Scan Team Report
NCHRP Project 20-68A, Scan 10-03

Best Practices In Performance Measurement For Highway Maintenance And Preservation

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The purpose of each scan and of Project 20-68A as a whole is to accelerate beneficial innovation by facilitating information sharing and technology exchange among the states and other transportation agencies, and identifying actionable items of common interest. Experience has shown that personal contact with new ideas and their application is a particularly valuable means for such sharing and exchange. A scan entails peer-to-peer discussions between practitioners who have implemented new practices and others who are able to disseminate knowledge of these new practices and their possible benefits to a broad audience of other users. Each scan addresses a single technical topic selected by AASHTO and the NCHRP 20-68A Project Panel. Further information on the NCHRP 20-68A U.S. Domestic Scan program is available a http://144.171.11.40/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=1570.

This report was prepared by the scan team for Scan 10-03, *Best Practices in Performance Measurement for Highway Maintenance and Preservation*, whose members are listed below. Scan planning and logistics are managed by Arora and Associates, P. C.; Harry Capers is the Principal Investigator. NCHRP Project 20-68A is guided by a technical project panel and managed by Andrew C. Lemer, Ph.D., NCHRP Senior Program Officer.

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Disclaimer

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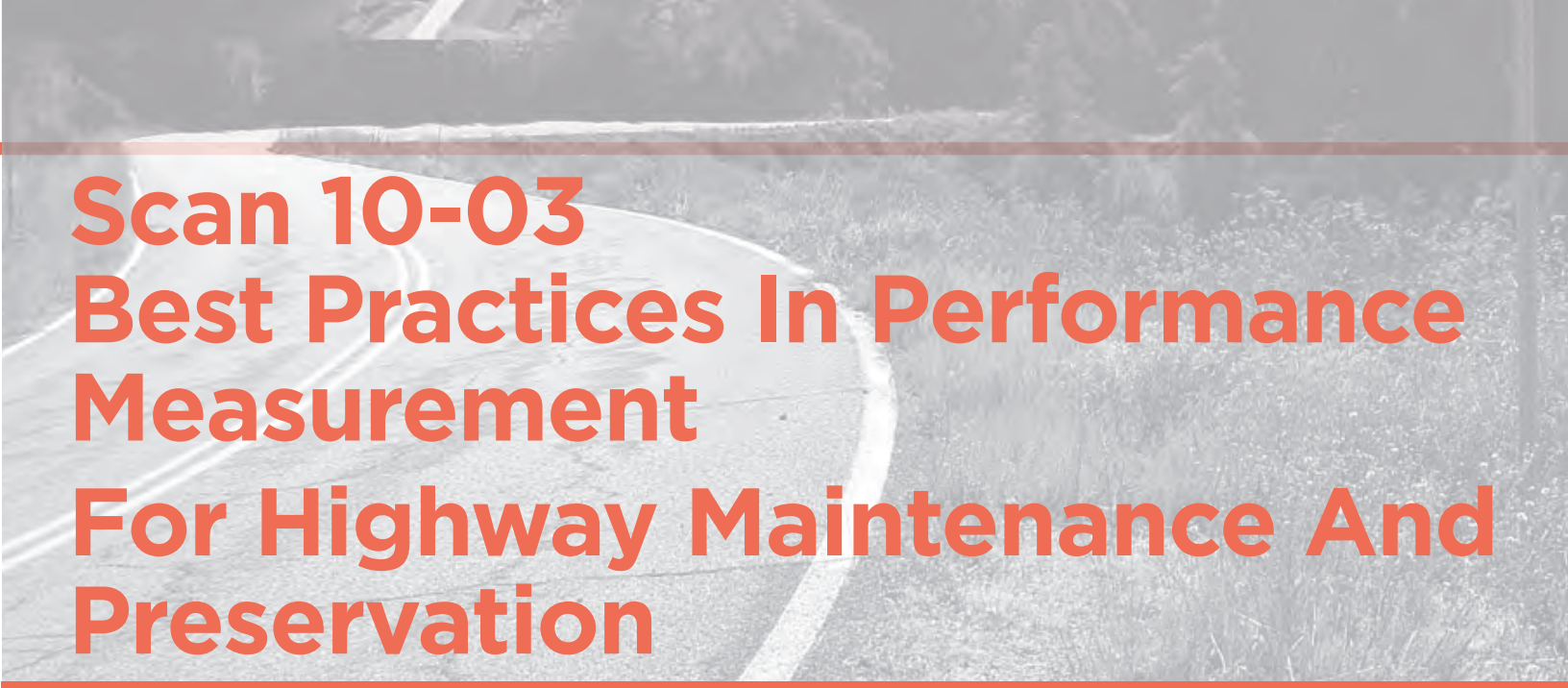

Scan 10-03
Best Practices In Performance Measurement For Highway Maintenance And Preservation

REQUESTED BY THE

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March 2012

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Abbreviations and Acronyms

AASHTO	American Association of State Highway and Transportation Officials
ADOT	Arizona Department of Transportation
Caltrans	California Department of Transportation
DOT	Department of Transportation
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
GIS	Geographic Information System
GPS	Global Positioning System
IT	Information Technology
KDOT	Kansas Department of Transportation
KTC	Kentucky Transportation Cabinet
LOS	Level of Service
MAP	Maintenance Accountability Process
MMS	Maintenance Management System
MnDOT	Minnesota Department of Transportation
MoDOT	Missouri Department of Transportation
MQA	Maintenance Quality Assurance
MRP	Maintenance Rating Program (Florida, Kentucky)
MRUTC	Midwest Regional University Transportation Center
MSHA	Maryland State Highway Administration
NCDOT	North Carolina Department of Transportation
NCHRP	National Cooperative Highway Research Program
NYSDOT	New York State Department of Transportation
ODOT	Ohio Department of Transportation
OPI	Organizational Performance Index (Ohio)

QA	Quality Assurance
SCDOT	South Carolina Department of Transportation
SCOM	Subcommittee on Maintenance (AASHTO)
SHA	State Highway Agency
TxDOT	Texas Department of Transportation
UDOT	Utah Department of Transportation
WisDOT	Wisconsin Department of Transportation
WisTrans	Wisconsin Transportation Center
WSDOT	Washington State Department of Transportation

Executive Summary

Overview

Preserving and maintaining the condition of highway assets is a key component to enable state highway agencies (SHAs) to provide a safe, smooth, and sustainable transportation system. While the construction phase of the highway life cycle often receives the most attention from elected officials and the public, responsibility for maintaining the roadway infrastructure assets is typically the longest phase of the highway life cycle and one of the most important factors in determining the frequency with which assets need to be reconstructed or replaced. As many transportation agencies have realized, ongoing investments in planned maintenance activities are a cost-effective way to postpone more costly treatments in the future and an important strategy for achieving customer satisfaction with the road system.

The use of performance-based management is gaining national attention as the Federal Highway Administration (FHWA) and other organizations promote a more systematic and transparent process for making transportation investment decisions. At the national level, the attention on transportation performance management is focused primarily on performance measures in these areas:

- Safety (e.g., number of fatalities and serious injuries)
- Infrastructure condition (e.g., state of good repair)
- Freight mobility and economic vitality (e.g., speed, travel time, and/or reliability on key networks)
- Mobility (e.g., travel time and reliability)
- Environment (e.g., greenhouse gases and storm water runoff)
- Livability (with potential measures to be determined)

The importance of maintenance and operations activities to highway agencies and the relationship between maintenance activities and their impact on asset performance have led to the design of numerous initiatives to improve maintenance quality and better defend maintenance budget requirements. Maintenance quality assurance (MQA) programs first emerged in the 1990s as a method of assessing and documenting maintenance quality. In their infancy, these programs focused primarily on documenting work accomplishments to report the resources used and production rates and reporting planned versus actual accomplishments. Within the past decade, however, these programs have become more customer-oriented, with an increased focus on maintenance outcomes and targeted performance levels. As a result, several SHAs are using their MQA results to set performance targets and estimate budgets needed to achieve those targets. Consequently, these agencies now can better defend

budget requests, establish maintenance priorities, and demonstrate the impact of different investment levels on maintenance quality than they could in the past.

