea)	0	11	0.00	% Deficient	0.00	A+	A+				
	133.03.01/05.01	Sweepable Area (Sq Ft)	10,760	72,071	14.93	% Deficient	14.93	C			C		
Group 134/135 - Maint. of Roadside Appurtenances	134.03.03	Rock Mulch (Sq Ft)	4,700	128,808	3.65	% Deficient	3.65	C+			C+		
	135.01.01	Wire/Fabric Fences (Lin Fet)	1,731	503,903	0.34	% Deficient	0.34	A+	A+				
	135.01.02	Chain Link Fences (Lin Ft)	62	15,051	0.41	% Deficient	0.41	A+	A+				
	135.01.03	Glare Screens (Lin Ft)	0	598	0.00	% Deficient	0.00	A+	A+				
Group 141 - Traffic Services	141.01.01	Traffic Signs (Ea)	78	1,656	4.71	% Deficient	4.71	C-			C-		
	141.02.01	Guardrail (Lin Ft)	828	43,689	1.90	% Deficient	1.90	B		B			
	141.02.03	Guardrail End & Impact Attenuator (Ea)	7	91	7.69	% Deficient	7.69	F					F
	141.02.06	Cable Barrier (Lin Ft)	170	5,951	2.86	% Deficient	2.86	C+			C+		
	141.04.01	Paint Stripes (Lin Ft)	106,429	1,824,325	5.83	% Deficient	5.83	A	A				
	141.06.01	Raised Pavement Markers (Ea)	824	19,457	4.23	% Deficient	4.23	A-	A-				
	141.08.01	Pavement Markings (Ea)	156	5,263	2.96	% Deficient	2.96	A+	A+				
	141.09.01	Street Lights (Ea)	6	226	2.65	% Deficient	2.65	A	A				
	141.09.02	Structure & Tunnel Lights (Ea)	0	8	0.00	% Deficient	0.00	A+	A+				
	141.09.03	High Mast Lights (Ea)	1	17	5.88	% Deficient	5.88	B		B			
	141.09.05	Overhead Sign Lights (Ea)	1	34	2.94	% Deficient	2.94	A	A				
	141.11.01	Roadway Markers (Ea)	251	4,786	5.24	% Deficient	5.24	C+			C+		
Group 161 - Structure Maintenance	161.01.05	Structure Drains (Ea)	0	2	0.00	% Deficient	0.00	A+	A+				
	161.01.07	Retaining, Sound & Bin Walls (Sq Ft)	0	6,162	0.00	% Deficient	0.00	A+	A+				
	161.02.02	Sweep Structures (Sq Ft)	0	38,816	0.00	% Deficient	0.00	A+	A+				
	161.03.01	Graffiti (Sq Ft)	216	1,025	0.21	Sq Ft / Mi	0.21	A+	A+				

Figure 3-5 Sample scorecard from Nevada DOT

Montana

Doug McBroom reported that Montana DOT (MDT) initially implemented its MMS in 1983. At that time, the system was designed to track work activities to the roadway (not by asset) using manual processes. Since activities were tracked by roadway, the DOT could not easily differentiate activities performed in locations with multiple assets present and had no way to assess why work activities were being performed. To track the costs of individual assets, maintenance personnel had multiple spreadsheets that were being

used by the five districts; no centralized or consistent process was in place. To overcome these shortcomings, the DOT acquired a new MMS that is being used to manage 16 assets, including bridges and culverts, facilities, fuel vaults, rest areas, radios, relays, signals, luminaires, guardrail and crash barriers, roadway sections, fence, RWIS, signs, and variable message signs. Safety assets are managed in separate systems, so Maintenance does not have responsibility for them.

MQA data is collected using ArcGIS Collector. The application can be used offline, which is important for the rural areas in Montana. The DOT developed its own interface for the Collector application. Asset inventories are maintained using information provided by Construction as part of project closings, which is verified by Maintenance and updated in the system. Condition data is collected in eight areas (i.e., bridges, buildings/facilities, radios, culverts, pavement markings, rest areas, bike paths, and signs) and reported in terms of good, fair, or poor condition. The form relies extensively on checkboxes, as shown in Figure 3-6, so it is quick and easy to use in the field.

Sign Inspection Sheet

Section: 1102 Seeley **Inspection Date:** **Survey Foreman:**

Route and C000024E MP 20 + 0.39 to 51 + 0.2

Route and Dir.	MP	Offset	Sign Pic	Desc. of Sign	Years Life			Sign Condition			Remarks
					Replace	1-5	6-12	Poor	Fair	Good	
C000024E	20	0.422		Miscellaneous	☐	☐	☐	☐	☐	☐	
C000024E	20	0.423	STOP	Regulatory	☐	☐	☐	☐	☐	☐	
C000024E	20	0.988		Warning	☐	☐	☐	☐	☐	☐	
C000024E	21	0.001		Milepost	☐	☐	☐	☐	☐	☐	
C000024E	21	0.004		Milepost	☐	☐	☐	☐	☐	☐	
C000024E	21	0.373		Warning	☐	☐	☐	☐	☐	☐	
C000024E	21	0.638		Warning	☐	☐	☐	☐	☐	☐	

Figure 3-6 Example sign inspection sheet from Montana DOT

The MMS that has been implemented includes a planning module that will allow the DOT to conduct a tradeoff analysis in the future, once it has three years of data and cost versus LOS curves.

Mr. McBroom indicated that the DOT has realized some unexpected benefits from the use of the new MMS tools. For instance, the information it had on luminaires led to a project to replace all high-pressure sodium luminaires with LED, which will cut utility costs in half and require no ongoing maintenance. The DOT estimates that the project will have a four-year return on investment in terms of utility savings alone.

Facilitated Discussion

Following the presentations, the moderator facilitated a discussion around the topics of data quality, data use, staffing, and data quantity. Key points raised during the discussions are captured below.

Keeping the Inventory Current and Ensuring Data Quality

Several state DOT participants indicated that they have multiple asset inventories that are not centrally managed. Efforts to establish central inventories suffered because processes are not established to keep the

inventory current.

- Mississippi DOT indicated that this prompted it to focus attention on data governance so roles and responsibilities for data are clear.
- TDOT process uses ghosting to highlight differences from prior inventories.
- Utah DOT (UDOT) extracts inventory data every two to three years from the LiDAR collected as part of the agency's annual pavement condition surveys. The DOT is moving toward a continuous inventory updating process that would be the responsibility of Maintenance supervisors.
- New Hampshire DOT (NHDOT) estimated that it would take 1.5 years to establish a baseline inventory for drainage assets. Since this seemed impractical, it asked how other states had been able to establish drainage inventories. The North Dakota DOT has established a five-year centerline pipe rotation and it used that time in the field to update conditions. If there are critical problems, they flag the pipe for more frequent inspections.
- FDOT reviews and updates the inventory every five years and inspects the assets within 90 days of a construction project.

Data Usage

Many of the participants reported that the condition assessment information is not being used for budget activities but this seemed to be an area of interest. Some of the challenges that emerged are summarized below.

- For WSDOT, reporting backlog is important. Since it doesn't have a culvert inventory at this time, it is difficult for the DOT to estimate a backlog or estimate what it will cost to get to a certain LOS.
- Mississippi DOT indicated that it does not have confidence in its ability to estimate the funding needed to move from one LOS to another.
- Several state DOTs indicated that they estimate maintenance needs but the number is generally so high that it is not funded. When they are only allocated a small percentage of the needs, it can be frustrating to go through the annual needs-assessment process. For that reason, MaineDOT indicated that it starts with a constrained budget so that the only needs that are identified are activities that can be done for the available funds. The needs are identified by experienced personnel, many of whom will be retiring in the next few years. Transitioning that institutional knowledge to avoid becoming too reactive will be a challenge.
- NHDOT was asked to determine the minimum LOS that could be accepted and then calculate the budget needed to achieve it. The exercise helped it identify what had to be done and any extra money went toward activities the DOT thought it should do. Things that weren't funded were communicated with maintenance staff. At the end of the year, it was able to achieve the target that had been set.
- In Florida, funding is provided to achieve 80% of the Maintenance Rating Program (MRP) targets. If funding levels decreased, safety activities would get done and aesthetics would not. These kinds of decisions are made by decentralized districts; however, a process has been established to inform the decisions and evaluate supervisors based on the work completed at the program level.

Staffing

MaineDOT's comment about losing institutional knowledge promoted a series of discussions about staffing levels, staff retention, and skill development

- Several of the participating agencies sponsor sessions of the MLA offered through the NHI and recommended the course as a good way to train new maintenance personnel.
- ARDOT had a challenge retaining personnel because there was no way to increase pay without moving up in the organization. To address this problem, it established a performance-based method of pay. It also has instituted online training that employees can use to enhance their skills.

Sampling and Improving Inspection Efficiency

There was a lot of interest in how states determine the number of samples to inspect as part of the MQA process. Several states indicated that they had recently reduced the number of samples inspected due to budget and staffing issues; however, that has impacted how the data can be reported from a statistical perspective. Some of the issues that arose during this discussion are captured below.

- WSDOT was comfortable reducing the number of samples inspected because maintenance crews are reporting information on assets daily into the Highway Activity Tracking System (HATS) using the new iPads. The crews aren't necessarily conducting condition assessments but they're reporting preventive maintenance activities or areas that need attention.
- MDT is exploring the use of virtual personal assistant devices, such as Alexa[8], to report asset conditions. For instance, an inspector could alert Alexa that a sign at his or her location is in poor condition.
- In the past, UDOT inspected 100% of its network but that could not be maintained. The agency conducted a study to determine what sample rate would give it valid data from a statistical perspective and found that the number was about 20%. Another state DOT indicated that it did a similar type of study and found that 10 to 12% of the network should be sampled for statistically valid data. The Arizona DOT (ADOT) indicated that it is only collecting data on about 3% of its network, which is inadequate for what it needs.
- UDOT has established a critical category of assets that is inspected annually. Other assets are inspected every three years.
- The Minnesota DOT (MnDOT) asked whether samples are selected randomly each year. Most state DOT participants indicated that their samples are random.
- MaineDOT asked whether state DOTs set different sampling rates for certain parts of their network. ADOT had to establish different sampling rates for cattle guards and electrical features (e.g., pump houses) since they do not appear often in randomly selected samples. They target a 50% inspection rate for those assets.
- ALDOT inspects 11,000 samples, which was determined based on a 95% confidence level and 8% margin of error for reporting at the district level. The agency investigated the variation in scores from one year to the next and found that the numbers don't shift dramatically. It is investigating whether it can reduce the number of samples by shifting to a 90% confidence level.

8 Amazon Alexa, https://en.wikipedia.org/wiki/Amazon_Alexa

Key Session Takeaways

- Several state DOTs are reducing the amount of MQA data being collected due to staffing and budgeting issues. As a result of the decrease in the number of samples, the data is statistically significant at the state level but grades cannot be reported reliably at the district or region level. NCHRP Report 422, Maintenance QA Program Implementation Manual[9], includes an equation for calculating the number of samples needed for a statistically representative sample size.
- Some agencies have assigned responsibility for MQA surveys to central office personnel to ensure that the surveys are done and to improve consistency. Additionally, several agencies are using data from other sources (e.g., pavements, bridges, and traffic safety) to reduce the amount of data collected by maintenance personnel.
- Agencies are increasingly using technology to improve the reliability and efficiency of data collection activities. Several of the participating agencies were using tablets and LiDAR techniques. The increased use of technology is forcing maintenance personnel to develop skills in this area.
- The availability of complete inventories is a key component to using MQA information for performance-based budgeting. Several agencies have been able to establish and maintain asset inventories by using asset extraction tools available from the contractors conducting automated pavement condition surveys for the agencies.
- Data governance is becoming increasingly important to ensure consistency in available information.

9 NCHRP Report 422, Maintenance QA Program Implementation Manual, National Cooperative Highway Research Program, 1999, http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_422.pdf

4 Selecting Performance Measures and Setting Performance Targets

Performance measures and targets are critically important for making performance-based investment decisions. The information is used to set investment priorities, to communicate needs to various stakeholders, and to hold agency personnel accountable. This chapter summarizes the use of performance-based maintenance programs to set performance targets and introduces some of the challenges participating agencies face in using performance-based data to drive maintenance investment decisions.

Presentation Summaries

Arizona

Approximately 900 of the 3700 people ADOT employs are in maintenance. The agency uses a needs-based budgeting process that is performed using its Performance Control Section (Pecos) system, illustrated in Figure 4-1. John Roberts described several characteristics of the Pecos system, which contains about 200 maintenance activities and is used to track all maintenance expenditures. The system tracks who performed the work, what was done, what resources were used, and what it cost. All inventories are managed in Pecos and action plans are developed using this process.

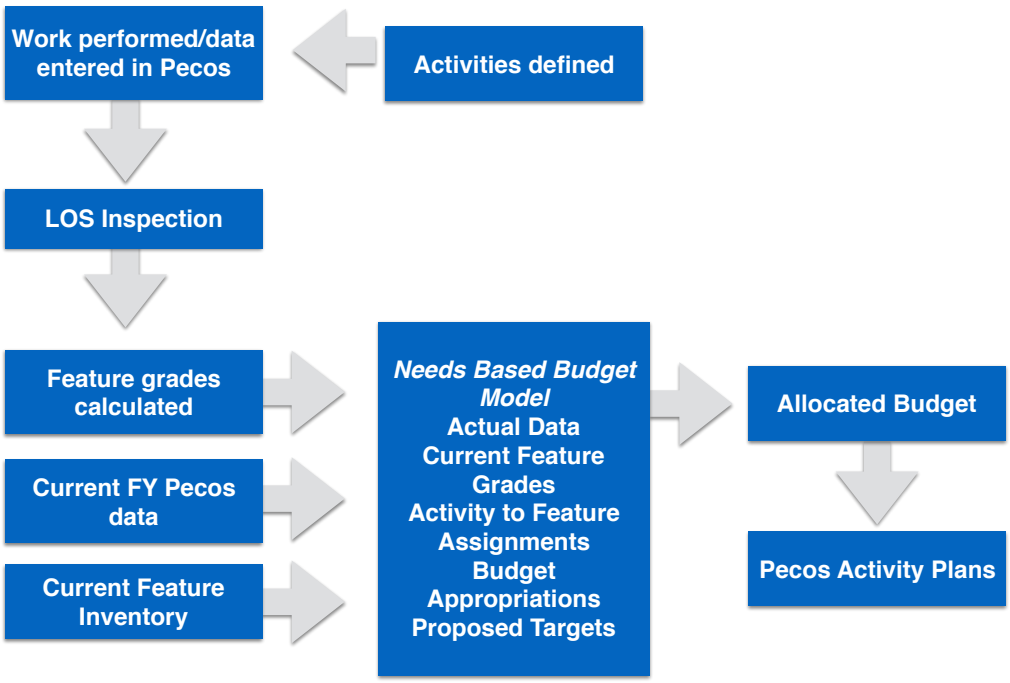


Figure 4-1 The Arizona DOT needs-based budgeting process

In addition to Pecos, ADOT has a feature inventory system, which is a web-based application that identifies and locates all highway features except bridges.