To date, there has been a great deal of variability in how agencies have established these MQA components and how the results have been used to establish accountability, improve maintenance effectiveness, establish budget requirements, and allocate resources. Therefore, a domestic scan was organized through the U.S. Domestic Scan Program, which is managed under the auspices of the National Cooperative Highway Research Program (NCHRP). The American Association of State Highway and Transportation Officials (AASHTO) and NCHRP selected a scan team to establish the scan's scope and to identify the agencies to select for participation in the scan. A facilitator/report writer was selected to support these efforts by conducting a desk scan of current practices in this topic area and recommending agencies that had established strong practices in the topic areas the scan team had chosen.

The domestic scan took place in October 2011 in Anaheim, California. The scan team structured the scan in a peer exchange format and included representatives from 17 SHAs, who participated in discussions structured around these topic areas:

- Establishing reliable and cost-effective methods of monitoring the quality of maintenance and operations activities
- Using MQA data to establish accountability with internal and external stakeholders
- Using the MQA results to
  - Set budgets
  - Establish performance targets
  - Allocate resources
  - Justify needs
  - Establish strategic plans
  - Monitor customer satisfaction
  - Measure contributions to an agency's strategic performance targets

The team conducted the scan over a three-day period, with sessions organized to examine the organizational and institutional structures, programs, policies, operational practices, and delivery mechanisms that have enabled agencies to successfully use performance-based management practices for highway maintenance and preservation.

The scan's specific objectives included:

- Explore the experiences of top-performing agencies, examining the degree to which their business plans and system-preservation strategic plans are linked to their MQA programs

- Identify successful strategies for linking customer expectations to agency performance measures
- Examine the variables that have most influenced the use of MQA results to improve agency accountability and/or support budgeting and resource allocation decisions
- Examine if, and how, different data measures, data-collection procedures, and data verification activities influence MQA program costs and the use of MQA results
- Examine the ways in which innovation has been incorporated into MQA programs
- Explore the ways highway maintenance and preservation information is presented to senior management, elected officials, and the public
- Explore the strategies (e.g., education and training programs) that have been used successfully to build buy in and accountability among field personnel
- Identify technical and/or organizational challenges to overcome and strategies to improve the use of performance measures for highway maintenance and preservation activities

The findings and recommendations from the scan are summarized in this report.

Summarized Findings

Based on the information presented during the scan in each of the topic areas, the scan team made several significant conclusions. These findings represent the current state of the practice in the use of performance measurement for highway maintenance and preservation activities.

- Performance-based data (e.g., inputs to MQA programs) provide the foundation for assessing maintenance needs and for reporting results in all of the participating agencies. Several of the participating agencies have successfully used their MQA results to secure additional funds and improve communication with both internal and external stakeholders.
- The most successful agencies have established organizational cultures that support the use of performance data to drive maintenance and preservation decisions. Some of the participating agencies have been able to change their organizational cultures by holding people accountable for the decisions they make. Other agencies have used training programs effectively to help change the culture in support of performance-based programs and to build buy in among field personnel.
- No single approach represents best practice in the use of performance-based data for highway maintenance and preservation. In practice, the intended use of the data drives the system requirements and the amount of data needed.
- The quality of the data used in performance-based decision-making is critically important. Therefore, the agencies represented by the scan participants have

developed strong quality assurance (QA) programs to help ensure the reliability and completeness of the data.

- Technology has had a significant impact on the efficiency with which data can be collected, integrated with other programs, analyzed, and reported. The South Carolina Department of Transportation (DOT), for example, reported that it doubled the productivity of its surveys and improved its data accuracy by incorporating innovations into the data-collection process. In a pilot study, the Utah DOT found that data could be collected using semi-automated or manual means and handheld devices as quickly and as accurately as with automated data-collection vans, demonstrating that data can be collected very cost-effectively.
- Most of the scan participants roll their MQA results into a single statewide maintenance score that is weighted to reflect their own agency's priorities.
- Some standardization of commonly used performance measures would facilitate the exchange of information among agencies and simplify the startup activities in agencies that are just beginning to build their performance-based programs. The availability of guidelines and training in this area would benefit the industry.
- The cost of collecting data for MQA programs is insignificant when compared to the impact the results can have on maintenance budgets. The Utah DOT, for example, spends less than 1% of its maintenance budget on these activities, even while performing a 100% survey of most items each year.
- It is important that links be established between the performance data and budget changes. For instance, changes in budgets or standards should have a corresponding change in the achievable level of service (LOS). This link establishes a connection between the performance data and agency decisions that is important for building buy in and justifying maintenance expenditures.
- Additional efforts are needed to improve the methods used to report the results of performance-based programs to both internal and external stakeholders. Most of the participating agencies would welcome guidance on more-effective strategies for reporting needs that will resonate with politicians.

Recommendations

The scan team developed recommendations for each of the topic areas explored during the scan. The team organized the recommendations into six activities that will promote and facilitate the use of a performance-based, customer-oriented approach for estimating maintenance needs and budgets, communicating with various stakeholder groups, improving the transparency of maintenance activities, and allocating resources effectively. The team also identified suggested actions within each of the six activity areas. The six activities and the action items include the following:

- **Measure**—Recognizing the national trend toward performance measures, initiate and lead activities that identify common performance measures that align with and contribute to high-level goals, such as safety and pavement/bridge condition
  - Elevate the importance of maintenance by establishing a link to the agency's asset-management framework and strategic performance measures
  - Charge the AASHTO Subcommittee on Maintenance (SCOM) with identifying commonly used performance measures in the areas of safety, asset preservation, environment, and mobility to support the development of national performance measures that "measure what matters"
- **Report**—Identify communication and analysis tools that enable maintenance agencies to better "tell their stories" and move the industry toward an open-architecture platform
  - Conduct a study to evaluate the impact of maintenance performance measures on national strategic goals
  - Develop methods of using technology and innovation to produce timely and actionable data or reports
  - Promote mechanisms for sharing technology that establish stronger collaborations between industry and the maintenance community and accelerate the application of technology in transportation agencies
  - Initiate research to develop deterioration models and/or life-cycle models for key maintenance assets and identify reciprocal relationships between capital investments (for preservation and expansion) and maintenance requirements
- **Improve**—Develop strategies that improve the quality of data used for performance-based maintenance programs, including strategies that accelerate the use of new technology and innovation
  - Document the benefits of MQA data-collection activities to support the agency's maintenance, preservation, and asset-management needs
  - Charge the SCOM with developing guidelines for data collection at various levels of sampling to ensure the statistical validity of the data and to evaluate underrepresented assets appropriately
  - Given that performance-based contracting for maintenance is becoming more widely used, develop the means to use MQA tools to manage such contracts and help compare the costs of contract forces to the costs to achieve the same LOS using in-house forces
- **Train**—Develop and conduct training programs to support performance-based maintenance programs

- Review existing training programs and needs, assess gaps between the two, and support the development of new or modified training initiatives to address those gaps
- Encourage federal support for sponsoring training and technology-transfer activities to promote performance-based maintenance programs

- **Share**—Develop a sustainable mechanism for sharing performance-based maintenance practices and experiences in SHAs
  - Update and maintain the MQA Web site maintained by the Midwest Regional University Transportation Center at the University of Wisconsin[1]
  - Develop guidelines illustrating how agencies can use MQA data to improve performance, support budgeting activities, build buy in, and hold people accountable
- **Promote**—Actively promote the use of performance-based maintenance programs among SHAs and develop strategies to increase the number of agencies using these programs
  - Promote the best practices from this scan to SHAs and other transportation agencies and the transportation industry in general
  - Document the contribution of performance-based programs to support the agency's asset management and pavement preservation programs and demonstrate how agencies have successfully built collaborative programs
  - Disseminate the results of current NCHRP research on promoting the benefits of maintenance
  - Develop marketing material that agencies can use to promote and sustain the use of performance-based programs to decision makers

[1] http://www.wistrans.org/mrutc/events/maintenance-quality-assurance/

1.0 Introduction

Overview

Preserving and maintaining the condition of highway assets is a key component to enable state highway agencies (SHAs) to provide a safe, smooth, and sustainable transportation system. While the construction phase of a highway's life cycle often receives the most attention from elected officials and the public, responsibility for maintaining the roadway infrastructure assets is typically the longest phase of the highway life cycle and one of the most important factors in determining the frequency with which assets need to be reconstructed or replaced. As many transportation agencies have realized, ongoing investments in planned maintenance activities are a cost-effective way to postpone more costly treatments in the future and an important strategy for achieving customer satisfaction with the road system.