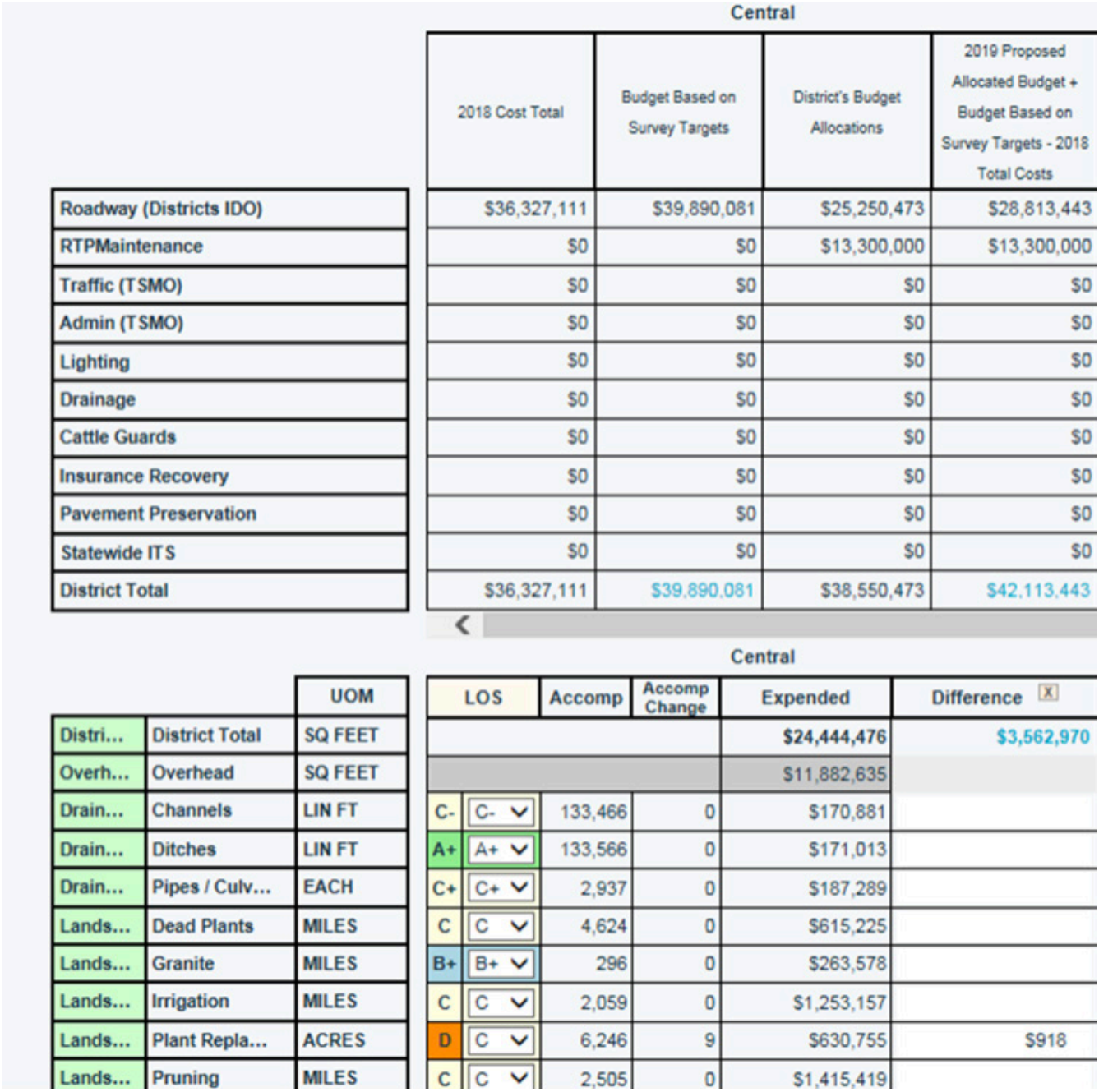
District staff once performed field inspections to establish LOS ratings; central office personnel now conduct these inspections. Approximately 2000 1/10-mile samples are inspected annually, which represents approximately 3% of the system. Longer segments are used to evaluate signing and striping and a percentage of electrical assets are inspected separately. The LOS grade, which ranges from A to F, represents the amount of deficiency present.

To set performance targets, the previous year's data is used to determine actual accomplishments. Work activities needed to achieve each LOS level are established and used to estimate the amount of work that will be required for various target levels. For example, using the information provided in Figure 4-2, the previous year's accomplishments are represented by a level of effort (LOE) factor of 1.0, which is represented by a current work program of 268 lane miles and a score of a C-. If a target of B- were set for the current year, an additional 302 lane miles would need to be addressed, resulting in an adjusted program of 570 lane miles. As shown by the LOE in the bottom line of the table, this represents approximately 12.19% of the inventory. Once the level of work is known, associated costs can be calculated.

Work Program Adjust. Needed:	A+	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F
Current Program	268	268	268	268	268	268	268	268	268	268	268	268	268
Difference	901	738	629	520	302	302	193	84	0	-134	-243	-407	-570
Total Program (Adjusted)	1,169	1,006	897	788	570	570	461	352	268	134	25	-139	-302
LOE Factor	4.36	3.75	3.35	2.94	2.13	2.13	1.72	1.31	1.00	0.50	0.09	0.00	0.00
LOE (Work Units/Inventory Unit)	25.03%	21.53%	19.19%	16.86%	12.19%	12.19%	7.53%	7.53%	5.74%	2.86%	0.53%	0.00%	0.00%

Figure 4-2 Sample work accomplishment table from Arizona DOT

Once the available funding level is known, final targets can be established and funds can be allocated equitably to the districts accordingly, using the needs-based budgeting model represented in Figure 4-3. The top portion of the graphic summarizes the prior year's expenditures for one district, the funding needed to address the LOS targets, the district's budget allocation, and the final proposed budget for the current year. The bottom portion of the graphic reflects differences in accomplishments from the prior year that will be required to meet a different LOS target in the current year. For example, the LOS target for plant replacement changed from a D to a C, requiring $918 more to address the increased accomplishments that will have to be addressed. The district allocations are then entered in Pecos and the districts allocate funding to individual units, which represents the level at which individual activities are managed. Additional funding for drainage, ITS, lighting, pavement, and cattle guards has been allocated by the legislature to address specific needs.



Central

	2018 Cost Total	Budget Based on Survey Targets	District's Budget Allocations	2019 Proposed Allocated Budget + Budget Based on Survey Targets - 2018 Total Costs
Roadway (Districts IDO)	$36,327,111	$39,890,081	$25,250,473	$28,813,443
RTPMaintenance	$0	$0	$13,300,000	$13,300,000
Traffic (TSMO)	$0	$0	$0	$0
Admin (TSMO)	$0	$0	$0	$0
Lighting	$0	$0	$0	$0
Drainage	$0	$0	$0	$0
Cattle Guards	$0	$0	$0	$0
Insurance Recovery	$0	$0	$0	$0
Pavement Preservation	$0	$0	$0	$0
Statewide ITS	$0	$0	$0	$0
District Total	$36,327,111	$39,890,081	$38,550,473	$42,113,443

Central

		UOM	LOS	Accomp	Accomp Change	Expended	Difference
Distri...	District Total	SQ FEET				$24,444,476	$3,562,970
Overh...	Overhead	SQ FEET				$11,882,635	
Drain...	Channels	LIN FT	C- C-	133,466	0	$170,881	
Drain...	Ditches	LIN FT	A+ A+	133,566	0	$171,013	
Drain...	Pipes / Culv...	EACH	C+ C+	2,937	0	$187,289	
Lands...	Dead Plants	MILES	C C	4,624	0	$615,225	
Lands...	Granite	MILES	B+ B+	296	0	$263,578	
Lands...	Irrigation	MILES	C C	2,059	0	$1,253,157	
Lands...	Plant Repla...	ACRES	D C	6,246	9	$630,755	$918
Lands...	Pruning	MILES	C C	2,505	0	$1,415,419	

Figure 4-3 Needs-based budgeting model from Arizona DOT

Utah

Kevin Griffin reported that UDOT's initial MQA program, which was implemented in 1997, was modeled after the WSDOT program. A Quattro Pro spreadsheet was used initially but the agency transitioned to its Maintenance Management Quality Assurance (MMQA+) program in 2003. It has since moved to Oracle Database and formed an MMQA+ coalition made up of two representatives from each district serving two-year terms to help with further enhancements to the program and to promote data consistency and buy-in. Mr. Griffin indicated that significant changes to the data collection aspects of the program are underway to develop a dynamic quality assurance program and to make the inspections less labor intensive; these changes are addressed in Chapter 7.

When the MQA program was first established, UDOT collected data on 95 1/10-mile samples. The surveys were conducted twice a year and were statistically significant for a statewide assessment. In 2003, the agency wanted to use the data to establish feature condition thresholds that could trigger maintenance activities, so it moved to a 100% sample that was collected twice a year; however, there were challenges to maintaining this level of detail and data quality was an issue. In 2012-2013, UDOT formed data collection teams to limit the number of people conducting the inspections and that has had a significant impact on improving the quality of the data. The inspection teams now conduct inspections at each shed every other year, with approximately 20 sheds inspected in the spring and another 20 in the fall. Quality assurance (QA) checks are performed one to two days after the inspections. The QA teams conduct meetings at the stations to compare results, allowing the teams to use the QA inspections for both consistency checks and training.

The MMQA+ results are used to establish levels of maintenance (LOM) on a scale from A to F. Targeted LOM are set by asset and are generally established at the A to C level. Maintenance resources and schedules are managed to meet the LOM targets for 16 asset categories in the following groups:

- Snow and ice control
- Hard-surface maintenance
- Non-hard-surface maintenance
- Roadside maintenance
- Vegetation control
- Drainage and erosion repair
- Major structure maintenance
- Traffic services

Maintenance activities are focused on the low-volume roads in the state rather than interstate and high-volume road maintenance needs.

Florida

In Florida, a statute is in place that establishes preservation as the prevailing principle for FDOT. Rudy Powell indicated that this preservation-first requirement established performance measures and targets for pavements, bridges, and roadway maintenance. Under the statute, FDOT is required to achieve 100% of the acceptable maintenance standard on the state highway system. The department's MRP is used to define the acceptable maintenance standard.

FDOT's MRP is a systematic, sample-based evaluation system that includes three primary components: field assessments, administration, and quality control (QC)/QA reviews. A handbook defines the maintenance conditions for various assets and includes a procedure for setting performance targets. The MRP divides the state highway system into four facility types (based on traffic and functional classification), five elements (i.e., roadway, roadside, traffic services, drainage, and vegetation/aesthetics), and 35 characteristics (i.e., unique features for each individual element). Field assessments use a pass/fail approach that compares actual maintenance conditions to the desired maintenance conditions to determine whether the sample meets or does not meet established criteria. The results are compiled into a numeric score ranging from 0 to 100 at the characteristic, element, and overall levels. The target scores include an MRP score of 70, 75, and 80 at the characteristic, element, and overall levels, respectively. District secretaries, directors, maintenance engineers, and operations engineers are held accountable for meeting the targets. MPR specialists, team

leaders, and technicians are held accountable for meeting MRP QC/QA reviews.

An example of the rating criteria is shown in Figure 4-4. In this example, a sample on a rural arterial road would "meet" the criteria if no more than 1% of the vegetation exceeds 12 inches. If 5% of the vegetation in the sample exceeded 12 inches, the sample would be marked as "not meeting" the criteria.

VEGETATION AND AESTHETICS			
ROADSIDE MOWING:	No more than 15 of vegetation exceeds (varies) inches high. This excludes allowable seed stalks and decorative flowers allowed to remain for aesthetics.		
FACILITY TYPE	CLASSIFICATION		DESIRED HEIGHT
1	Rural Limited Access		5 inches - 18 inches
2	Rural Arterial		5 inches - 12 inches
3	Urban Limited Access		5 inches - 12 inches
4	Urban Arterial		9 inches maximum

Figure 4-4 Sample rating criteria used by the Florida DOT for vegetation and aesthetics

Colorado

B.J. Jacobs summarized the maintenance LOS (MLOS) budgeting tools that the Colorado DOT (CDOT) first launched in 1999 and updated in 2015. The MLOS system rates performance in terms of letter grades ranging from A+ to F. When targets are set, budget estimates are developed to meet the targets. Targets are set at the activity level and weighted averages at the maintenance program area (MPA) level are used at the supervisor, section, and statewide levels. Individual targets are established annually for each MPA based on the current inventory, current LOS, and targeted LOS. MPA supervisors are now being held accountable for achieving their targets each year. If unexpected events occur, the targets are re-evaluated to reflect the necessary adjustments. The MLOS information is also used to allocate funds to the MPAs based on the available budget and MPA priorities (i.e., snow and ice control; roadway surface; tunnels; roadside facilities; roadside appearance; structure maintenance; traffic services; materials, equipment, and buildings; and planning and scheduling).

Ms. Jacobs reports that the new budgeting system is easy to use and enables the agency to link performance goals to work activities. The system also allows CDOT to track workloads, equipment, and materials to monitor accomplishments.

Information used to support the MLOS program comes from various sources. Maintenance worked with the pavement management staff so that the pavement survey information that is collected annually could support the MLOS needs. The Bridge Division provides the bridge data and collects data on half of the state-maintained bridges each year. The Striping Task Force also collects data, such as retroreflectivity, that is provided to support MLOS. Night inspections provide necessary information on reflectivity and lighting, and snow removal data is used to report the time to bare pavement. Maintenance staff collects the remaining information needed to support MLOS (including roadsides, guardrail, signals, and signs) each summer.

In response to a 2015 initiative from the governor's office that is part of the Four Disciplines of Execution, specific lead and lag metrics are being reviewed monthly to ensure that DOT investments are driving the

organization in alignment with objectives established by the Transportation Commission. Each month, maintenance reports on specific lead and lag metrics are presented to the executive director, chief engineer, and other senior leadership. A variety of metrics are included in this initiative, including:

- Bridges – bridge deck area condition and scheduled performance index
- Pavements – drivability match and percent match to pavement model recommendations and high-priority corridors
- Transportation Systems Management and Operations – incident clearance time in high-priority corridors, average travel time, and travel incident management training
- Traffic safety – striping performance
- Maintenance – overall maintenance LOS, maintenance resurfacing projects, and winter operations LOS in high-priority corridors

Facilitated Discussion

Following the presentations, the moderator facilitated a discussion around topics raised by the meeting participants. Key points raised during the discussions are captured below.

How Are Letter Grades for LOS Established?

- UDOT uses pictures of assets at each grade to help people understand what each grade means. Once the grades were understood, it was easier to set targets. The DOT has revisited the letter grades several times, with the last evaluation taking place in 2012. The adjustments to the measures have resulted in changes to what is measured. For instance, it used to have a performance measure for mowing but no longer monitors it.
- Mississippi DOT admitted that it started with measures from other state DOTs and modified them to meet Mississippi's needs. After the initial performance measures and targets were established, the DOT found that the agency's expectations were higher than the public's and the budget wasn't adequate to achieve the DOT's targeted conditions.
- FDOT has a task team that reviews the measures each year and brings forward suggested changes.

Are Maintenance Crews Over-Servicing in Some Areas?