The importance of maintenance and operations activities to highway agencies have led to the design of numerous initiatives to improve quality and better defend budget requirements. Maintenance quality assurance (MQA) programs first emerged in the 1990s as a method of assessing and documenting maintenance quality. In their infancy, these programs focused primarily on documenting work accomplishments to report the resources used and production rates and reporting planned versus actual accomplishments. Within the past decade, however, these programs have become more customer-oriented, with an increased focus on maintenance outcomes and targeted performance levels. As a result, several SHAs are using their MQA results to set performance targets and estimate budgets needed to achieve those performance targets. Consequently, these agencies now can better defend budget requests, establish maintenance priorities, and demonstrate the impact of different investment levels on maintenance quality than they could in the past.

To date, there has been a great deal of variability in how agencies have established these MQA components and how the results have been used to establish accountability, improve maintenance effectiveness, establish budget requirements, and allocate resources. The absence of federal requirements mandating the development or scope of the MQA programs contributes to this variability. Each state has had the flexibility to establish a program tailored to its needs. For instance, at the individual asset level, some states rate the asset as merely passing or failing, while others grade each individual asset on a level of service (LOS) to indicate how close an asset is to failing. Additionally, a number of agencies use a sampling approach to represent overall maintenance conditions, while others collect condition data on each asset in the network. Further, some agencies collect data manually, while others make use of digital images collected by automated data-collection equipment. Together, these differences have a tremendous impact on the resources required to support an MQA program and the degree to which the information can be used for budgeting and resource planning.

The maintenance community is fortunate in that there have been several peer exchanges in which practitioners have had the opportunity to come together to discuss their MQA programs and practices. Most recently, the North Carolina DOT (NCDOT) hosted a peer exchange in 2008. Prior to that meeting, the Midwest Regional University Transportation Center[2] (MRUTC) at the University of Wisconsin–Madison (now the Wisconsin Transportation Center[3] [WisTrans]) hosted a peer exchange in 2004. In association with each of the peer exchange meetings, the University of Wisconsin collected and posted MQA manuals and other information provided by the states.[4] The information posted on the Web site has not been formally updated since 2009, although the scan team recommended to the scan participants that the Web site information be updated with information that was compiled for this domestic scan.

While the MQA Web site has proven to be a useful resource for maintenance practitioners, additional information is needed to enable agencies to evaluate the various options available as they initiate or enhance their efforts to better use maintenance performance data for the maintenance and preservation of highway assets. Therefore, a domestic scan was organized through the U.S. Domestic Scan Program, which is managed under the auspices of the National Cooperative Highway Research Program (NCHRP). The American Association of State Highway and Transportation Officials (AASHTO) and NCHRP selected a scan team to establish the scan's scope and to identify the agencies to select for participation in the scan. A facilitator/report writer was selected by AASHTO, NCHRP, and the scan team chair to support these efforts by conducting a desk scan of current practices in this topic area and recommending agencies that had established strong practices in the topic areas the scan team had chosen.

The domestic scan took place in October 2011 in Anaheim, California. It was structured in a peer exchange format. Representatives from 19 SHAs were invited to attend; of these, 17 attended, participating in discussions structured around the following topic areas:

- Establishing reliable and cost-effective methods of monitoring the quality of maintenance and operations activities
- Using MQA data to establish accountability with internal and external stakeholders
- Using the MQA results to
  - Set budgets
  - Establish performance targets
  - Allocate resources

[2] Midwest Regional University Transportation Center, http://www.wistrans.org/mrutc/
[3] Wisconsin Transportation Center, http://www.wistrans.org/
[4] The Web site address is http://www.wistrans.org/mrutc/events/maintenance-quality-assurance/.

- Justify needs
- Establish strategic plans
- Monitor customer satisfaction
- Measure contributions to an agency's strategic performance targets

The team conducted the scan over a three-day period, with sessions organized to examine the organizational and institutional structures, programs, policies, operational practices, and delivery mechanisms that have enabled agencies to successfully use performance-based management practices for highway maintenance and preservation. The scan participants received the scan's format well because of the amount of interaction that was possible by having everyone in one space.

The scan's specific objectives included:

- Explore the experiences of top-performing agencies, examining the degree to which their business plans and system-preservation strategic plans are linked to their MQA programs
- Identify successful strategies for linking customer expectations to agency performance measures
- Examine the variables that have most influenced the use of MQA results to improve agency accountability and/or support budgeting and resource allocation decisions
- Examine if, and how, different data measures, data-collection procedures, and data verification activities influence MQA program costs and the use of MQA results
- Examine the ways in which innovation has been incorporated into MQA programs
- Explore the ways highway maintenance and preservation information is presented to senior management, elected officials, and the public
- Explore the strategies (e.g., education and training programs) that have been used successfully to build buy in and accountability among field personnel
- Identify technical and/or organizational challenges to overcome and strategies to improve the use of performance measures for highway maintenance and preservation activities

This report documents the results of the scan. It summarizes the scan's findings and the team's recommendations for action to further promote the use of performance-based data to support the effective maintenance and operation of highway assets.

Scan Team and Participants

Scan Team

The scan team's members were:

- Russ Yurek (AASHTO Chair), Director of the Office of Maintenance, Maryland State Highway Administration
- Nancy Albright, Director of the Division of Maintenance, Kentucky Transportation Cabinet
- Jennifer Brandenburg, State Road Maintenance Engineer, North Carolina DOT
- Matt Haubrich, Asset Manager, Office of Maintenance, Iowa DOT
- Lonnie Hendrix, State Maintenance Engineer, Arizona DOT
- Don Hillis, Assistant Chief Engineer, Missouri DOT
- Luis Rodriguez, Pavement Management Engineer, FHWA Resource Center, Atlanta, Georgia
- Katie Zimmerman (Facilitator/Report Writer), Applied Pavement Technology, Inc. (APTech)

Harry Capers and Melissa Jiang of Arora and Associates, Inc., provided contract administration, scan organization, and travel support and were instrumental to the success of the scan.

Scan Participants

Based on the results of a desk scan, 13 additional SHAs (i.e., beyond the six agencies represented on the scan team) were invited to participate in the scan. These agencies represented a range of different approaches to assess, report, and use maintenance performance data to support the maintenance and preservation of highway assets. Each of these agencies were identified during the desk scan as having successful practices in one or more of the scan's focus areas. Although two of the invited agencies (Virginia and Georgia DOTs) were not able to participate due to travel restrictions or other conflicts, the scan participants represented a broad range of SHA practices. The following individuals from the selected SHAs participated in the scan:

- Auggie Rosales, Chief of the Office of Roadway Maintenance, Division of Maintenance, California DOT (Caltrans)
- Kirk Hutchison, Performance Management Administrator, Florida DOT
- Bob Fuller, Bureau of Construction and Maintenance, Kansas DOT
- Steve Lund, State Maintenance Engineer, Minnesota DOT

- Brad Allen, Maintenance Program Planning Bureau, Office of Transportation Maintenance, New York State DOT
- Mike McColeman, Assistant Administrator for Maintenance Conditions and Systems Management, Ohio DOT
- Jim Johannemann, Assistant State Maintenance Engineer, South Carolina DOT
- Tammy Booker Sims, Area Engineer, Paris District, Texas DOT
- Lloyd Neeley, Deputy Engineer, Maintenance, Utah DOT
- Anna Zaharris, Maintenance Accountability Process Specialist, Headquarters Maintenance and Operations, Washington State DOT
- Scott Bush, Compass Program Manager, Bureau of Highway Maintenance, Wisconsin DOT

Session Structure

The three-day scan consisted of eight sessions, each of which focused on a different aspect of the use of performance data for the maintenance and operation of highway assets. The topics discussed during the eight sessions were:

- Advantages and Disadvantages to Pass/Fail and LOS Approaches
- Impact of Agency Approach to Sampling on Quality, Cost, and Use of Data
- Use of Innovations in Data Collection
- Use of MQA Data for Maintenance Budgeting and Resource Allocations
- Linking Customer Expectations with Performance Targets
- Strategies for Building Buy in and Accountability Among Field Personnel
- Presenting and Selling Results
- Emerging Technology

Report Organization

The report is organized in the following manner to logically cover the various topics discussed during the sessions:

- Chapter 2.0 Data-Collection Approaches
- Chapter 3.0 Performance-Based Budgeting and Target Setting
- Chapter 4.0 Addressing Institutional Issues
- Chapter 5.0 Communicating Results

- Chapter 6.0 Key Findings
- Chapter 7.0 Recommendations
- Chapter 8.0 Implementation Strategy

Figure 1.1 shows the link between the sessions conducted during the peer exchange and the chapters included in this report.

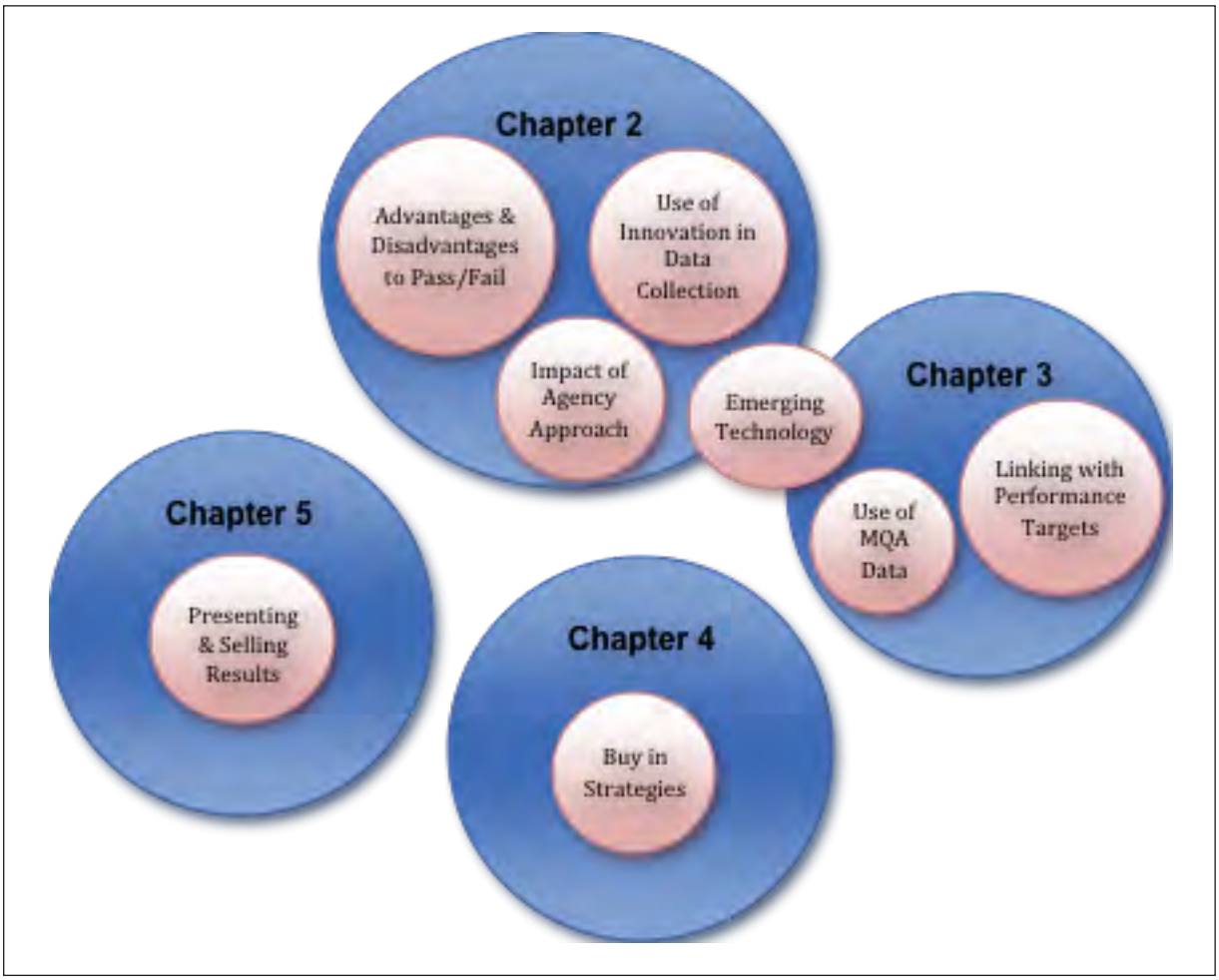

Figure 1.1 *Link of topics to chapters*

2.0 Data-Collection Approaches

Background

In many transportation agencies, the procedures being used to monitor and report maintenance condition information can be traced to the steps outlined in NCHRP Report 422, *Maintenance QA Program Implementation Manual*[5]. Since these concepts were introduced, they have undergone some refinement to respond to the demands placed on today's maintenance and operations personnel. As a result, the MQA programs and analysis tools that are available today can provide the information needed to set performance targets, link customer expectations to work efforts and budgets, and evaluate system performance.

In some agencies, the decision to utilize an MQA program is influenced by legislation that requires SHAs to report work accomplishments or to achieve targeted condition levels. For instance, the Florida state legislature mandates that the DOT achieve 100% of the acceptable maintenance standard on the state highway system (Florida Statute 334.046[6]). The standard is currently set at a maintenance rating program (MRP) score of 80, which is determined from a visual and technical evaluation of routine highway maintenance conditions. The resulting score is reported to the Florida legislature each year. NCDOT provides a similar report of work accomplishments and needs to its legislature every other year. In Washington State, the DOT's maintenance accountability process (MAP) was initiated for the agency to provide the information needed to respond to the legislature's questions regarding the way in which WSDOT was using funds.

The ability to report maintenance conditions and accomplishments depends on the availability of asset condition information. In addition to being used to report accomplishments, the condition information also serves as the basis for estimating maintenance needs and establishing budget requirements. The Florida DOT (FDOT) has used the information successfully to rate contractor performance under its performance-based maintenance contracts.

The data to support an MQA program includes both condition and inventory information. The participants discovered that the surveys had many similarities in terms of the asset categories and asset types (also known as features). Common categories and types of assets included in an MQA program are:

- Drainage structures (e.g., culverts, curbs and gutters, ditches, slopes, and drop inlets)
- Roadside, including fences, grass mowing, brush, litter, landscaping, and sound barriers

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[5] Stivers, ML, KL Smith, TE Hoerner, and AR Romine, *Maintenance QA Program Implementation Manual*, NCHRP Report 422, Transportation Research Board, Washington, DC, 1999, http://www.trb.org/NCHRP/Blurbs/163300.aspx

[6] Florida statute 334.046, http://www.myfloridahouse.gov/filestores/web/statutes/fs07/CH0334/Section_0334.046.HTM

- Pavement, including paved shoulders, unpaved shoulders, and driving lanes
- Bridges and other structures
- Traffic (e.g., signs, pavement markings, guardrails, impact attenuators, highway lighting, and signals)
- Special facilities (e.g., rest areas, tunnels, and weigh stations)

The states also indicated many similarities in the types of attributes that were being used to report performance. For example, culvert performance is commonly reported in terms of clogged or interrupted flow, and signs are evaluated based on the amount damage, the orientation of the sign, or its visibility (e.g., retroreflectivity). While the types of attributes were similar, the criteria that each of the participating agencies established had significant differences.

Other differences were reported, such as the methods used to collect the data. For instance, inventory and condition information can be collected in a number of different ways; however, most agencies use a windshield approach, a walking approach, or a combination of the two. As shown in Figure 2.1, three of the participating agencies that collect asset condition information for an MQA program reported that they use a windshield method, 10 reported that inspectors walk, and three reported that a combination of approaches is used. A number of different factors influence the selection of a survey approach. The Maryland State Highway Administration (MSHA), for example, selected a windshield approach because it best represents what the traveling public sees as they drive the roads.