- In Montana, the DOT found that the agency often exceeded snow and ice targets. The MnDOT also regularly exceeds snow and ice targets but reports that it is almost intentional. The agency is considering whether the targets should be revised to reflect the higher LOS that is routinely being provided.
- ADOT had several areas that were exceeding targets, such as raised pavement markers and delineators but it has revised the targets to reduce the expenditures on those assets. The agency also exceeds striping targets since some materials are lasting longer than expected.
- Maintenance personnel at MaineDOT develop work plans that are followed closely. In fact, the crews don't like to do work that isn't in the work plan, so they are not diverted from important targets. Mr. Doughty indicated that once an agency makes a habit of over-servicing an asset it is hard to correct because the higher conditions become the new expectation.

- If UDOT districts exceed a target, they are asked to explain their actions and the central office collaborates with the district to adjust spending to improve the condition of another asset.

Are Customer Surveys and Crowd Sourcing Used?

- WSDOT conducts customer surveys every five years through its publication office. The results from the surveys are not directly incorporated in the MQA program; however, MQA and survey results may be shown side by side in reports. UDOT indicated that its practices are like those used by WSDOT. Although the surveys in Utah look at data similar to performance data in the MQA program, the information is not collected at a level that is useful for MQA purposes.
- MnDOT asks the public the same question every year to monitor performance. In addition, the agency conducts surveys on snow and ice removal to determine customer expectations.

How Are Targets Communicated?

- Leadership from UDOT is involved in the Utah Transportation Coalition[10], which facilitates information exchange.
- ADOT maintenance staff works with senior leadership on target setting and loads the results into the model for the districts to use in allocating funds. In addition, maintenance conducts a road trip with each district to review needs and priorities. The LOS data is used to communicate underperforming activities (represented by LOS grades of D or F) to supervisors, who then communicate with their groups about adjustments that may be needed.
- In some cases, agencies have felt pressure to shift money from maintenance activities to address other agency priorities. For example, MnDOT has a moratorium in place because of pressure to protect pollinators and wildlife. CDOT provided incident management as an example of a high-profile activity that reduces the amount of time that crews can spend on other, less visible activities.
- MDT experienced this when money was shifted to address rest area needs. As a result of the funding shift, there was less money available for pavement preservation.
- Several state DOTs mentioned that they used customer survey results to establish priorities to some extent. For instance, Mississippi DOT did a survey and found that bridges were the top priority to the participants; however, most of their complaints dealt with litter removal. In New Hampshire, graffiti is a higher priority than in the past. When the North Dakota DOT did a survey, the participants indicated that there should be no difference in LOS between interstate and lower-volume roads. As a result, the DOT revised its LOS targets to be the same across the system.

Other Issues in Budgeting and Performance Target Setting

- Kansas DOT (KDOT) has had a pass/fail rating program for over 15 years. However, the information could not be used for budgeting because the DOT lacked a complete inventory and the level of inspection was not adequate from a statistical perspective (e.g., each area had 30 inspection areas out of 300 lane miles). The information is helpful to the areas to help them rebalance resources but it has been difficult to make the link to budgeting.
- Several state DOTs indicated that they report both aspirational and constrained targets. The aspirational targets represent conditions the agencies would like to achieve but can't due to funding

10 Utah Transportation Coalition, http://utahtransportation.org/

constraints. The constrained targets are realistic targets that can be achieved with the available funding; these are more useful when holding crews accountable for performance.

- Several state DOTs indicated that they are using an overall maintenance health index. North Carolina, Colorado, Florida, Tennessee, and Maryland DOTs indicated that pavements and bridges are not included in the health index. Both KDOT and FDOT indicated that they weight certain elements when calculating the index so it better reflects high-priority activities.
- In some cases, performance data was used to lower targets or obtain additional funding for maintenance. For example, WSDOT presented information showing that targets in three activities had not been accomplished in any of the past three years, so either additional funding was needed or the target needed to be lowered. MnDOT included several maintenance assets in its Transportation Asset Management Plan, which has helped raise the profile of maintenance activities in the agency. ADOT has used LOS data successfully to get funding for special line items.

Key Session Takeaways

- Few of the participating agencies are using performance data to drive budgeting decisions; the information is more commonly used to help agencies determine maintenance activities and priorities. Both ADOT and WSDOT were able to demonstrate tools each agency had developed to support their needs-based budgeting activities. FDOT has legislation in place that ensures that funding is provided to achieve maintenance targets. To advance in this area, state DOTs expressed interest in learning more about the benefits realized by being able to more effectively use performance data for target setting and budgeting. The importance of program champions was also emphasized by participants who have had programs in place for many years, including Iowa DOT and UDOT.
- Comprehensive and complete inventories are key to being able to confidently use performance data for target setting and budgeting. UDOT has established tiers to help prioritize the order in which inventories are established. To keep the inventory current, agencies must develop and implement effective processes, such as requiring construction crews to update the inventory as part of a project closeout (as FDOT does).
- There are differences in the terminology and performance measures that are being used by the participating DOTs and how the performance data is being used to establish targets.
- CDOT discussed the power of using lead measures rather than the more traditional use of lag measures to drive long-term decisions. The identification and use of lead measures shows potential as a future development in MQA programs.

5 Using Data to Evaluate Funding Needs and Allocate Funding

Performance-based decisions rely on the availability of sound, credible information. The degree to which data is used to make investment decisions is strongly related to the degree of confidence that managers have in the data. This chapter highlights the use of performance data to evaluate funding needs and to allocate funding to districts and regions.

Presentation Summaries

Mississippi

Heath Patterson indicated that the LOS analysis for Mississippi DOT begins with an analysis of what it has (from the inventory), what condition it is in (from the MQA data), and how much work has been done on it (from the work reporting capabilities in its MMS). While the LOS analysis captures most costs, certain expenditures (e.g., salaries, cyclical work, contractual expenditures, and historical expenditures that roll over to the next year) are excluded. Asset inventories are based either on actual data or extrapolated for a given district or county. Mr. Patterson suggested that the more accurate the inventories, the more accurate the results of the analyses would be.

The Mississippi DOT's Asset Management, Maintenance, and Operations system encompasses information from the agency's pavement management, bridge management, MQA, and work reporting systems. Work reporting is tracked using an average wage rate per position rather than actual rates. This has impacted the agency's ability to file Federal Emergency Management Agency (FEMA) claims because FEMA requires actual rates. The work reporting system also tracks actual equipment rental rates and material costs to maintain the current LOS by county and route using in-house forces.

For work planning activities at the district level, the analysis converts the amount of work completed divided by the total inventory to a percentage (e.g., 1,000 linear feet of guardrail work completed divided by 10,000 linear feet in the inventory means that 10% of the system was addressed). Then, using LOS tables, such as the one shown in Figure 5-1, the current LOS (a C) is used to estimate the percent of guardrail that is defective (e.g., 3 to 5%) and the targeted LOS (a B) is used to specify the acceptable percent of guardrail that can be defective (e.g., 1 to 3%). Using the middle of each range, the increased LOE required is 4% (representing the current LOS) minus 2% (representing the targeted LOS), resulting in an increased LOE of 2%. Since the current LOS was determined to be 10% and the increased LOE is 2%, the needed LOE is 12%. This equates to 1,200 linear feet of guardrail, which can be converted to crew days and equipment/material costs using historical statewide averages.

Maintenance Element	LOS Measure	LOS Classes				
		A	B	C	D	F
Guardrail	% of guardrail length defective	0-1	1-3	3-5	5-10	>10

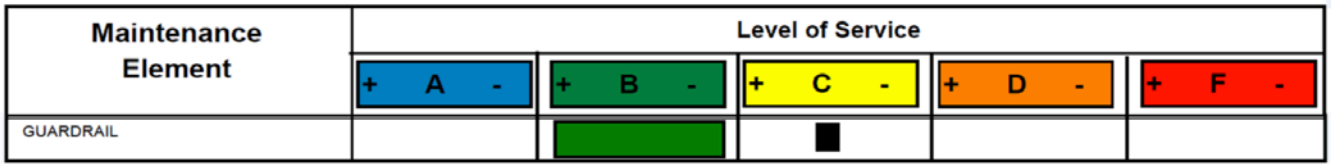


Figure 5-1 LOS deficiency definitions for guardrail from Mississippi DOT

Once the LOS needs are determined for each item, historical and contractual amounts are added to the work plan and the final numbers are rolled up into a statewide cumulative budget. Final budgets for each district are adjusted based on the final funding level that is allocated, determining the pavement overlay distribution and routine maintenance distributions separately based on percent of statewide need. The pavement overlay distribution is used as a check against the recommendations being generated separately by the agency's pavement management system. The funding is used for both preservation and rehabilitation overlays, so decision trees are applied to determine the appropriate treatment for each section. Districts are required to apply at least 10% of the pavement overlay funding to preservation treatments but most are applying more than that.

Since historical maintenance costs are factored into the needs calculations for each district, it has been hard for the agency to move away from historical funding distributions. The DOT has established limits for how much a district's budget can change from one year to the next. Since funding has not been adequate to address needs, the agency is working on strategies to prioritize the work that is done. Mr. Patterson, who is in the central office, works with each district to manage statewide priorities while adjusting for regional differences.

The bridge program is entirely separate from the activities described since it is managed at the executive program level, where funding levels are established. The exception to this is bridge maintenance repair work, which is included in the routine maintenance distributions provided to districts.

In the future, Mississippi DOT will continue to work with the districts to emphasize the use of work plan outputs for planning purposes. In addition, the agency intends to gradually shift toward a needs-based distribution and to develop a weighted priority system focused on safety.

Utah

Kevin Griffin established that his presentation addressed "Code One" funding for pavements on low-volume roads (i.e., 1000 average daily traffic or < 400 trucks a day) and funding needed for roadside and snow-removal activities. The agency's bridge and pavement preservation programs, which use federal dollars, are managed separately. Since UDOT decided to put all federal dollars toward high-volume facilities, maintenance receives about $40 million in gas tax funding to address maintenance needs on low-volume roads.

Maintenance budgeting is performed at the station level. Each station considers the performance targets established for the station for each of the 16 assets included in the program and the ratings determined by the data collection teams. Deficiencies between reported conditions and targets, such as those shown in Figure 5-2, are used at the station level to trigger work orders.

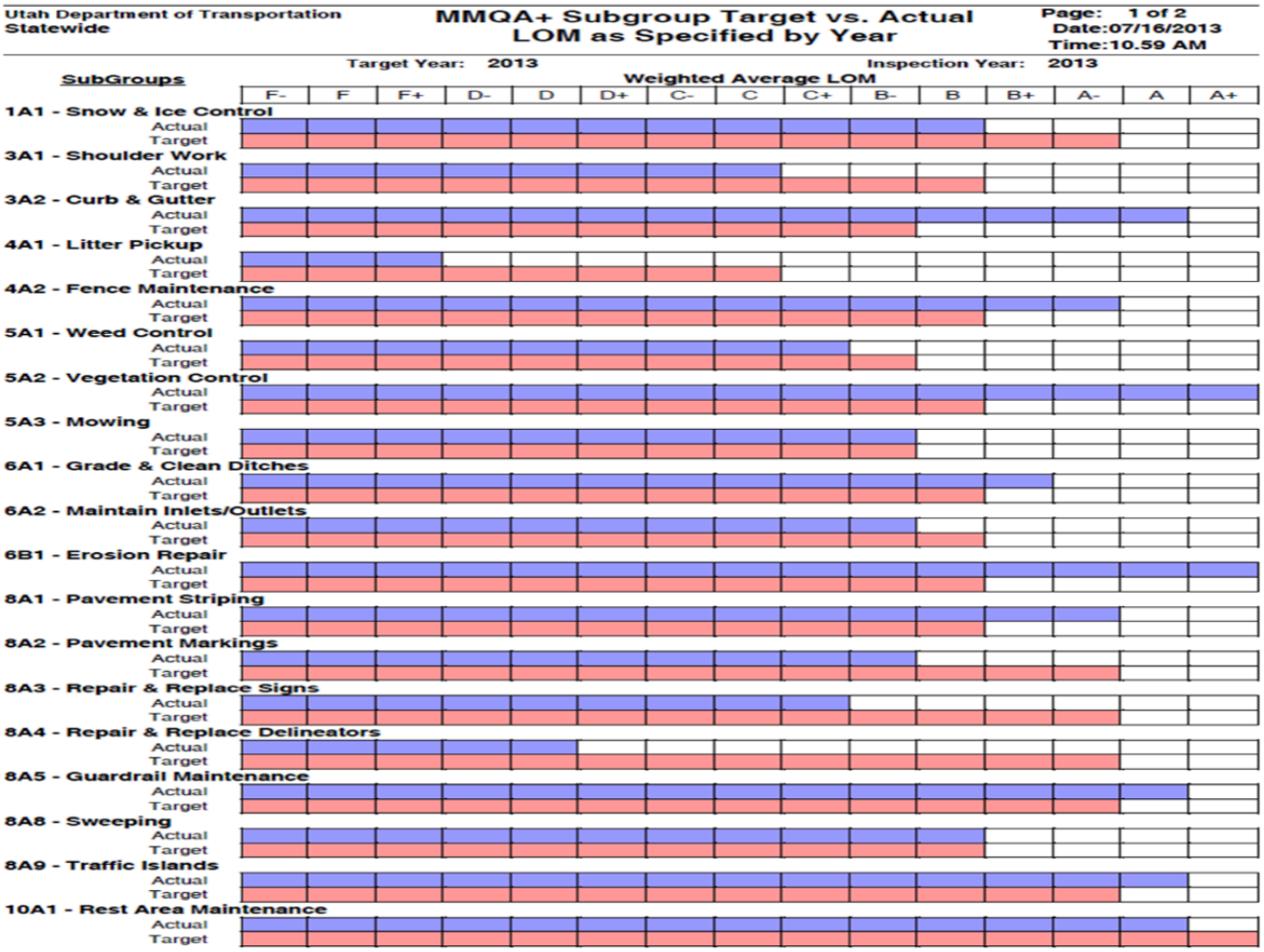


Figure 5-2 Sample station report showing targeted and actual LOS ratings from Utah DOT

Each station develops a budget identifying the funding needed to support labor, equipment, and materials for all activities based on the MMQA+ information, historical data, special projects, and input from a regional analysis. The funding requests are input into a budgeting tool. The station requests are reviewed and adjusted at the region level before being submitted to the central office's financial manager, who incorporates any statewide considerations that may influence the budget.

Once statewide funding levels are determined, central office Maintenance runs an analysis and uses the data to determine the final budget for all four regions. Maintenance uses an analysis of regional and statewide unit costs, as well as three-year average regional and statewide costs, to establish the final budgets. The resulting distributions are discussed with each region and performance targets are established. Regions have flexibility in how the funding is used, with the exception of snow and ice funding, but station personnel are held accountable for meeting targets. As activities are conducted, the MMQA+ program is used to analyze dollars spent and reports are sent to the stations to show them where they are overspending or underinvesting.

UDOT's DOT MMQA+ program is currently suspended due to the labor demands associated with data collection and analysis. Recent shifts in the workforce, which has combined maintenance and construction responsibilities, have resulted in changes in the manpower available to support the program. The DOT is currently working on an MQA program that minimizes the labor effort and optimizes efficiency for data collection. The new program is expected to be mobile, using iPads and map interfaces to tie work activities

to each asset. The agency also plans to implement new MMS software to assist with performance-based budgeting but has had challenges with trying to find off-the-shelf tools to support the agency's needs.