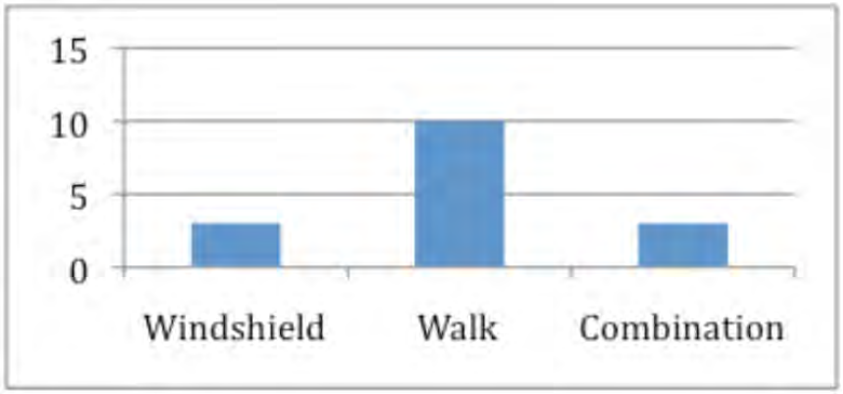


Figure 2.1 ***Method of collecting condition information***

There are also differences in who collects the information. Nine of the participating agencies have district or division personnel collect MQA data; two agencies reported that the central office collects the information; and five agencies rely on the areas, field managers, regions/counties, sheds, or a combination of central office and field personnel to collect the data. In some cases, information from other agency programs is used to support the MQA program. For example, NCDOT uses the results of its pavement management surveys for its pavement LOS

ratings to reduce the demands on maintenance personnel.

The scan participants discussed several aspects of the data-collection approaches used to support an MQA program: the advantages and disadvantages to the different approaches being used, the impact of sampling on data quality and cost, and the use of innovations and new technology in data-collection activities.

Differences in Survey Approaches

Three predominant approaches are being used to monitor and report maintenance quality:

- Pass/fail approach
- LOS approach
- Hybrid approach (i.e., a combination approach that uses a variation of both of the other approaches)

Pass/Fail Approach

Agencies using the pass/fail approach define deficiency criteria for each asset being inspected. For instance, a guardrail may be considered deficient if 10% or more of the guardrail length is not performing as intended. During the MQA inspection, raters count the number of guardrails that pass or fail based on the criteria established. Figure 2.2 shows an example from the FDOT MRP. In this example, a pavement section is considered to have failed in terms of edge raveling if more than 25% of the shoulder is raveled or if more than 50 continuous feet of edge raveling is 4 inches or wider. If either criterion were met, the section would fail in terms of this rating factor.

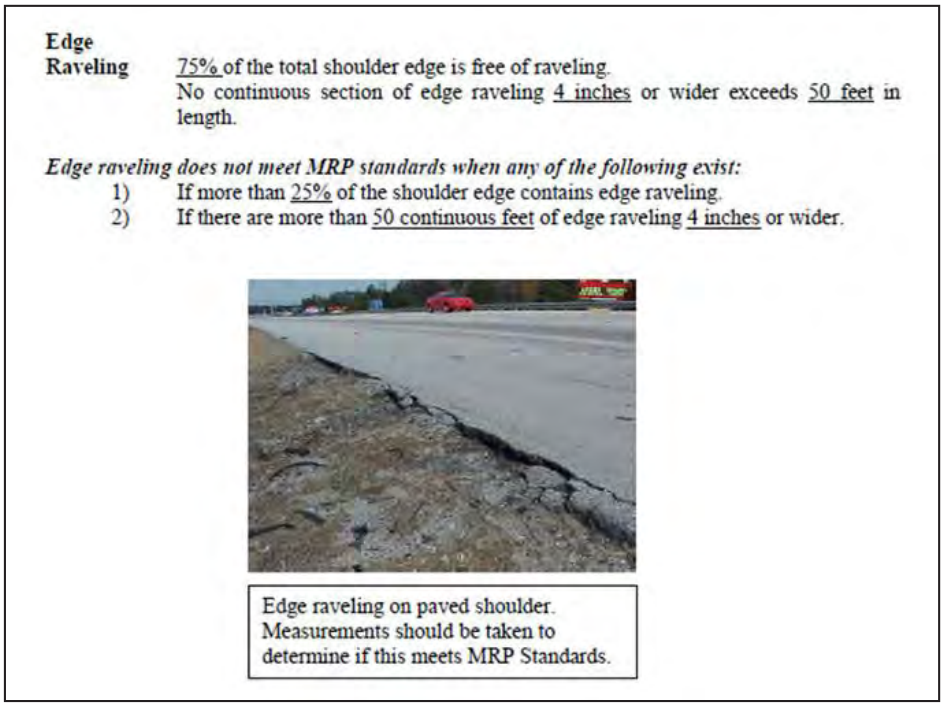


Figure 2.2 ***Example of a pass/fail rating criteria (source: FDOT)***

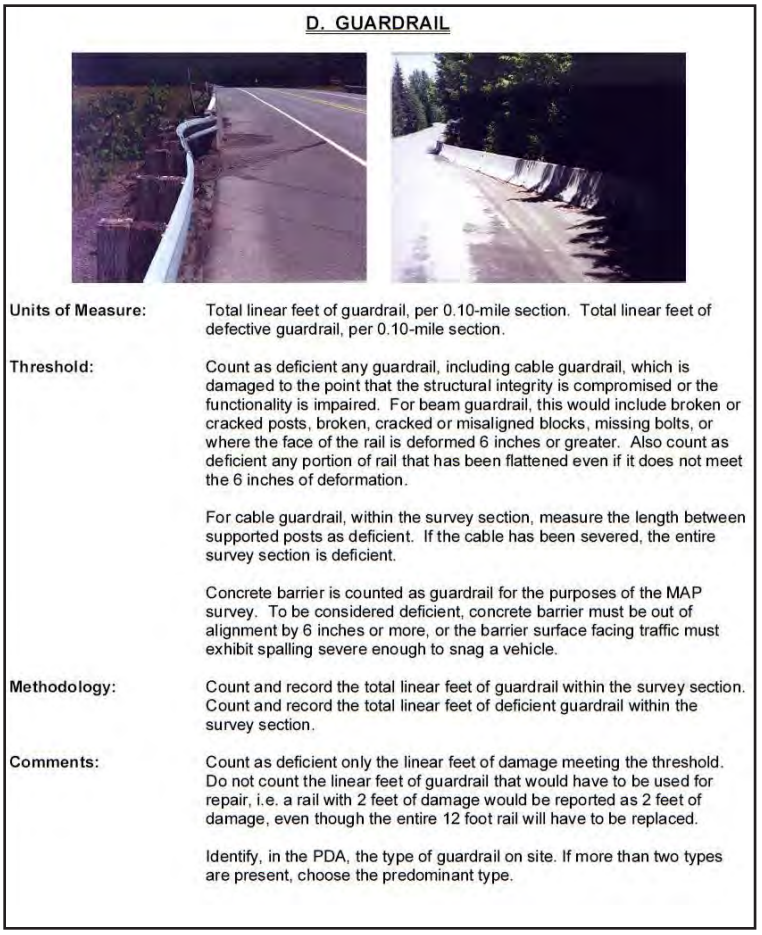
The pass/fail approach is relatively quick and easy to conduct in the field, which is why some agencies prefer it. The biggest disadvantage of the pass/fail approach is that the ratings provide no information about how close the asset is to passing or failing. For instance, the survey does not indicate whether 12 or 100% of the guardrail was deficient. Therefore, while the survey results can be used to report guardrail condition, it is difficult to use the information for budgeting and scheduling maintenance repairs. Additionally, if the definition of what is considered a deficiency changes, then all of the guardrails must be reinspected to determine their condition under the new criteria.

Level of Service Approach

To address these deficiencies, some agencies have moved toward using a graded LOS approach, in which the amount of a defined deficiency is recorded in the field in accordance with pre-established criteria. Under this approach, instead of a yes/no answer about whether a criterion is met, an estimate of the actual amount of damage is recorded. The amount of damage is then assigned a grade (e.g., A, B, C, D, or F) based on the criteria established by the agency for each asset type. Since this approach requires that the amount of a deficiency is estimated or measured, it takes longer to conduct this type of survey than it does a pass/fail survey. However, the information provides the data needed to estimate work quantities for budgeting and maintenance planning.