Colorado

Kyle Lester used two examples, striping and snow removal, to illustrate the maintenance budgeting allocating process CDOT uses. These examples were selected because of their importance to the department from a safety perspective. He indicated that currently, maintenance LOS receives about 33% of the asset management allocation (e.g., $870 million) and the balance goes toward capital projects. Each year, allocations are voted on at the executive level based on need projections. The final budget is based on factors such as the targeted LOE, the current LOS, the new annual work plan, and LOE factors. Supervisors are expected to be able to use the LOS program to ensure that LOS targets are met.

The work plans are analyzed to determine the reasonableness of what is being planned. In some cases, the DOT doesn't have adequate resources to make planned improvements in LOS in one year, so the needs analysis also considers whether it would be better to fund improvements over a three-year period. In another example, a research study conducted on the DOT's striping program showed that regardless of the type of material used, most striping wasn't visible by January due to snow plow damage. This analysis led to an estimate that 67% of the network needed to be touched each year, which was incorporated into individual work plans.

Winter storms are funded at about $85 million per year of the $266 million budget. In addition, the agency has a $10 million contingency that it can tap into for significant storm events. If the contingency is not needed for snow and ice removal, Maintenance can keep 50% of the money for unfunded priorities. The remainder is returned to the Transportation Commission to redistribute.

One of the challenges CDOT faced with its use of random segments for determining LOS is that field personnel didn't believe that the samples were representative of their roads. To address this issue for snow and ice control, all snow plow drivers now enter their thoughts on the LOS provided so it can be compared to the established performance criteria that have been set for achieving bare pavement (shown in Figure 5-3). Current technology allows the agency to provide operators with performance feedback immediately after the storm, which had not been possible in the past. The DOT is currently developing an approach for correlating storm severity with LOS so it can determine the cost of attaining a certain LOS for different types of storms at the route level.

Category 1	Category 2	Category 3	Category 4	Category 5
Interstate > 75,000 ADT	Interstate 15,000 - 75,000 ADT	Interstate < 15,000 ADT	NHS > 75,000 ADT	NHS 15,000 - 75,000 ADT
A Bare Pavement	A Bare Pavement	A < 2 Hours	A Bare Pavement	A < 2 Hours
B < 1 Hour	B < 2 Hour	B < 4 Hours	B < 2 Hour	B < 4 Hours
C < 2 Hours	C < 4 Hours	C < 6 Hours	C < 4 Hours	C < 6 Hours
D < 3 Hours	D < 6 Hours	D < 8 Hours	D < 6 Hours	D < 8 Hours
F > 3 Hours	F > 6 Hours	F > 8 Hours	F > 6 Hours	F > 8 Hours
Category 6	**Category 7**	**Category 8**	**Category 9**	**Category 10**
NHS < 15,000 ADT	Other > 50,000 ADT	Other 5,000 - 50,000 ADT	Other < 5,000 ADT	MTN Passes (Non-Interstate)
A < 4 Hours	A < 2 Hours	A < 4 Hours	A < 6 Hours	A < 8 Hours
B < 6 Hours	B < 4 Hours	B < 6 Hours	B < 8 Hours	B < 24 Hours
C < 12 Hours	C < 6 Hours	C < 12 Hours	C < 16 Hours	C < 48 Hours
D < 16 Hours	D < 8 Hours	D < 16 Hours	D < 24 Hours	D < 72 Hours
F > 16 Hours	F > 8 Hours	F > 16 Hours	F > 24 Hours	F > 72 Hours
Category 11 - Seasonal Highways (Mt. Evans and Independence Pass)				
"<" means "less than"				
">" means "greater than"				

Figure 5-3 Colorado DOT performance criteria for time to bare pavement after a snow event

CDOT was able to use its performance data to evaluate the costs associated with the current LOS provided on 14-hour coverage routes, which are low average daily traffic (e.g., 1000 or less) with daytime snow removal. The analysis showed that if the 14-hour coverage allowance for these roads were eliminated and more rapid coverage were required, it would cost the department between $1.4 and $1.8 million annually, depending on the severity of the winter season. These costs are made up of increases in labor, equipment, and materials associated with the higher LOS.

Tennessee

Jerry Hatcher reported that in 2017, TDOT benefited from the first fuel tax increase since 1989, which raised the gas tax $0.06 and the diesel tax $0.10 over a three-year period. In addition, electric vehicle registration rates were established and the cost of other vehicle registration fees increased. In all, the increases provided approximately $10.5 billion for 962 projects in 95 counties, which will be addressed over a 14-year period. The gas tax is designated for highway needs; other state taxes (e.g., sales taxes) were reduced to offset the increases.

Mr. Hatcher's presentation focused primarily on the process for developing the routine maintenance budget, since the Structures Division is responsible for the bridge preservation program and the pavement preservation program is managed using the pavement management system (located in the Maintenance

Division) and funded using both federal and state funds. Approximately 39.5% of the total funding for routine maintenance is performed as contract maintenance and the balance is done in-house.

The data used to populate the department's MQA program is obtained from various sources. Headquarters performs the inventory data collection using a van outfitted with cameras and LiDAR (see Tennessee). The districts perform condition assessments and consultants are hired to perform QA checks. Headquarters manages the MMS and the districts enter daily work reporting. Budget development is also a headquarters activity.

Approximately two years ago, TDOT revamped its program and moved from a pass/fail approach to an LOS approach with grades ranging from A to F for six elements (i.e., pavement, shoulder, roadside, drainage, traffic services, and ramps) and 61 characteristics. At the same time, the department reviewed what was being measured and how it was being done. For the past two years, the DOT has relied on monthly inspections on 1/10-mile random samples. The department has a steering committee whose primary focus has been on educating maintenance personnel about the new system and emphasizing the importance of accurate data.

The department is currently in the process of setting targets for each characteristic and element group so the agency can time the targets to funding levels. Mr. Hatcher indicated that the agency is working toward having enough confidence in its ability to estimate the funding needed to move from one LOS to another.

Texas

Alanna Bettis provided an overview of the Texas DOT's routine maintenance program, which 267 maintenance sections in 25 districts use. The department is in the process of establishing asset inventories; the guardrail end treatment inventory was approximately 76% complete at the time of the peer exchange. The asset data is being captured using the ArcGIS Collector application. In addition, the pavement and bridge inventories are well established.

The department's MMS is used to manage maintenance activities performed by both state and contract forces (each at approximately 50%). Most of the contract work goes toward pavements, roadside assets, traffic operations assets, and services; however, some in-house money also goes toward these areas. The MMS information is used to report to the legislature but also enables the department to analyze data, distribute budgets, submit FEMA requests, track costs, and manage maintenance resources. The districts use the MMS in conjunction with the pavement management system for developing four-year work plans.

Currently, maintenance funding is distributed using a formula that is based primarily on system size and condition scores. Work function needs are determined by considering factors such as system use, environmental factors, prior work activities, and so on; the approach is not currently performance-based. The department has developed an Excel spreadsheet, illustrated in Figure 5-4, to calculate funding distributions and budget limitations for the districts, which are restricted from varying by more than 5 or 10% from the prior year. The districts then allocate funds to each of the maintenance sections based on size, lane miles, and historical spending. The performance target that district engineers are held to is spending 95 to 100% of their budget.

CODE	FY 2019 Proposed Allocations FUNCTION	STATE COST	DISTRIBUTION FORMULA
	PAVEMENT MAINTENANCE	2017	
110&120	Base Repair	30.50	(Failure-Intolerable LM/10) / Reg Factor * 1564 CY/LM * State Avg Cost * Rainfall Inde
211-214	Levelup/Overlay	5.53	Ride Quality / Regional Factor * 7040 * State Avg Cost * Rainfall Index *[300 LM max]*
225	Crack Sealing	115.00	(Lane Miles/5) * Rainfall Index * State Avg Cost
231	Seal Coat	1.42	(Lane Miles<10k ADT) / (Regional Factor * 20) * 7040 * State Avg Cost
232	Spot Seal	2.24	(CLM<=24') * (2350) / (Regional Factor * 5) * State Avg Cost
233	Fog Seal	0.25	(Seal Coat LM)/State Avg $ FC 231 * State Avg Cost
241	Pothole Repair	18.86	(Failure Intolerable LM) * 50 * State Avg Cost
245	Pavement Widening	9.71	(CLM<24') * (2350/20) * State Avg Cost
252	Milling	2.78	(Daily Truck VM) / 10 * State Avg Cost
270	Edge Repair	0.98	(CLM<=24') / 20 * 5280 * 2 * State Avg Cost
360	Concrete Pvmt Remove & Replace	49.54	Conc Pvmt LM * 7040 * 0.25% * State Avg Cost
455	Blading Shoulders	0.26	(CLM<=24') * 5280 * 2 / 25 * Rainfall Index* State Avg Cost
	PAVEMENT MAINTENANCE SUBTOTAL		
	ROADSIDE MAINTENANCE		
511	Mowing	27.63	Cycle Based on Policy * Acres * State Avg Cost *[added .25 to Cycles for FY 16]*
513	Spot Mowing		4% of Function 511 - Mowing
521	Litter	13.2	(Cycle Based on VM/LM) * Acres *-State Avg Cost
522	Street Sweeping	0	(State Total Cost / State VM) * District VM * 1.3
524	Litter, Spot		(80% of Function 521 - Litter)
525	Adopt-A-Highway	48.12	CLM * State Avg Cost
530	Removal of Graffiti	0.0013	(State Total Cost / SF State Bridges) x SF District Bridges * 1.6

Figure 5-4 Sample routine maintenance budget computation from Texas DOT

The condition information input into the MMS is obtained as part of the Texas Maintenance Assessment Program, which was mandated by the legislature in 1999 along with the Texas Traffic Assessment Program, to satisfy Government Accounting Standards Board requirements. The maintenance assessment program's condition information is collected on 1-mile samples and ratings ranging from 1 to 5 are assigned (with a 5 representing the best condition) based on 22 elements within three groups (pavement, traffic, and roadside). An overall score is generated based 55% on the pavement score, 25% on the traffic score, and 20% on the roadside score. The overall score is not yet incorporated into the budgeting process.

Interactive reporting software is used to improve the accessibility and use of the data at the district and section levels. The available tools allow users to update numbers and drill down to various levels of information.

Ms. Bettis also reported that every four years, teams of maintenance experts travel to a district to review practices over a two-day period. During the visit, the teams drive the section roads with district personnel to discuss practices on topics ranging from safety, administration, budgeting, planning, performance, and emergency operations. A close-out meeting and final report provide feedback to the district on good practices, areas for improvement, and recommendations. Approximately five or six district maintenance peer reviews are conducted annually.

Facilitated Discussion

Following the presentations, the moderator facilitated a discussion around the topics raised by the participants. The discussion topics and the key points raised during the discussions are captured below.

Considerations in Using Historical Funding Allocations

- MnDOT is shifting from historical funding allocations to a needs-based approach but is taking steps to limit the fluctuations in district funding during the transition. This has been a challenge because most costs are associated with labor costs, which are fairly fixed.

Practical Considerations in Implementing Performance-Based Budgeting

- Mississippi DOT identified three changes it would make to its program to better address its needs: the agency would collect more data, allocate funding based entirely on performance-based needs, and add an accountability piece to the process. In the past, there has been a question as to who is responsible for the statewide maintenance budget. Is it the districts' responsibility to manage the budget or is there a central office accountability piece? If it is the latter, the central office could set targets and the districts would be held accountable for meeting the targets.
- UDOT emphasized the importance of changing the organizational culture to successfully implement a performance-based budgeting approach and overcome any lack of buy-in. The DOT has reduced funding for some districts that are over-performing to shift money to other areas that are under-performing; however, it has taken time for the districts to accept the data and trust the statewide approach to managing maintenance activities. The agency also recognizes that not all assets can be managed using performance-based budgeting because it isn't practical.

Addressing Differences in Priorities Across a State

- MDT expressed interest in being able to account for differences in the inventory across the state when determining needs, based on the number of employees or asset age. In Montana, targets are not met because the amount of work exceeds the resources. Traditionally, the problem has not been due to underperforming work crews.
- Alaska Department of Transportation and Public Facilities (ADOT&PF) recognizes that its regions have different priorities that are hard to address with a statewide maintenance rating. ARDOT noted similar issues but found that some of the differences in priorities were cultural. For example, pavement problems that could have been addressed with a seal coat were instead overlaid. The DOT has had to address this issue head-on by limiting the access to overlay funding.
- CDOT allocates funding based on performance-based needs; any extra funding is directed toward other priorities that should be addressed. UDOT does something similar and illustrated a current priority to address stormwater that has reduced the funding available for the pavement program.
- TDOT was looking at significant vacancy rates, so districts were not able to complete all their planned work and excess funds were available. The DOT asked districts to apply for the remaining funds and justify their needs. Since that time, the DOT has raised the salaries of entry-level workers to address the retention issue.
- MnDOT suggested that underfunding can drive innovation and creativity within a program and it helps agency personnel focus on priorities. The agency representative emphasized that accountability is also important, and the targets need to be realistic.
- Virginia DOT (VDOT) is in the process of moving toward performance-based budgeting and is in the first phase of collecting data on the first phase of assets that will be managed this way. The agency's goal is to push decisions to the smallest business unit possible.
- NDOT has specialty crews for certain types of activities but suggested that most agencies don't have the staff to support specialty groups in every station. MDT concurred, stating that for it, windshield time required to get to a work site is a significant factor. The ADOT&PF reported that it has had success setting up patching crews, which has worked effectively.
- The group was asked if it is hard to determine how much work can be done in a day. TDOT uses

its MMS data to calculate work accomplishments based on the work entered by the field crews. The information can be averaged over one or three years and different work rates can be generated for rural and urban areas.

Steps Needed to Establish Performance-Based Budgeting

- Several agencies, including the Vermont DOT and KDOT, indicated that funding is not adequate to support a performance-based program. In KDOT, it would mean redesigning the MMS and collecting enough information to provide the necessary detail.
- NHDOT separated winter and regular maintenance funding so ongoing maintenance activities can be performed throughout the year.
- ADOT has experienced increases in funding because of the agency's ability to link condition information to funding. The agency has seen a positive return on investment.
- Other state DOTs suggested that they would need new software tools to support performance-based budgeting. Some suggested that there is a human resource aspect to the program that would also need to be addressed.
- Iowa DOT has experienced the negative impact associated with the loss of a program champion to sustain interest in the program and to use the data effectively.

Key Session Takeaways

- To a limited degree, the use of performance-based budgeting seemed unattainable to some of the participating DOTs. Agencies that have been able to put performance-based budgeting tools in place, however, have been able to use the information to defend maintenance budget needs or obtain additional funds to support specific maintenance activities.
- Organizational culture must be considered when developing a performance-based maintenance approach. Because of the importance of data to support the process, data quality is critical. This involves establishing buy-in among field crews and demonstrating the importance of data for budgeting decisions.
- Emergency events and severe winters make it difficult to adhere to performance-based budgets unless contingencies are incorporated into the process. CDOT, for example, is incentivized to improve snow and ice efficiencies because Maintenance has access to half of any unused snow and ice contingency funds.

6 Building an Organizational Culture to Support Performance-Based Decisions for Maintenance

The initial scan discovered that an agency's organizational culture plays a significant role in the degree to which performance-based management decisions are supported throughout the organization. Within these agencies is support for performance-based management decisions at all levels, from upper management to maintenance crews. Personnel are held accountable for achieving performance objectives and data is used to establish realistic targets. This chapter focuses on the aspects of a successful performance-based maintenance program related to organizational culture.

Presentation Summaries

Florida

Rudy Powell introduced culture as an agency's predominant attitudes, values, and practices. He indicated that several factors contributed to the culture at FDOT; it helped that agency employees were repeatedly told that the priority was on preservation first. The existence of the Florida statute (see Florida) and the DOT's mission statement focus on safety, mobility, economic prosperity, and the environment also helped to reinforce the preservation-first mindset to the point that it has permeated the agency.

The DOT's culture promotes responsibility and accountability as important tenets, endorsing the belief that anyone with responsibility should be held accountable for their decisions. Mr. Powell indicated that the DOT also recognizes the importance of training at all levels of the organization using formal and informal processes. Mr. Powell uses an informal training process during the seven-month period when budget requests are being developed. By floating information ahead of time and gauging reactions, he can identify areas that are not well understood. At the field level, individuals are responsible for data quality and they are expected to raise concerns early in the process rather than after a problem has arisen.

The culture has benefitted the agency in several ways. For example, management has a high degree of confidence in the data that is used to prepare funding requests; this data has enabled DOT executives to earn the trust of elected officials. The existing culture has also led to statewide consistency in the data and led to suggestions for improvements and innovations at all levels.

Washington State

Andrea Fortune cautioned that an agency's culture is vulnerable and at any time any agency is just a few retirements from seeing support for performance-based decisions fizzle away. At WSDOT, the organizational structure doesn't help it because Maintenance reports to one assistant secretary, the Maintenance field staff reports to another, and preservation is under the capital program. Since Maintenance is funded entirely using state funds, all three of the assistant secretaries must be in agreement with the policy direction. For that reason, any time new assistant secretaries are hired, Maintenance meets with them within the first week and presents a summary of the budgeting process and why the process is important.

At WSDOT, the director of Maintenance is on the same level as a regional Maintenance engineer. Although

the director of Maintenance provides oversight from a statewide perspective, the regions implement the program. For that reason, there is constant communication and coordination between the central office Maintenance staff and the regional Maintenance engineer to ensure that the regions have bought into the statewide program and support it through the collection of quality data and the alignment of the agency's spending. A key to this process is building trust and respect between participants so everyone is a willing partner in the process.

WSDOT is investing heavily in workforce development and has created a Maintenance Operations Leadership series with courses to help retain and promote maintenance personnel. This has become an important retention tool since the DOT is not competitive with local agencies in terms of maintenance salaries.

The agency has established five organizational expectations to which everyone is expected to adhere:

- Safety is our culture.
- Create a positive work environment.
- Communication is key to success.
- Ride the DOT brand (i.e., be on board with DOT decisions).
- Everyone is a program manager.

The last of the organizational expectations was explained further. Everyone is expected to understand the big picture and overcome organizational silos; understand the work, how it is done, and how it is measured; adhere to project schedules and deliverables; and know the budget and understand variances between planned and actual budgets.

WSDOT has also experienced success overcoming field crews' frustration at being told there is no money by educating them on how the data is being used to decide how available funds should be spent, establishing a sense that "Data = Dollars." As an example of this, WSDOT instituted a "one touch policy" requiring all capital projects to have had at least one pavement preservation project by Maintenance before it can be programmed. This has enabled the DOT to defer capital improvements on pavements by four to six years for a very low cost. In 2018, the agency received an additional $6 million to test a similar program on bridges. These types of examples have helped build buy-in among maintenance personnel by demonstrating the importance of the data they collect.

Colorado

Kyle Lester discussed a recent maintenance optimization project that helped establish the current maintenance culture at CDOT. The study, which focused on how to improve maintenance effectiveness, created awareness for what Maintenance was trying to accomplish and allowed input into developing systems that would address the needs of both field and central office personnel. Prior to that time, the field crews had no idea how the LOS ratings were generated, even though they were the ones entering the data. The study looked a variety of issues, including strategies for integrating the MLOS into the financial management system and the distribution of maintenance staff by lane mile in each region. Mr. Lester suggested that most maintenance organizations focus on the information needed to report up to the management level. He found that some of the greatest benefit came from being completely transparent with the field personnel and using their suggestions to develop practical, useful solutions.

The early findings from the maintenance effectiveness project show that it has been beneficial. The study

that reviewed the number of FTEs per lane mile was used to address staffing levels in comparison to statewide averages to better identify regions that were understaffed and/or underfunded. The figures are now being reviewed annually and will be used in the future to support personnel decisions. The MLOS integration study resulted in improvements to data input screens that facilitate faster data entry by clearly defining and labeling mandatory fields and to security features to guard against invalid entries. In the past, data entry was done using forms, such as the one shown in Figure 6-1, which included more than 300 input fields on a screen. Since the analysis was completed, data entry was converted to a map-based program, using touch screens such as the one shown in Figure 6-2.

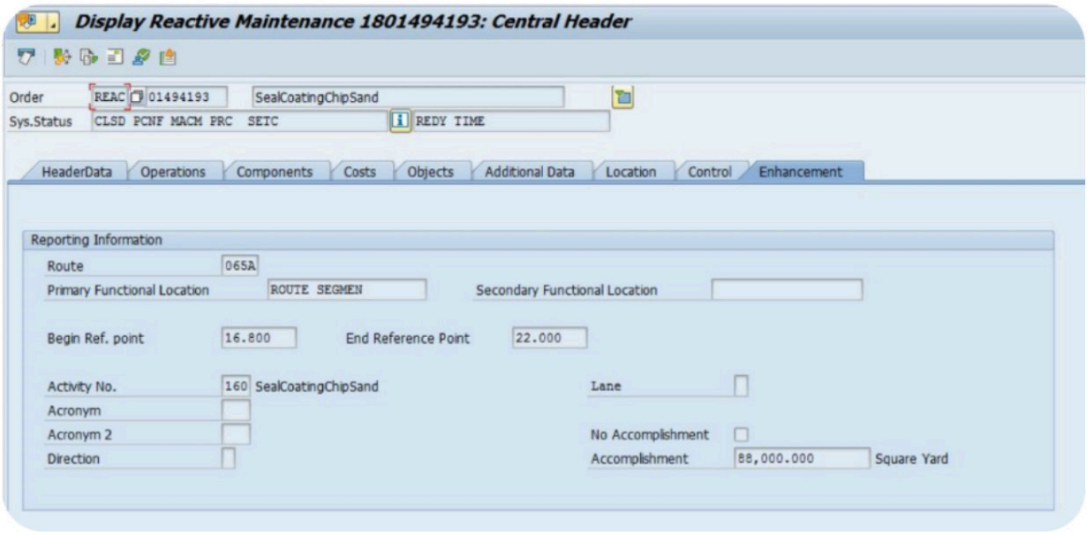


Figure 6-1 Old forms used by the Colorado DOT

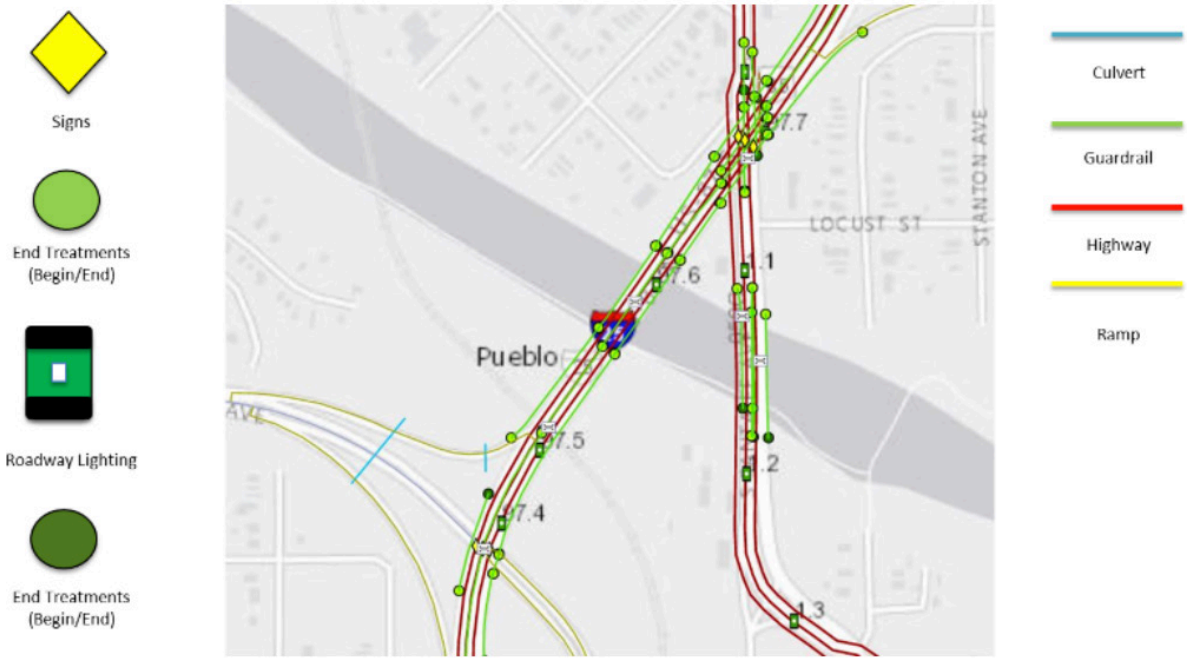


Figure 6-2 New map-based data entry screens used by the Colorado DOT

CDOT is currently working on an application for entering asset condition information using a map interface that is tied to pavement management information and work orders. This application is expected to provide

field personnel with information on asset conditions, work tracking, and budget tracking in an easy-to-use format so that this information can inform decisions efficiently.

Facilitated Discussion

Following the presentations, the moderator facilitated a discussion around topics of interest to the participants. Key points raised during the discussions are captured below.

Workforce Issues Related to Organizational Culture

- MaineDOT has experienced a reduction in the number maintenance personnel, which has raised concerns about where the next generation of supervisors will come from. Mississippi DOT has experienced changes in the skills that new employees bring to the job. For instance, in the past maintenance staff members were familiar with operating tractors and other equipment that newer members may not have necessarily used.
- WSDOT had more-experienced staff who were not familiar with iPads and less-experienced staff who were comfortable with the technology. The DOT partnered the two groups, which had multiple benefits. Not only did the more-experienced staff become comfortable with the technology but the less-experienced staff members were mentored in a way that has enabled them to move up in the organization quickly.
- Texas DOT has begun using YouTube videos to train staff.
- Delaware DOT has found that by putting specifications on an iPad, more inspectors are using them. Other forms of technology, such as global positioning systems and drones, are exciting the technicians and helping them learn the agency's practices relatively quickly.
- WSDOT indicated that productivity has improved with the use of iPads in the field. The DOT restricts the access to applications that are available on the iPads so there's no temptation to use the technology for anything other than work-related activities.
- Initially, WSDOT issued iPads only to crew leads; however, as the need for and use of the tools increased, the agency found that more field staff would benefit from having access to the technology. In Delaware, iPads are assigned to a truck and not individuals; trucks also have a hot spot. CDOT didn't start by making tablets available to everyone. However, after a cyberattack shut down all department technology, the agency began using iPads as the work computer provided to each employee. None of the agencies indicated that they had to increase support staff to facilitate the use of technology in the field.

Centralized Versus Decentralized Decision-Making

- In VDOT decisions are decentralized, which can feel like a loss of control from a statewide perspective. The current agency administration is very business minded and is looking for strategies to place more control in the central office; however, the culture could change each time there are leadership changes.
- In the early 2000s, leadership in UDOT was pushing for an MQA program. Now, with changes in leadership, the program does not have the support it once had. Mr. Griffin noted that the same is true on a national level because many of the early MQA champions have retired. He would like to see MQA brought to the forefront on a national basis so managers have a better understanding of

the information they are presented.

- The biggest change for ADOT was initiated by the governor, who decided that the agency would become lean-certified. That has changed the culture and there is now more of a focus on continuous improvement and the use of data to drive decisions.

Building a Performance-Based Culture

- NDOT has found that an important part of building the culture includes involving field crews in the process and explaining what the information means to them. Ms. Bush indicated that it would be helpful to have best practices available that could be used to show staff what can be done with the information it collects.
- NHDOT's culture changed with a new commissioner, who had a bridge background. In addition, the agency is providing an opportunity for all employees to submit feedback on a policy change that is being considered, which has helped build buy-in within the organization.
- KDOT conducts a training class each year for inspectors and subarea supervisors. The class has helped establish expectations and communicate agency priorities.
- FDOT ties its mission to jobs at every level of the organization so performance can be linked directly to each employee's behavior. NHDOT agreed and emphasized the importance of making examples used in training relevant to the crews. FDOT found that once it overcame the initial hesitation to measure performance, employees became energized. MnDOT spells it out to employees in terms of, "you're getting paid to …."

Key Session Takeaways

- It is important to have a champion to maintain organizational interest in the program and to ensure that the program remains relevant to the organization. FDOT reports that the process is so ingrained in its operations that the policy is sustainable through changes in leadership. However, several other state DOTs have lost their champions and experienced less support for the MQA program and the information it provides.
- Successful agencies have recognized the importance of ongoing training at all levels. WSDOT meets with new agency executives within their first few days on the job and meets with them regularly to maintain interest in the program. FDOT illustrated the importance of training that links work activities to the mission.
- The increased use of technology and computerized analysis tools are changing the skill sets required of maintenance supervisors and managers. Training and mentoring programs have been established in several agencies to address these changes. WSDOT shared its experiences with partnering less-experienced personnel with senior personnel to bridge differences in maintenance experience and familiarity with technology.

7 The Use of Technology to Support Maintenance-Based Planning Activities

Many of the agencies that participated in the initial scan have used technology to improve the efficiency and effectiveness of maintenance decisions. Technology and tools have been used to improve data collection and data entry activities, as well as to support the analysis and presentation of maintenance performance data. This chapter highlights the innovative use of technology to support performance-based maintenance decisions.

Presentation Summaries

Utah

Kevin Griffin presented a summary of the mobile MMQA+ process that UDOT implemented in 2014 to better link field conditions to maintenance budgeting activities. The tool is used to record the condition of 15 assets, each of which has a performance target. The mobile application relies heavily on GIS and the department has an entire division for GIS now because of its importance to the agency. GIS Division employees are assigned to other divisions to support their data collection, analysis, and reporting needs.

One of the challenges that the DOT tried to address with its mobile application was the disconnect that occurred with the maintenance sheds when the agency went to centralized data collection teams. Since the stations weren't monitoring their own conditions, they felt left out of the process and the data collection teams weren't always aware of all the assets along a route. This led to the DOT's decision to use iPads with geolocated data on map displays so data collection crews can easily locate assets and maintenance shed personnel can easily see the assets where damage was noted. There are several advantages to using the iPad, including its ability to show maps in an offline mode for areas with poor internet connections and the intuitive design of its apps. In the future, UDOT may move to a phone application; currently the iPads are more visible in the sun. The current application uses locally stored maps but requires no data plans. A minimum of 3G is required to be able to access the global positioning system features. An illustration of the application is shown in Figure 7-1.