Figure 2.3 is an example of the rating criteria for the LOS approach. The figure illustrates the criteria WSDOT uses to rate guardrails for its MAP. The rater reports the total linear feet of guardrail in a sample and the total linear feet of defective guardrail. The deficiencies are then linked to service levels so that an overall LOS can be reported.

One of the factors that led the New York State DOT (NYSDOT) to use the LOS approach was its hesitation to "draw a line in the sand" related to safety assets. The flexibility the LOS approach provides allows the DOT to avoid setting fixed criteria and influence proposed policy changes based on programming decisions. Other factors included the ability to plot data trends and use the results to measure the effectiveness of maintenance investments.



D. GUARDRAIL

Units of Measure:	Total linear feet of guardrail, per 0.10-mile section. Total linear feet of defective guardrail, per 0.10-mile section.
Threshold:	Count as deficient any guardrail, including cable guardrail, which is damaged to the point that the structural integrity is compromised or the functionality is impaired. For beam guardrail, this would include broken or cracked posts, broken, cracked or misaligned blocks, missing bolts, or where the face of the rail is deformed 6 inches or greater. Also count as deficient any portion of rail that has been flattened even if it does not meet the 6 inches of deformation. For cable guardrail, within the survey section, measure the length between supported posts as deficient. If the cable has been severed, the entire survey section is deficient. Concrete barrier is counted as guardrail for the purposes of the MAP survey. To be considered deficient, concrete barrier must be out of alignment by 6 inches or more, or the barrier surface facing traffic must exhibit spalling severe enough to snag a vehicle.
Methodology:	Count and record the total linear feet of guardrail within the survey section. Count and record the total linear feet of deficient guardrail within the survey section.
Comments:	Count as deficient only the linear feet of damage meeting the threshold. Do not count the linear feet of guardrail that would have to be used for repair, i.e. a rail with 2 feet of damage would be reported as 2 feet of damage, even though the entire 12 foot rail will have to be replaced. Identify, in the PDA, the type of guardrail on site. If more than two types are present, choose the predominant type.

Figure 2.3 LOS rating criteria used for guardrail (source: WSDOT)

NYSDOT also recognizes the disadvantages associated with its decision to use the LOS approach. For instance, it reports that agency personnel can become confused if the LOS rating scale differs from ratings used in other programs (e.g., pavement, bridge, or sign management programs).

Hybrid Approach

Other agencies have adopted a hybrid approach that combines the best features of the pass/fail and LOS approaches. For example, one approach would be for an agency to rate asset conditions using pass/fail criteria and then report regional, district, or network conditions using a graded LOS approach. For example, an agency might consider the guardrail LOS to be rated A if less than 5% of the guardrails were reported to be in failed condition. Another approach, which the Wisconsin DOT (WisDOT) uses, includes a combination of grading factors (e.g., the ones shown in Figure 2.4 for drainage) along with a deficiency threshold (e.g., pass/fail rating) for each feature.

Figure 2.4 Example of grading factors used for drainage (source: WisDOT)

Examples of the types of general deficiency thresholds WisDOT uses in its Compass[7] program are listed below.

- Does it meet specifications defined in the *Highway Maintenance Manual*, an internal document with standards for hazardous debris, shoulder drop-off, cracking, cross slope, potholes, and ditches?
- Are culverts, drains, curbs and gutters, or storm sewers obstructed or collapsing?

[7] Wisconsin Safety Resource Data Portal, http://wisconsinsafetydataportal.org/index.cfm/roadway/roadway-resources/compass/

- Are signs, flumes, special markings, delineators, fences, or protective barriers missing or not functioning as intended?
- Is more than 20% of the centerline or edgeline missing?
- Is a sign being used beyond its useful life?

Summary of Approaches Used by Participating Agencies

Table 2.1 summarizes the participating agencies' use of the three data collection approaches. The three approaches are relatively equally distributed among the participating agencies; however, the Minnesota DOT (MnDOT) does not conduct formal maintenance condition surveys, so it is not included in the table.

Pass/fail approach	Graded LOS approach	Hybrid approach
Florida DOT	North Carolina DOT	Kentucky DOT
Iowa DOT	South Carolina DOT	Missouri DOT
Kansas DOT	Texas DOT	Ohio DOT
Maryland SHA	Washington State DOT	Utah DOT
		Wisconsin DOT

Table 2.1 *SHA use of data-collection approaches for MQA purposes*

Other Factors Influencing the Rating Approach

To some degree, stakeholder input and/or agency liability have influenced some of the MQA programs. For instance, some SHAs do not use the terminology pass/fail due to negative connotations associated with the term "fail." Instead, FDOT and the California DOT (Caltrans) use terms that indicate whether a feature meets or does not meet performance standards. WSDOT also recommends that agencies using an LOS approach consider using a 1 through 5 rating rather than an A through F rating because of the connotations associated with the F rating.

In a similar vein, tort liability issues have impacted some programs. For example, the Utah DOT (UDOT) emphasizes that its ratings are guidelines or desired conditions rather than standards. In part because of tort requirements, Caltrans established these ratings:

- Meets standards (100% of standards)
- Needs 1 (50 to 100% of threshold)
- Needs 2 (0 to 50% threshold)

Alternatively, the Arizona DOT (ADOT) emphasizes that its method of rating asset conditions does not provide data for particular locations so that the agency is not aware of specific sections that are deficient.

In Wisconsin, tort liability is less of a concern since the DOT was advised that its process

demonstrated a good faith effort at a systematic approach for maintaining assets, which significantly reduces the agency's risk.

The former chief counsel to the Kansas DOT (KDOT) issued a similar message regarding levels of risk with respect to mapping and reporting of results. To further protect the agency, KDOT set its threshold level at a point that will occur before a policy level threshold is met. For example, if a policy indicates that 70 feet of deterioration is considered failure, the rating program will consider an asset to be failed at 53 feet so that the agency has time to correct the problem before it becomes a liability.

Ensuring Data Quality

Because of the importance of MQA performance data, most agencies have implemented processes to help ensure rating reliability and consistency. The scan results indicate that many different formats can be used for this activity. For example, NYSDOT uses a shadow program to help ensure data quality. Regional and central office staff members conduct the shadow program since maintenance managers are responsible for rating their own roads. In the Texas DOT (TxDOT), three former maintenance supervisors with more than 75 years of collective experience work with district personnel to complete the surveys.

UDOT conducts audits yearly so that within a year it has audited a portion of the ratings each maintenance shed has conducted. The sections are statistically selected and are conducted by a central office team, ideally one to two days after the shed team has inspected them. The results of the audits are compared to the ratings the station staff has compiled, and any areas in which further education is needed are discussed with the shed personnel and called to the area supervisor's attention.

WisDOT has a strong training program that is considered an important component of quality control. The training includes a two-day introductory class in the first year of rating followed by a one-day refresher course in subsequent years. The department also credits its attempts at keeping the methodology relatively simple and the availability of a pocket-sized reference manual as other factors that have contributed to the repeatability of its ratings. It also has developed a mechanism for incorporating suggestions from the raters into improving the training classes or the survey procedure to help eliminate sources of confusion or inconsistency in the process.

Impact of Agency Approach to Sampling on Quality, Cost, and Use of Data

Collecting the data to support an MQA program can be very demanding in terms of the resources required. For that reason, some SHAs have elected to collect data on a sampling basis rather than on the entire asset inventory. With this approach, agencies randomly select and inspect a statistically representative number of samples. They then aggregate the results and use them to represent conditions at a state, regional, and/or district level. Guidance on selecting the appropriate number of samples is available in the final report for Midwest

Regional University Transportation Center Project 06-04, *Development of a Guide to Statistics in Maintenance Quality Assurance Programs in Transportation*[8].

The use of sampling was widespread among the participants in the scan. In fact, only the Ohio DOT (ODOT) and UDOT reported collecting condition data on 100% of most of their roadway assets. Table 2.2 lists the number or percentage of samples inspected each year by the remaining agencies.