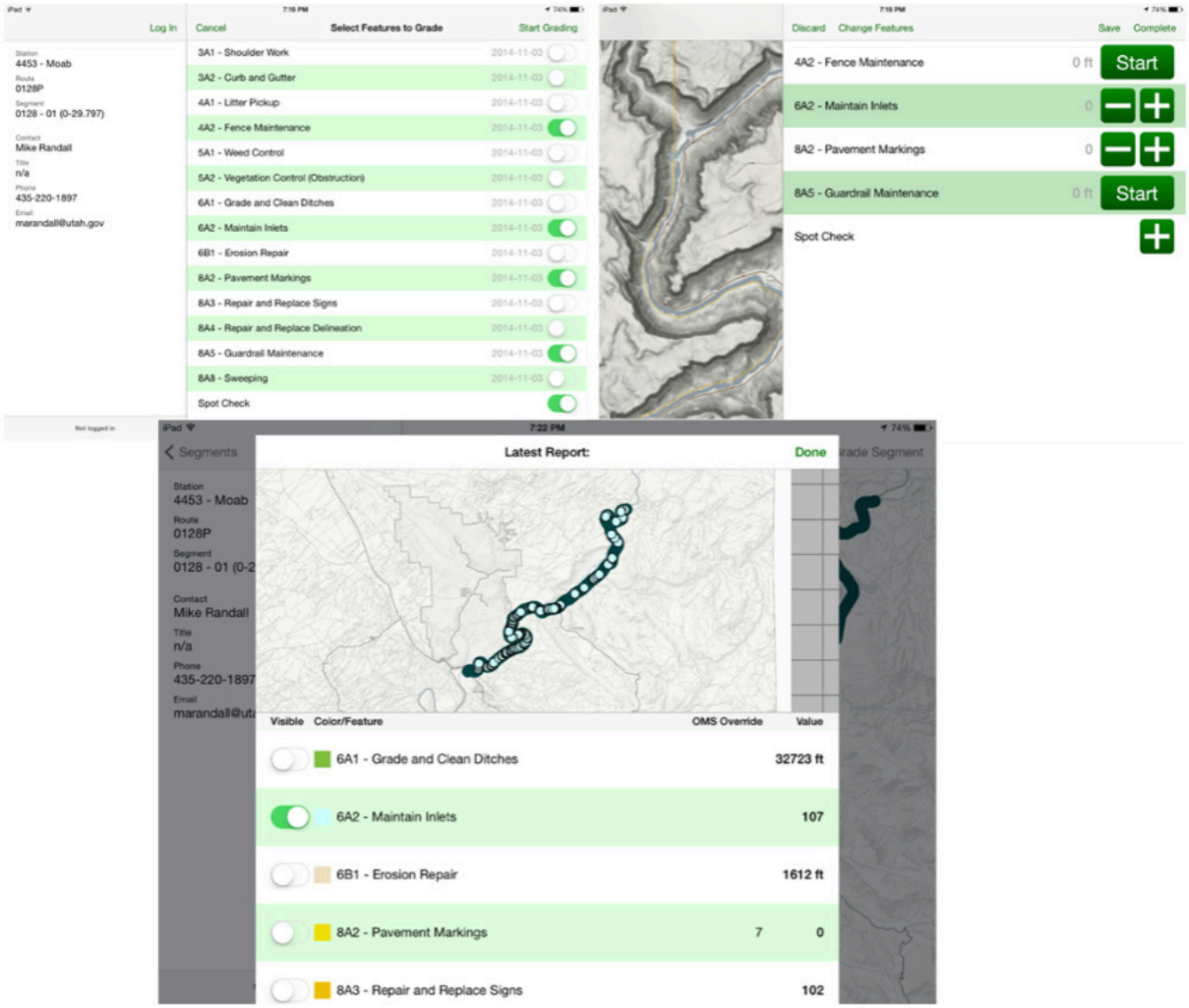


Figure 7-1 Example of features available in Utah DOT's iPad mobile app

UDOT plans to build mobile capabilities into its MMS to help reduce the number of standalone programs being used. The agency would like a program that allows easy identification of all defective assets and the ability to view all assets along a road whether the field crews are online or not. In addition, the department intends to implement an improved performance-budgeting model.

Washington State

Andrea Fortune shared that WSDOT has added a Maintenance Technology Resource Team within the Maintenance Division. Her staff includes four individuals who handle the hardware and training requirements; she pays the salaries of four software developers from IT so they can devote their time to maintenance needs. The Maintenance Division has also placed staff members who were particularly strong in technology in each of the regions to support the use of technology.

Ms. Fortune shared several examples of technology WSDOT is using, including the HATS field data collection program that has been developed for iPad data collection. The division has also developed training programs and training videos, including YouTube videos, and is in the process of putting specifications and manuals

online. The Maintenance Technology Team works closely with field personnel to ensure that the products that are developed fit practitioners' needs. For example, the DOT bought iPads because many of the field personnel complained that their fingers were too big for the personal digital assistants they had been using. The team has also worked with drones and other unmanned aircraft systems to evaluate where they might be useful and how to operate them safely. In one instance, an unmanned aircraft system was used on a geotechnical slide and the DOT was able to open the road a day earlier because of the rapid response.

The DOT also has mobile RWIS but the agency wasn't doing much with the data. The technology team is now doing research to determine how the information can be better used. The DOT is also trying to re-establish the automatic vehicle location units that had not been maintained over time.

Ms. Fortune went into more detail on the HATS program, which communicates with the department's mainframe financial system but has had some problems because of disconnects between the two systems. The department will have a new labor and financial management system by 2023 that should eliminate those problems. The HATS program is used to collect all inventory information using a map interface that was developed in-house and is shown in Figure 7-2. The program uses all drop-down boxes for adding, moving, or deleting assets but headquarters verifies all assets that are deleted before the database is changed. The program works offline so maintenance sheds can sync it when they return to the office; the department had to add wireless connectivity to each of the sheds. When the program was rolled out in 2015, the Maintenance Division conducted a road show to train field personnel to use the program and build buy-in. HATS also includes a dashboard, such as the one shown in Figure 7-3, to track the inspection progress.

Figure 7-2 HATS map interface from Washington State DOT

Figure 7-3 Example of HATS dashboard showing inspection status from Washington State DOT

WSDOT also has a cost-estimating tool (shown in Figure 7-4) for reporting third-party damage to any assets on the system. Since third-party damage costs the department about $30 million annually, the agency has made a concerted effort to bill out as much of the repair work to insurance companies as possible. With the new cost-estimating tool, which includes preloaded equipment and material estimating tools, the department can issue an estimate as soon as the damage is noted. The agency is currently billing the insurance company based on the estimate, through finance and risk management, with the option for the insurance companies to wait for the actual cost.

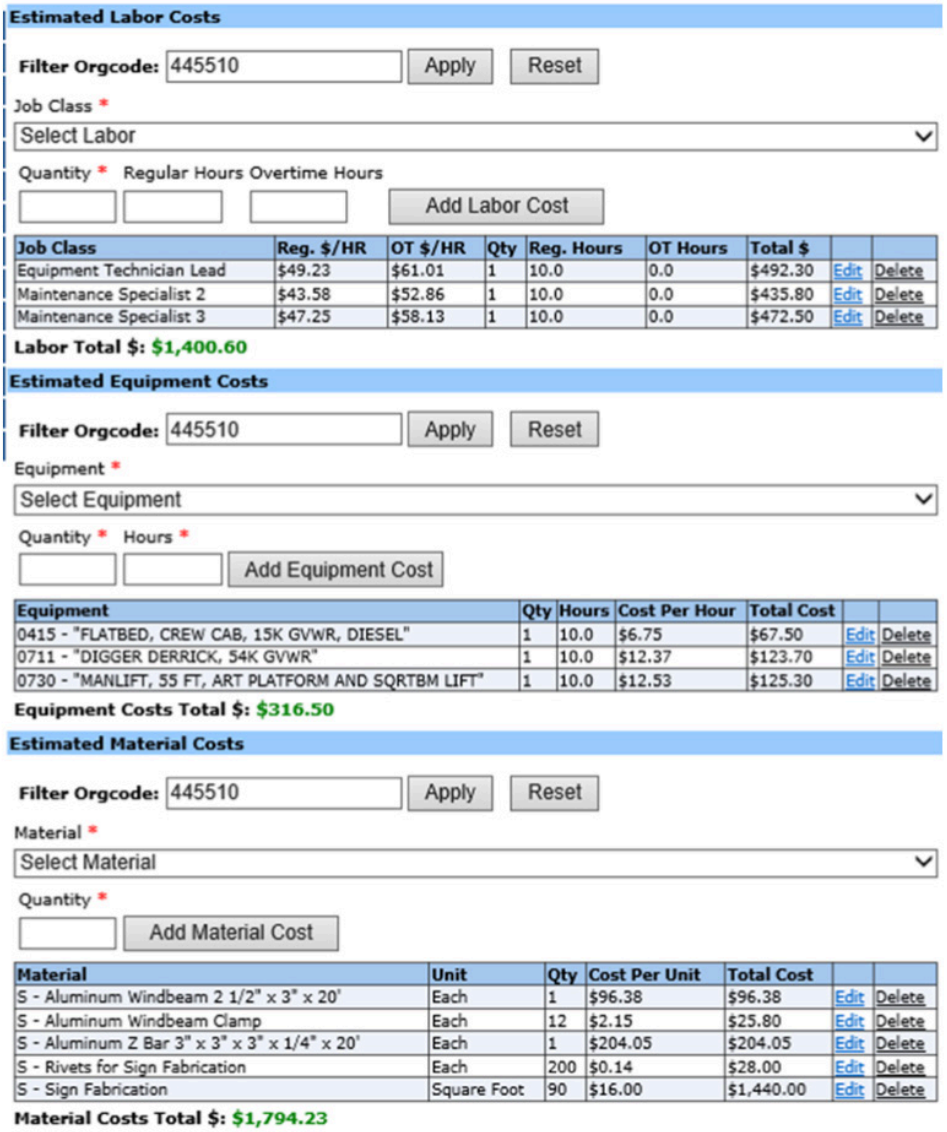


Figure 7-4 Entry screen used for estimating third-party asset damage from Washington State DOT

The Maintenance Division also developed a budgeting tool to overcome frustrations with the previous tool. The new tool is available to everyone in the field, so anyone can see the budget and better understand the funding limitations the agency faces. The DOT has also developed a tool for planning work and associated budgets that can be preloaded with work and finalized once the work is completed.

Arizona

John Roberts shared several tools that ADOT uses to support maintenance activities. Since the agency uses Microsoft, the department uses structured query language and server reporting services. In the field, the agency uses rugged tablets to enter inspection data collected by the four inspectors while in the field. The same type of equipment is used for remote entry of asset inventory for the feature inventory system. The data entry program (shown in Figure 7-5), includes a map, geospatial locations, GIS, photos, and Excel reports. In addition to field applications, the DOT also has a budgeting model that was moved from a spreadsheet solution to make it easier to use.

ADOT

Roadway Survey Form

Date: Inspector: Phone:

District/Region: Route: BMP: # of Shoulders: # of Lanes:

Condition Indicator						Ratings
Roadway: ☐ Mainline ☐ Frontage ☐ Ramp						Check the box(s) at the left that describes the portion of the roadway being inspected.
PAVEMENTS AND SHOULDERS:						ALL Fields Are Mandatory
1. Asphalt: # of Unfilled Potholes: *(All Lanes)*						# of Potholes
2. Length of Cracks in Asphalt Surface with Open Cracks:						
a) Alligator Cracking: *(Total Length of Cracking in ALL Lanes-Cumulative)*						LF
b) Other Cracking, greater than ¼" Wide: *(Total Length of Cracking)*						LF
3. Length of Surface with Raveling: *(Total Length of Raveling)*						LF
4. Total Length with Edge Drop-off > 2":						LF
5. Sweeping:	○ No Debris	○ Few Pieces	○ Small Patches	○ Unsightly Areas	○ > Half the Area	○ N/A
6. Litter:	○ No Litter	○ Few Pieces	○ Small Patches	○ Unsightly Areas	○ > Half the Area	○ N/A

Figure 7-5 A sample of the Arizona DOT roadway survey form

ADOT is using Tableau[11] for reporting and to visually display data so it is easier to use. An example of a report showing maintenance performance measures is presented in Figure 7-6. One of the benefits to being able to visualize data is that it has helped the DOT improve data quality because missing inspections can be seen, as can data that doesn't make sense. The use of available information is currently more important to the DOT than expanding the MMS to include more information. Most of the technology that is used to support maintenance has been developed by analysts within Maintenance, since IT typically was slow to respond to needs.

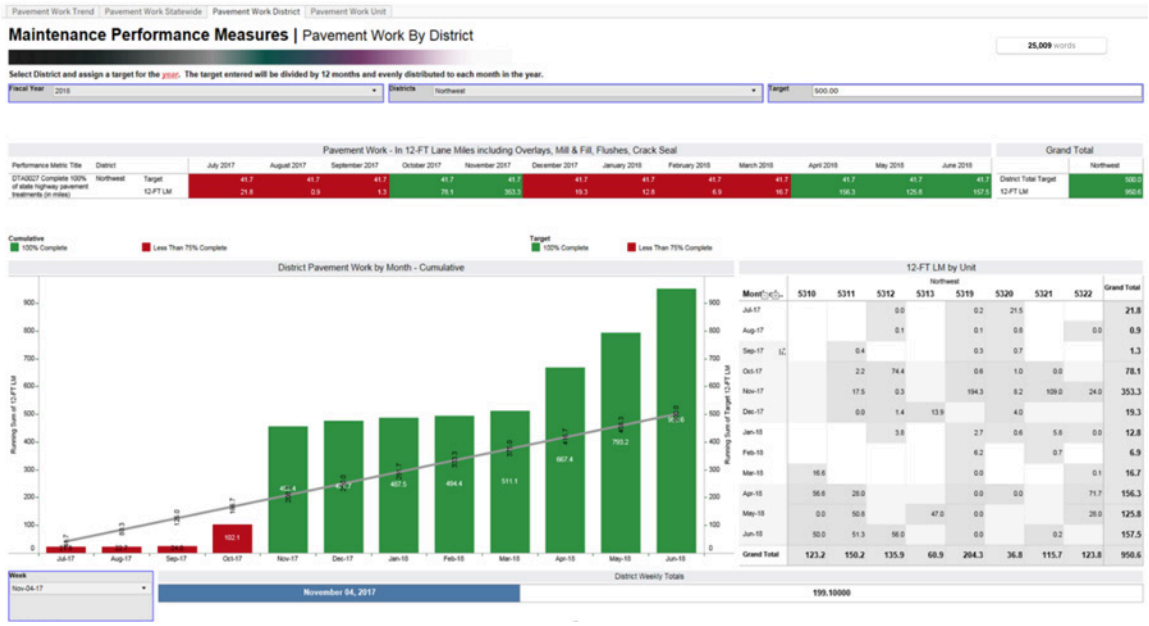


Figure 7-6 Example performance measure report from Arizona DOT

11 Tableau, Tableau Software, https://www.tableau.com/

In the future, ADOT will seek out ways to update the feature inventory using automated data collection equipment rather than putting people in the field. In addition, the agency is working on data synchronization between field offices and the central office.

Colorado

B.J. Jacobs provided a summary of some of the ways technology is being used to support maintenance activities at CDOT. One example included inventory extraction that was done using information collected during annual pavement management condition surveys. The majority of the inventory was able to be extracted, with the exception of ramps and frontage roads. Even latitude and longitude information that was needed for CDOT's Work Manager program was able to be extracted. The asset extraction added approximately $400,000 to a $900,000 contract to collect pavement condition data. The additional funds allowed nine assets to be extracted: signs, runaway ramps, pavement marking, light poles, guardrail, sign posts, point of interest, traffic signal poles, and fences. The DOT had to work with the data collection vendor to ensure that each asset was identified correctly. The agency now has a data dictionary for each asset that explains the level of detail that is being collected.

To facilitate an expanded use of the data extracted from the automated equipment, a partners group was formed with individuals from different areas of the DOT who could use the asset inventory information. The partners group consisted of individuals who had not worked with maintenance previously but were able to collaborate to ensure that the data addressed as many of the agency's needs as possible and to share in the data collection costs.

The DOT's Work Manager program is a geocoded tool with various layers than can be turned on and off. As maintenance crews are working on assets in the field, the work activities can be entered directly into the program. Now, if a maintenance person sees an asset on a map that is not in the field, Maintenance can check it and the GIS team can remove it from the inventory. Esri's Asset Inventory is being used to add to and manage the inventory.

Facilitated Discussion

Following the presentations, the moderator facilitated a discussion around specific questions related to the types of tools that have been developed, the staffing issues associated with using technology, and related challenges that agencies have faced. Key points raised during the discussions are captured below.

What Other Ways Has Technology Been Used to Support Maintenance Activities?

- WSDOT has had success with pictures that technicians have taken to show the amount of work that needs to be done as part of various maintenance activities. For instance, photos of homeless encampments show the amount of waste and other materials that maintenance crews must deal with. ARDOT mentioned that it has also used photographs successfully and has used photography to illustrate snow and ice conditions as weather events occur.
- WSDOT has an innovation program in place that rewards individuals and/or regions with funding to test innovations.

What Challenges Has Your Agency Faced With Technology?

- ADOT has selectively used consultants to develop some applications. Ideally, the agency would have a dedicated team within IT but that level of service has not always been available.

- VDOT has seen the agency's vision change with turnover, forcing personnel to defend data collection activities. The inventory is considered to be the most basic information the department needs.
- Several participants noted that as with hard assets, agencies don't always consider the ongoing costs of ownership when adding to an asset inventory.
- There are ongoing costs associated with customized software programs that must be considered. With homegrown systems, there is often no commitment to future development so the programs don't keep pace with changing technology.
- A bridge management program is available through AASHTO for bridge management but not for other assets. As a result, agencies have developed their own tools and often have developed their own performance measures to support their tools. This has led to inconsistencies in the types of data collected and used for maintenance.
- Business functions must drive IT, so maintenance has to define its needs and establish a roadmap for IT to follow. Maintenance must take responsibility for establishing and defining the processes that the software will support. If IT doesn't understand the processes, there is a good chance the software will not satisfy the needs.
- Technology is changing so quickly that it is difficult for agencies to keep pace.

Key Session Takeaways

- There are many examples of how technology has been used to support maintenance activities, including field data collection applications with map interfaces. GIS and geospatial data are fundamental elements of these types of tools.
- CDOT was able to expand the scope of its pavement management data collection effort to address Maintenance's needs as well as the needs of other groups within the department.
- The lack of common tools for maintenance has contributed to some degree to the inconsistencies in data collection procedures, performance measures, and budgeting approaches state DOTs use.
- WSDOT is an example of an agency that was able to partner with IT to assign software programmers specifically to Maintenance to support the development of applications and tools. The Maintenance Division pays the salaries of these IT employees.
- Training is an important component of any release of new technology, especially to build buy-in among field personnel. Having field personnel contribute to the development of programs and applications is one strategy to ensure that the final product meets the needs of those individuals in the field.

8 Key Findings

The peer exchange provided an opportunity for the scan team and meeting participants to investigate the current practices the participating state transportation agencies use to determine and allocate funding levels for maintenance and preservation.

Accomplishment of Meeting Objectives

Four objectives were established for the peer exchange, each of which was successfully accomplished, as described below.

Sharing of Best Practices

The peer exchange provided an opportunity for 45 individuals representing 27 state transportation agencies, FHWA, and TRB to learn from the best practices of leading agencies that are successfully using MQA data to support performance-based maintenance activities. The presentations represented agencies at different levels of maturity, illustrating the success that is possible with different approaches to an MQA –program.

Reinstituting the MQA Document Library

Since 2004, the Midwest Regional University Transportation Center at the University of Wisconsin-Madison housed an MQA document library containing MQA manuals, rating forms, and other documents provided by state agencies. The information in the MQA document library is outdated and the University of Wisconsin-Madison[12] has not actively been supporting updates to the library.

In late 2014 to early 2015, FHWA partnered with AASHTO and other organizations to create the Maintenance Peer Network, which was an effort to collect and share information between maintenance and operations professionals to improve roadway maintenance practices across the country. One of the network's recommendations was to reinstitute the MQA document library and website. North Carolina DOT has agreed to help recreate the library and sponsor the development of a new website until a more permanent solution can be found.

The peer exchange was a major step toward reestablishing the library. Peer exchange participants were introduced to the MQA document library in the pre-workshop webinar conducted on August 15, 2018, by Lacy Love (Volkert); Mr. Love was the project manager responsible for the MQA document library project. Participants were asked to provide copies of their MQA materials prior to the peer exchange and reminded during the peer exchange of the benefits of making this type of information available. To date, most participants in the peer exchange have provided information to support the new MQA document library[4]

Establishing a State Directory of Contacts for MQA Programs

The peer exchange also helped to establish a peer network between the agency representatives who were able to participate in the technology exchange. The contact information for each of the participants was distributed to all participants and the information will also be submitted to Mr. Love for inclusion on the MQA document library website. The benefits of the peer-to-peer network were evident before the peer

12 Midwest Regional University Transportation Center, University of Wisconsin-Madison, http://www.wistrans.org/mrutc/

exchange was over, with several participants promising to follow up with some of the presenters afterward to get more information on their practices.

Development of a Summary Report

This report satisfies the last objective's requirements (i.e., documenting the results from the peer exchange and offering suggestions for advancing the state of the practice).

Summary of Key Findings

In addition to satisfying the objectives outlined in the proposal, the information presented during the peer exchange led to the development of the key findings discussed in this section of the report. The key findings are presented within the following topic areas: data, processes, staffing, and technology.

Data

- There are differences in the performance measures that are being used to support MQA programs but the extent and impact of the differences are not well known. The use of a combination of LOS and pass/fail approaches appeared to be common among many of the participating agencies. Based on the pre-workshop survey, most of the participating state agencies are collecting MQA data at least annually on 1/10-mile samples.
- Most agencies participating in the peer exchange indicated that they did not collect enough asset performance data to confidently report LOS at the state, district, and shop levels; most report only at the statewide level. According to the pre-workshop survey, only eight of 27 state agencies collect data on 5% or more of their networks.
- Several participating agencies have moved toward central office data collection teams to reduce district maintenance requirements and improve quality.
- A key to ensuring data quality is to make sure the data is used and understood. It is important to leverage the data available, even beyond the Maintenance Division. Data that isn't used is not regarded as being important by those collecting the information, so data quality suffers.
- Data dictionaries and other methods of data governance have also become increasingly important for data consistency and ownership.
- An inventory is critical to performance-based budgeting and processes must be established to keep the interval current. UDOT is moving toward a process that facilitates continuous updates to the inventory that are generated as maintenance supervisors work in the field.
- Several agencies are forming internal partnerships so that data from other data collection efforts, such as pavement and bridge management or traffic safety, can be used to support maintenance data needs.

Processes

- There was tremendous benefit to the participating agencies from hearing about the practices in other state DOTs. In the final session, several of the participants stated that they were reenergized by the successes in peer states, had a better understanding of what it takes to be successful, and had ideas for making improvements to their existing programs.

- Historical budgeting or budgeting allocations based on formulas remain the norm in maintenance; however, these practices are not necessarily addressing performance-driven needs.
- One of the challenges to performance-based budgeting is the lack of knowledge as to what resources (e.g., staffing, equipment, and materials) are required to move from one LOS rating to another. Agencies do not have a clear understanding of how to use historical records to prepare these models.
- It may be worthwhile analyzing the cost of moving from one LOS category to another over a three-year period since agencies don't always have the resources available to make changes in conditions in just one year. Spreading the resources over a three-year period makes it easier to tackle.
- Agencies do not recognize the benefits associated with modifying existing programs to accommodate a shift toward performance-based budgeting and expressed interest in information that would demonstrate the potential benefits that could be realized.
- Extreme weather events and emergencies impact the availability of funding for other maintenance activities. Several agencies, including FDOT and CDOT, have contingency funds available to preserve funding for planned activities.
- Several participating agencies, including WSDOT, have developed technology that allows them to quickly generate estimates for reimbursement from insurance companies for third-party damage.

Staffing

- There are gaps between the skills needed by maintenance workers today and those traditionally required. Training has become increasingly important to familiarize maintenance workers with the technology that is currently being used. One individual stated that maintenance workers will have to be comfortable with an iPad in three years or will have to find a new job. FDOT emphasized the importance of linking work to the agency's mission through performance measures. WSDOT shared that pairing experienced maintenance personnel with inexperienced but technology-savvy personnel has been a successful method of two-way mentoring.
- With responsibility comes accountability; however, to hold employees accountable, performance targets must be realistic and attainable.
- Involving field personnel in the development of field applications, performance targets, and MQA program changes enabled WSDOT to build buy-in and ensure that the products were used.
- Communication with field personnel and ongoing training at all levels are important to the continued success of an MQA program.
- MQA champions are important to build and maintain support for the program. Once the program is fully ingrained into the way the organization does business, it is difficult for changes in leadership to derail it. WSDOT meets with new assistant secretaries within the first week of their appointment to introduce the MQA program and its benefits.
- Several participants noted that promoting an MQA culture is not at the forefront of the national maintenance community any longer. This is perceived as having negatively impacted the importance of MQA programs.

Technology

- Several agencies have had MQA programs for many years but it appears another evolution is underway due to the technology now available to assist with collecting and using data. In particular, the use of data extraction tools to build asset inventories was suggested to reduce manpower requirements and improve efficiency.
- Several examples were provided illustrating how map-based interfaces and touch-screen applications are being used to simplify maintenance data collection activities. These applications are envisioned as a way to keep inventories updated as work is being performed.
- The increased use of technology has led several agencies to hire data analysts (e.g., CDOT) and place IT staff in Maintenance divisions (WSDOT).
- There are numerous examples of available tools, such as Tableau, for data analytics and reporting; however, most agencies have had to customize the off-the-shelf programs they have implemented in some way.
- The use of iPads seemed to be common among the participating agencies but the extent to which they are used can vary tremendously. For example, WSDOT provides iPads to all maintenance workers but other agencies provide them only to maintenance supervisors.
- Data integration is important. For maintenance programs, integration with the agency's payroll program is especially important and an often-mentioned source of frustration when it is not integrated with the MMS.

9 Recommendations

The recommendations included in this chapter were developed to address the findings outlined in Chapter 8. They include several specific activities to promote and facilitate the use of performance-based management practices in state transportation agencies to determine and distribute funding levels for maintenance and preservation.

Improve the Understanding of MQA Programs in the Maintenance Community

- Distribute peer exchange information throughout the state DOT maintenance community.
- Identify a list of experts willing to speak about MQA programs with different DOT audiences.
- Develop a set of webinars tailored to different DOT audiences to promote the use of MQA data for performance-based budgeting.
- Develop case studies for several of the leading agencies based on the information presented during the peer exchange to promote the benefits of performance-based budgeting.
- Integrate MQA into the AASHTO MAC structure to address issues common to state DOTs looking for strategies to overcome implementation challenges.
- Incorporate the peer exchange results into the update of the asset management module included in the NHI's MLA[13].

Foster Activities That Improve the Effectiveness of MQA Programs

- Develop data governance guidance on how to collect performance data, how to maintain quality, and how to manage the data effectively.
- Conduct a technology showcase highlighting the use of LiDAR to establish asset inventories, iPads for field data collection, applications for budgeting activities, and other ways that agencies are using technology to improve the effectiveness of their MQA programs.
- Establish and pilot a peer-to-peer mentoring program to promote the use of MQA data to support maintenance budgeting activities.
- Develop case studies showcasing how maintenance business units have partnered with IT to better use available information to maintain assets.
- Scope a research effort to evaluate the benefits associated with the use of technology for MQA data collection activities.

13 Maintenance Leadership Academy, National Highway Institute, https://www.nhi.fhwa.dot.gov/course-search?tab=0&key=maintenance+leadership+academy&sf=0&course_no=134063

Develop Tools and Resources to Support the Increased Use of MQA Data in DOTs

- Develop a primer on MQA data collection activities, including the level of data needed to support reporting at the state, district, and field office levels.
- Work with the AASHTO MAC to develop standardized terminology and performance measures to be used with MQA programs.
- Develop and document a process for developing condition grading cost models to enable agencies to estimate the costs associated with moving from one LOS grade to another.
- Promote efforts to reestablish the MQA document library.

10 Implementation Strategy

The following actions are recommended to help promote the findings and advance the recommendations from the peer exchange.

Conference Presentations of Peer Exchange Results

- 2019 TRB Annual Meeting committee meetings
- 2019 regional AASHTO meetings
- 2018 AASHTO MAC meeting

Webinars

- MQA webinar series (potentially delivered via AASHTO).
  - Collecting and maintaining MQA inventory and condition assessment data
  - Selecting performance measures and setting performance targets
  - Using data to evaluate funding needs and allocate funding
  - Building an organizational culture that supports performance-based decisions for maintenance
  - Using technology to support maintenance-based planning activities

Technology Showcase

- In conjunction with the AASHTO MAC meeting, organize a technology showcase to promote the use of technology to support the development of asset inventories and MQA data collection.
- Repeat the showcase at least every other year.

Peer Support

- Develop a list of experts to share experiences with MQA programs and maintain it on the MQA document library website.
- Establish a peer-to-peer mentoring program to promote the use of MQA data to support maintenance budgeting activities. Use the issues that are addressed through the peer mentoring program to identify future research and dissemination activities.
- Have scan team members and participants in the peer exchange conduct informal outreach within their organizations and communities.

MQA Resource Development

- Develop case studies that promote the practices in at least two of the leading agencies featured

during the peer exchange. Distribute the case studies widely within the maintenance community and post them on the MQA document library.