Agency	Number of samples	Sampling percentage	Agency	Number of samples	Sampling percentage
Arizona DOT		2.5%	Missouri DOT		10%
Caltrans		20%	New York State DOT		4%
Florida DOT		9%	North Carolina DOT	23,000	
Iowa DOT		5%	South Carolina DOT	1,440	
Kansas DOT		3%	Texas DOT		5%
Kentucky DOT		2%	Washington State DOT		3%
Maryland SHA		30%	Wisconsin DOT		1.5%

Table 2.2 ***Annual sampling rate used by scan participants***

The scan participants identified a number of advantages and disadvantages associated with sampling. In terms of advantages, sampling requires fewer resources and can be much more cost-effective. In addition, the inspectors may be more thorough if sampling allows them more time to complete each survey. A disadvantage to random samples is that some elements may not occur in many samples (e.g., cable guardrail or concrete barriers), and it could be difficult to get a statistically representative performance rating for those elements. However, collecting data on 100% of the network can be very costly and may require so much time that the information is not available when needed to support decisions.

The participants reported that the number of samples collected had a significant impact on the use of the condition data. For instance, agencies collecting a relatively low number of samples statewide (e.g., ADOT and KDOT) reported that they do not have sufficient data to be able to report results for any unit smaller than a district because only a few samples are collected in each subsection. Other SHAs that collect a lot of data (e.g., UDOT and NCDOT) can report results at any level and can make budget decisions using the data because of the number of samples they inspect. NCDOT reported that it also uses the data to compare performance across regions and incorporates the information into managers' performance reviews.

[8] Schmitt, RL, S Owusu-Ababio, RM Weed, and EV Nordheim, *Development of a Guide to Statistics in Maintenance Quality Assurance Programs in Transportation*, Midwest Regional University Transportation Center, Madison, WI, 2006, http:// www.wistrans.org/mrutc/research/completed-research/06-04/

Although the cost of collecting MQA data can be significant, some participants consider it a relatively small percentage of the maintenance budget. For example, UDOT collects information on its entire network each year for a total cost of $812,000, which is less than 1% of the total maintenance budget. The department considers the investment worthwhile because of the importance of the data at the station, area, region, and statewide levels. In addition to using survey results to monitor conditions, the stations use the survey results for scheduling and budgeting activities. At the area, region, and statewide levels, UDOT uses the information both to report performance and in preparing budget requests and monitoring conditions against expenditures. This allows the department to produce reports such as the one shown in Figure 2.5, which highlights areas of over- or under-spending for a particular station. In this example, it is evident that the station has not spent adequately on activities such as weed control and sweeping and has overspent on curb, gutter, and island maintenance, relative to the grade actually achieved.

Station 1421

FY 2006 Front Line Asset Management Review Sheet

Group	Description	FY 2006 Target	Station Performance		Deviation from Target		Station Budget	Station Budget Spent	Station Budget Spent	Overspending on Compliant Features	Underspending on Deficient Items
			FY to Date	Most Recen	FY to Date	Most Recen					
1A1	Snow Removal	B+	A+	NA	3	0	$120,184	$116,455	97%		
3A1	Shoulder Work	B-	B+	B+	2	2	$31,404	$31,407	100%	0.00%	0.00%
4A1	Litter	B	C+	C-	2	4	$7,686	$7,162	93%	0.00%	0.34%
4A3	Fence	B	NA	NA	0	0	$0	$0	0%	0.00%	0.00%
5A1	Weed Control	B	F-	F-	10	10	$15,057	$816	5%	0.00%	9.26%
5A2	Vegetation Obstruction	B	F-	C-	10	4	$9,956	$6,651	67%	0.00%	2.15%
5A3	Mowing	B	B-	D-	1	7	$10,032	$7,348	73%	0.00%	1.75%
6A1	Grade and Clean Ditches	B-	C	D+	2	4	$5,536	$45,395	820%	0.00%	0.00%
6A2	Maintain Inlets	B-	B+	B	2	1	$23,374	$16,777	72%	0.00%	0.00%
6B1	Erosion Repair	B-	A+	A+	5	5	$2,135	$1,506	71%	0.00%	0.00%
8A3	Repair and Replace Signs	A	A	A	0	0	$20,526	$17,277	84%	0.00%	0.00%
8A4	Repair and Replace Delineation	A	A-	B+	1	2	$10,026	$5,493	55%	0.00%	2.95%
8A5	Guardrail Maintenance	A			14	14	$1,974	$136	7%	0.00%	0.00%
8A8	Sweeping	A	D-	D-	10	10	$14,981	$12,300	82%	0.00%	1.74%
8A9	Curb, Gutter, and Island	A	A+	A+	1	1	$1,062	$1,888	178%	0.54%	0.00%
Totals					**60**	**64**	**$153,749**	**$154,156**	**100%**	**0.54%**	**18.19%**
						Current MMQA Budget Deviation		0.26%			

Figure 2.5 ***Sample report showing over- and under-spending based on performance targets (source: UDOT***

The Iowa DOT collects data on approximately 6,000 1/10-mile segments each year for monitoring maintenance performance measures, representing about 5% of the system lane miles. Six district crews conduct approximately half of the surveys in the spring and the rest in the fall. The two-person survey crews are responsible for rating 47 features in four different asset categories at a reported annual cost of approximately $400,000. The survey results are rolled up into a maintenance performance composite measure that is then used to compare performance in each district. Caltrans, on the other hand, annually surveys about 20% of its

system (i.e., approximately 3,200 1-mile segments). Caltrans estimates that it spends about 20 person years of effort on its MQA program each year when the labor requirements associated with both the surveys and the quality assurance (QA) activities are considered.

Several of the agencies that sample were able to increase the number of samples inspected without increasing inspection costs. For example, MSHA was able to inspect 30% of the system when it switched from a paper-based rating system to an electronic form that is filled out as part of a windshield survey. In the past, the crews were rating just under 20% of the system. TxDOT increased the size of its samples based on a recommendation from a statistical analysis of its data. The increase comes from averaging the ratings over two years, which doubled the number of samples being considered and helped eliminate some big spikes in the data.

The number of samples to inspect should be based on a statistical analysis of the data; however, once the analysis is conducted, most agencies reported that they use the smallest number of samples possible that will still be statistically valid. TxDOT was the exception to this; it inspects more samples so it can minimize the alpha and beta errors in the statistical computations.

Use of Innovations and New Technology in Data Collection

Since data-collection activities can be labor intensive, it is important that available technology be used as much as possible. Scan participants identified innovations that they have used to improve the cost-effectiveness or the reliability of their data-collection activities.

ODOT conducts a maintenance quality survey using two two-person crews that inspect 100% of the state-maintained routes each year from the windshield of their vehicles. They record the information using a touch-screen laptop equipped with global positioning system (GPS) technology with the interface shown in Figure 2.6. Because the survey data are linked to a field location using GPS, the survey results can be presented on maps within two weeks.

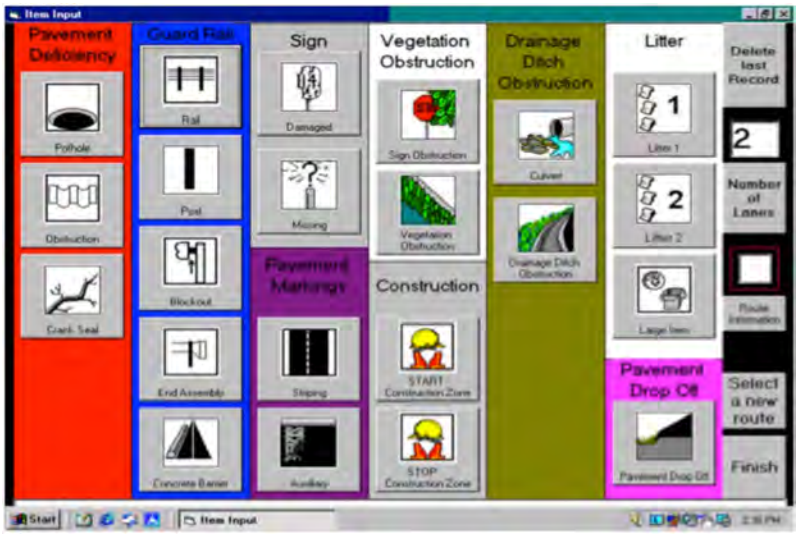


Figure 2.6 *Touch screen display used by ODOT*

The South Carolina DOT (SCDOT) was able to increase the productivity of its survey crews by setting SMART (specific, measurable, attainable, realistic, and timely) goals that are assigned to each inspector. Performance is monitored monthly and the ratings quality is checked regularly. This information is provided to the raters monthly and is considered heavily in the annual employee evaluations. As a result, production has doubled and accuracy has improved by 10 to 15%. In addition, the inspectors have taken on increased responsibility for managing their time so that they meet their goals, which has freed up their manager's time. The department is currently testing the use of iPads for collecting and reporting culvert information in real time. The iPads allow the condition information to be linked with GPS data and photos taken at the site. Another innovation is using hybrid vehicles for inspections, which has reduced vehicle costs by 30%.