- Develop a primer on MQA data collection activities, including the level of data needed to support reporting at the state, district, and field office levels. Distribute the primer widely within the maintenance community and post it on the MQA document library.
- Coordinate with the AASHTO MAC leadership to integrate MQA into the committee's organizational structure.
- Integrate the results from the peer exchange into the MLA course materials as appropriate.
- Scope and initiate implementation funding through NCHRP to:
  - Develop data governance guidance specifically tailored to MQA programs.
  - Document the improved efficiencies realized by using technology to support MQA data collection activities.
  - Showcase how maintenance business units have partnered with IT to better use available information to maintain assets.
  - Document a process for developing condition grading cost models to enable agencies to estimate the costs associated with moving from one LOS grade to another.

Appendix A:
Scan Team Contact Information

Scan Team Members Involved with the Peer Exchange

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Appendix B:
Scan Team Biographical Sketches

The following scan team members were involved with the peer exchange.

MARK C. McCONNELL, PE (Scan Team Chair), is the vice president and MS Operations manager at Volkert. He retired from the Mississippi Department of Transportation in November 2016 after almost 29 years of service. He held various roles at the DOT, including construction inspector, project manager, project engineer, district maintenance engineer, assistant state maintenance engineer, assistant chief engineer – field operations, and, finally, deputy executive director/chief engineer. A large part of his time with the agency was serving in maintenance and operations, both in the field and in the central office. Because of his maintenance and operations background, he was appointed chairman of the American Association of State Highway Transportation Officials (AASHTO) Subcommittee on Maintenance, chairman of AASHTO's US Route Numbering Committee, chairman of AASHTO's TSP2 Oversight Committee, and a member of the AASHTO Standing Committee on Highways prior to his retirement. McConnell now manages the design and operations for Volkert's Mississippi office, located in Jackson, and his responsibilities include managing the staff and operations as well as marketing to the DOT, local entities, and private clients. McConnell is a registered professional engineer in Mississippi and an active member of the Mississippi Engineering Society. McConnell received his bachelor's degree in civil engineering from Louisiana State University in Baton Rouge.

DALE DOUGHTY is the Director of the Bureau of Maintenance and Operations at MaineDOT. The Bureau of Maintenance and Operations has a budget of approximately $160M annually and consists of approximately 1450 full time equivalent positions, numerous contracting partners. The Bureau is responsible for operating and maintaining all State owned transportation assets. Maine's State owned assets include approximately 8800 miles of highway, 2750 bridges, 7 ferries -serving 6 island communities, 550 miles of railroad right of way, and various other assets. Dale is a 1986 graduate of the University of Maine at Farmington in Geology and Chemistry and did additional graduate work at West Virginia University in geology. Dale has been at MaineDOT for almost 19 years, previously working at as hydrogeologist, planner and regional manager. Prior to coming to MaineDOT he worked as an engineering geologist with two Maine based consulting firms. Dale has been licensed as a Maine Certified Geologist since 1996.

LAURA J. MESTER, CPA, is the chief administrative officer for the Michigan Department of Transportation. In this role, she oversees the Bureaus of Finance and Administration; Transportation Planning; the Aeronautics, Passenger Transportation, and Rail Offices; and the Sault Ste. Marie International Bridge operations. Mester serves as vice chair of AASHTO's Subcommittee on Transportation Finance Policy and is a member of the Subcommittee on Finance and Administration. She is also a member of the FHWA's Transportation Asset Management Expert Task Group. She received her bachelor's degree in accounting from Michigan State University and master's degree in business administration from Central Michigan University. She is a registered certified public accountant in Michigan.

RUDY POWELL, PE, is the Director, Office of Maintenance for the Florida Department of Transportation. He has more than 20 years of experience in the transportation industry in both the private and public sectors, including 12 years with the Department where he recently held the positions of State Construction Engineer in the State Construction Office, State Specifications Engineer in the Specifications and Estimates Office, and Area Engineer in the Structures Design Office. He earned his bachelor's degree in civil engineering from The Citadel, The Military College of South Carolina. He is a licensed Professional Engineer in Florida and South Carolina.

TONY SULLIVAN recently retired from his position as the assistant chief engineer – Operations for the Arkansas Department of Transportation. In this role, he oversaw the Operations Branch of the department, which includes the Construction, Maintenance and Materials Divisions and the 10 district offices throughout the state. He previously served as traffic engineer, assistant state maintenance engineer, and state maintenance engineer with the department. He has served on several AASHTO subcommittees, including Traffic Engineering; Transportation Systems Management and Operations; and Construction, Materials, and Maintenance. He received his bachelor's degree in civil engineering from the University of Arkansas and is a licensed professional engineer.

THOMAS VAN is a Civil Engineer in the Federal Highway Administration's Office of Asset Management. In this position, he serves as the lead specialist on asset management and performance management issues related to highway pavements. He is one of the primary developers of the federal rules implementing recent legislation. He has served in positions in the field of pavements and materials within FHWA in New Jersey and Washington, DC, for over 20 years. Van holds a master's degree in civil engineering from Virginia Tech and is a licensed professional engineer.

KATIE ZIMMERMAN, PE (Subject Matter Expert) is the executive vice president and founder of Applied Pavement Technology, Inc. She is actively involved in the asset management community, working with transportation agencies to develop asset management plans and to better use asset data to improve planning, programming, budgeting and investment decisions. Her work has included the development of guidelines on the use of maintenance quality assurance (MQA) programs and she recently completed a synthesis of field inspection practices used to support MQA activities. In 2011, Zimmerman served as the subject matter expert for both a NCHRP Project 20-68A, Domestic Scan 10-03, Best Practices in Performance Measurement for Highway Maintenance and Preservation and, in 2015, served as the SME for the domestic scan that recommended this peer exchange. She is currently the chair of the Transportation Research Board section on management and leadership and is an emeritus member of the TRB's Transportation Asset Management Committee. She received both her bachelor's and master's degrees in civil engineering from the University of Illinois.

Appendix C:
Peer Exchange Agenda

Final Agenda

Thank you for agreeing to participate in the peer exchange. We expect it to be highly interactive, with participants involved in presentations and group discussions. This agenda lists the topics that will be covered during the state presentations. There will be facilitated discussions after each topic to allow participants an opportunity to share ideas and learn from others.

Peer Exchange Agenda

During the peer exchange, there will be a series of presentations and discussion sessions to address the following aspects of a strong performance-based maintenance program:

- Collecting and maintaining inventory and condition assessment data
- Selecting performance measures and setting performance targets
- Using data to evaluate funding needs and allocate funding
- Building an organizational culture that supports performance-based decisions for maintenance
- Using technology to support maintenance-based planning activities

After the presentations, all participants will have the opportunity to share ideas and learn from their peers during the facilitated discussions.

Day 1: September 18, 2018 8:00 a.m. to 4:30 p.m.

8:00 – 8:45 a.m. **Welcome Session – Mark McConnell, Scan Chair**

- Welcoming Remarks
- Summary of Scan Approach and Findings
- Participant Introductions
- Peer Exchange Objectives and Format

8:45 – 10:30 a.m. **Session 1: Collecting and Maintaining Inventory and Condition Assessment Data (15-minute presentations) –**
Rudy Powell, Florida DOT, Moderator

- Washington State DOT – Andrea Fortune, Maintenance Policy Branch Manager
- Mississippi DOT – Heath Patterson, State Maintenance Engineer
- Maine DOT – Dale Doughty (Scan Team Member)
- Nevada DOT - Anita Bush, Nevada DOT, Chief Maintenance and Asset Management Engineer
- Montana DOT – Doug McBroom, Maintenance Operations Manager

10:30-10:45 a.m. **Break**

10:45 – Noon **Session 1 Facilitated Discussions**

Discussion Questions:

- What are some of the biggest challenges you face in collecting and maintaining inventory and condition information?
- How do you keep your asset inventory current?
- What steps have you taken to ensure the quality of the data?
- How are you using the inventory and condition information now? What would you like to be able to do with the data that you aren't currently doing? What's

holding you back?

Noon – 1:15 p.m. **Lunch**

1:15 -2:30 p.m. **Session 2: Selecting Performance Measures and Setting Performance Targets (15-minute presentations) –**
Dale Doughty, Maine DOT, Moderator

- Arizona DOT – John Roberts, Maintenance Management Services Manager
- Utah DOT – Kevin Griffin, Director of Maintenance
- Florida DOT – Rudy Powell, Scan Team Member
- Colorado DOT – Kyle Lester, Director, Division of Highway Maintenance

2:30 – 3:00 p.m. **Break**

3:00 – 4:30 p.m. **Session 2 Facilitated Discussions**
Discussion Questions:

- What type of performance measures do you use for maintenance reporting? Levels of service? A-E grades? Numbers? How were they established?
- Do you use a statewide level of service or "health" index? What are the advantages you see to using a statewide measure?
- Do you adjust your targets based on the amount of funding available each year? Are separate targets established for districts? Are field personnel held accountable for meeting targets?
- What could be done better to make performance measures and targets more meaningful in your agency?

Day 2: September 19, 2018 8:00 a.m. – 4:45 p.m.

8:00 – 8:30 a.m. **Opening Remarks and Recap from Day 1**

8:30 – 9:45 a.m. **Session 3: Using Data to Evaluate Funding Needs and Allocate Funding (15-minute presentations) –**
Laura Mester, Michigan DOT, Moderator

- Utah DOT – Kevin Griffin, Director of Maintenance
- Colorado DOT – Kyle Lester, Director, Division of Highway Maintenance
- Mississippi DOT – Heath Patterson, State Maintenance Engineer
- Tennessee DOT – Jerry Hatcher, Maintenance Division Director
- Texas DOT – Alanna Bettis, MNT Contracts and MMS Support

9:45 – 10:15 a.m. **Break**

10:15 – 11:45 a.m. **Session 3 Facilitated Discussion**
Discussion Questions:

- What are the advantages and disadvantages to allocating funding based on historical data rather than performance data?
- How do you use performance targets in the maintenance budgeting process? Are there things you'd like to do better?
- What steps would do you think are required to make better use of performance data in your state for evaluating funding needs and allocating funding to districts?
- What steps have you taken to keep field personnel from over-allocating resources

to maintenance activities with low performance targets? In other words, how to do you keep field personnel from trying to achieve a condition of "A" when the state target is "C"?

11:45 – 1:00 p.m. **Lunch**

1:00 – 1:45 p.m. **Session 4: Building an Organizational Culture to Support Performance-Based Decisions (15-minute presentations) – Mark McConnell, Volkert, Moderator**

- Florida DOT – Rudy Powell, Scan Team Member
- Washington State DOT – Andrea Fortune, Maintenance Policy Branch Manager
- Colorado DOT – Kyle Lester, Director, Division of Highway Maintenance

1:45 – 2:15 p.m. **Break**

2:15 – 3:45 p.m. **Session 4 Facilitated Discussion**

Discussion Questions:

- What steps has your agency taken to establish a culture that embraces performance-based management at all levels? What have been the lessons you've learned from these activities?
- What impact has your performance-based culture had on your ability to communicate with internal and external stakeholders? Do you have an example where the data has made a difference?
- Are you regularly making improvements to your Maintenance Quality Program to make it better support performance-based decisions? What are some examples of changes you've made recently or plan to make?
- If an agency were just beginning to set up an MQA program, what advice would you give them?

3:45 – 4:45 p.m. **Session 5: The Use of Technology to Support Maintenance Budgeting (15-minute presentations) –**
Tony Sullivan, Arkansas Department of Transportation, Moderator

- Washington State DOT – Andrea Fortune, Maintenance Policy Branch Manager
- Utah DOT – Kevin Griffin, Director of Maintenance
- Arizona DOT – John Roberts, Maintenance Management Services Manager
- Colorado DOT – B.J. Jacobs, Asset Manager

Day 3: September 20, 2018 8:00 a.m. - Noon

8:00 – 8:15 a.m. **Opening Remarks and Recap of Day 2**

8:15 – 9:45 a.m. **Session 5: Facilitated Discussion**

Discussion Questions:

- What kinds of tools and technology do you use to support your MQA program?
- How have you been able to acquire the staffing or funding needed to incorporate technology into your processes?
- What challenges have you faced in terms of software maintenance, equipment upgrades, and so on? Have you been able to overcome these challenges in any way?
- Do you think it is feasible for state DOTs to pool resources to develop "shared" tools and applications? Why or why not? Do you know of any examples where this has been done? What was the outcome?

9:45 – 10:15 a.m. **Break**

10:15 – 11:45 a.m. **Session 6 Next Steps – Where Do We Go From Here?**

Through a facilitated discussion, participants will identify next steps to advance the state of the practice in the use of performance-based decisions for maintenance.

Discussion Questions:

- What additional questions do you have for your peers?
- Of all the things you've heard during the peer exchange, which things could be implemented if additional guidance or training were made available?
- Which of the things you heard about would require further development before they could become a reality?
- What 1-3 steps are you going to take when you get home based on what you learned?

11:45 – Noon **Closing Remarks**

Appendix D:
Pre-Workshop Survey of Practice

Summary of Practice

State Name: _____

Individual(s) Submitting Info: _____

Please answer the following questions as best you can. We don't intend for this to take more than 10 minutes to complete.

1. What is the approximately size of your network in lane miles? _____
2. What is the average size of the maintenance budget (in dollars)? _____

3. Do you have a Maintenance Quality Assurance program in place? Circle or highlight the appropriate response.
   a. Yes
   b. No
   c. We have parts of a program
   d. Other _____
4. Do you have a computerized Maintenance Management System in place? Circle or highlight the appropriate response.
   a. Yes. Please list vendor if applicable _____
   b. No
   c. In the process of implementing or updating
   d. Other _____
5. How are funds allocated to regions or districts? Circle or highlight all that apply:
   a. We have a formula that is used
   b. It is based on region or district needs
   c. It is based on statewide priorities
   d. Regions/districts submit plans showing how funds will be used
   e. Other: _____
6. How are inventory and condition data collected? Circle or highlight all that apply:
   a. We collect it in-house using DOT personnel
   b. We hire a contractor to collect data
   c. We conduct manual surveys

d. We use a specialized data collection van to collect data

e. We enter information in a handheld computer or tablet

f. Other: _____

7. Do you collect asset condition information at least annually?

   a. Yes

   b. No

8. Do you use 1/10-mi samples for inspections?

   a. Yes

   b. No. Enter sample size if applicable _____

9. If sampling is used, approximately what percentage of the network do you inspect?

   a. Don't use sampling

   b. <1%

   c. 1-2%

   d. 3-5%

   e. 5-9%

   f. 10% or more

10. Are inspection results used to develop a needs-based budget for maintenance?

    a. Yes

    b. No

11. Have you successfully used your performance data to increase maintenance funding?

    a. Yes

    b. No

12. Which assets are included in a complete and current inventory?
    Circle or highlight all that apply: _____

    a. Culverts

    b. Curb and gutter

    c. Sidewalks

    d. Ditches

    e. Drop inlets and storm drains

    f. Under drains and edge drains

    g. Retaining walls

h. Fences

i. Brush

j. Sound barriers

k. Shoulders

l. Signals

m. Signs

n. Pavement markings

o. Pavement markers

p. Overhead sign structures

q. ITS assets

r. Traffic barriers/median barriers

s. Highway lighting

t. Guardrail

u. Guardrail end treatments

v. Impact attenuators

w. Tunnels

x. Rest areas

y. Other: _____