UDOT conducted a pilot study in which it tested innovative approaches to data collection. One contractor gathered data by means of a hybrid system, a combination of a laptop and a handheld device with graphics for storing the information obtained in the field, as shown in Figure 2.7a. A second contractor used a van with cameras and GPS capabilities that required post-processing of the digital images of the items that could be seen from the van (Figure 2.7b). Both studies cost about the same amount of money, although the hybrid system was slightly less expensive (i.e., about 97% of the cost of the automated data-collection activity). However, the data collected from the hybrid system was more accurate, more complete (i.e., it was able to capture feature that were not visible from the van), and just as timely as the data collected using the automated equipment.

Figure 2.7A *Handheld data-collection equipment*

Figure 2.7B *Automated data-collection van*

In another data-collection study, the Utah DOT used college students as interns to collect culvert inventory and condition information over a three-year period. The interns collected information on 23,436 culverts at a cost of approximately $45,000. For safety reasons, culverts in urban areas and/or along interstates were excluded from the survey; other approaches were used for collecting data in those areas. As part of the study, the department found that Trimble[9] Juno[10] handheld computers running ArcPad[11] software were very useful during the data-collection effort. The only disadvantage to the equipment was that the lack of a flash

on the Juno camera meant that a separate camera had to be used to take photographs. As a result, there have been problems trying to match photos to the right culverts.

Findings

The scan identified the following issues regarding the use of sampling:

- Field personnel can view the program negatively if the level of sampling is not sufficient to report at a level that facilitates local planning and accountability. For example, if field personnel are responsible for collecting the data to populate the system, but the amount of data is not statistically significant to enable reporting at that level, the program might be viewed as a central office activity that has no purpose at the field level.
- There does not appear to be a consistent methodology for handling underrepresented assets in inspections (e.g., signs). In some agencies (e.g., Iowa DOT), there is interest in having access to guidelines for handling these types of assets.
- Some measures of performance relate to monitoring asset condition (e.g., pavements) and others relate to maintenance quality (e.g., plumb signs and mowing). This impacts rating methods; however, they all tie in to evaluating maintenance needs and effectiveness.
- Many factors influence whether maintenance targets are achieved. Even so, state agencies report that it is important for stations, areas, and/or districts to be able to explain why targets have not been met. This is considered an important step toward establishing accountability.

The participants also made the following recommendations for agencies considering a sampling approach:

- Capture both the costs and benefits associated with the program to help ensure that sufficient resources are available to support the program
- Measure those things that matter most. For example, MnDOT's performance management approach has evolved from a customer service approach that concentrates on areas that are of most importance to their customers (e.g., snow and ice rather than mowing and litter)
- Survey at least the minimum number of samples that will be statistically valid
- Select samples randomly each year to avoid any potential problems associated with inspected samples being maintained at a different level than the rest of the

[9] Trimble, http://www.trimble.com/index.aspx
[10] Juno SB handheld, http://www.trimble.com/junosb.shtml
[11] Esri, ArcPad, http://www.esri.com/software/arcgis/arcpad/index.html

network. For instance, the Missouri DOT ([MoDOT) found that when the samples that were being inspected were known ahead of time, they tended to be in much better condition than neighboring samples

The discussions on innovation led to the following findings:

- A hybrid approach to data collection that combined a laptop with a handheld device proved to be more accurate than, more complete than, and just as timely as automated data-collection vans in a UDOT pilot study. Therefore, agencies can establish a good part of the inventory fairly inexpensively, and sometimes older technology can be just as effective as new technology.
- When conducting pilot studies to test new technology, it is important to
  - Organize the data-collection effort
  - Verify that systems are in place for processing and storing the data
  - Confirm that the new data will be compatible with existing systems
  - Provide access to the new information to stakeholders
  - Establish procedures for maintaining the data over time (if the pilot is successful)
- Working with an information technology (IT) department can be a challenge. However, to build a strong team relationship, each party has to recognize the skills that the other group brings to the table. MoDOT, for example, had IT staff working in the maintenance department to help identify and articulate needs, which helped get things through the hierarchy.
- Improvements in technology are largely driven by the need to provide more information more quickly, more accurately, and/or more economically than with existing processes. Scan participants indicated that they would collect more data if they could afford it, could get it faster, could improve data quality, and/or could better influence decisions.
- The push for innovation can come from either the top or the bottom of the organization. For example, top management at UDOT fosters a leading edge culture that has enabled it to test new innovations fairly easily. This has benefitted the program because of the ease with which new technology can be integrated into the program. However, innovations in other agencies (e.g., SCDOT's productivity improvements) were initiated at the field level.
- When collaborative methods are used to build inventories, guidance must be developed to clearly specify how the baseline inventory will be maintained over time so that all parties know who is responsible for each type of data.

- In some cases, it takes time for field personnel to become accustomed to the new technology. NCDOT paired a senior technician with a tech-savvy technician to help with training and increase the level of comfort with new technology. WSDOT allows the staff to dictate the rate at which new technology is adopted. For example, if field technicians are not using the new PDAs in the field, they can record information on paper forms. However, they are responsible for entering the information in their PDAs as soon as they get back in the truck. After a three-year period, approximately half of the regions no longer use paper forms.

3.0 Performance-Based Budgeting and Target Setting

Background

Although many MQA programs are used primarily to report conditions and accomplishments, the information can also be used for allocating maintenance budgets and for resource planning activities. In addition, the results serve as a valuable input to the agency's target setting activities by providing the necessary link between the outcomes that can be achieved at different funding levels. As a result, the agency can establish a clear vision for the LOS that can be provided to the traveling public for its maintenance activities.

In his opening presentation at the scan meeting in Irvine, Peter Stephanos (FHWA) referred to performance management as a "systematic approach to making investment and strategic decisions using information about the condition and performance of the system." Mr. Stephanos (FHWA) shared recommendations from the National Surface Transportation Policy and Revenue Study Commission[12] that emphasized a surface transportation policy with a strong federal role based on national goals. In addition, the report recommends a consolidated program structure and a performance-based approach to managing decisions about the transportation infrastructure. From a national perspective, he suggested that performance measures of national interest that could serve as the basis for establishing goals include the following:

- Safety (e.g., number of fatalities and serious injuries)
- Infrastructure condition (e.g., state of good repair)
- Freight mobility and economic vitality (e.g., speed, travel time, and/or reliability on key networks)
- Mobility (e.g., travel time and reliability)
- Environment (e.g., greenhouse gases and storm water runoff)
- Livability (with potential measures to be determined)

For the maintenance community, a solution to establishing and reaching national goals or performance targets is developing a methodology that links maintenance accomplishments with methods of assessing performance and expected outcomes. In other words, a key is

[12] *Report of the National Surface Transportation Policy and Revenue Study Commission: Transportation for Tomorrow,* National Surface Transportation Policy and Revenue Study Commission, Washington, D.C., 2007. National Surface Transportation Policy and Revenue Study Commission, January 2008, http://www.mtc.ca.gov/news/NSTPRSC/nstprsc_exec_summ.pdf

establishing the link between maintenance activities (e.g., replacing pavement markings) and the rating methodology (e.g., visibility of the markings in low-visibility situations) with expected outcomes for different investments in maintenance (e.g., a reduction in the number of fatal car crashes). The increasing use of asset management principles nationally demands the creation of these links between the funding expended and the performance achieved.

Based on the discussions held during the scan, the links between maintenance accomplishments and strategic performance targets (e.g., crash reductions) typically have not been established. As a result, maintenance and operations programs are not always able to defend budget requests or justify maintenance expenditures. The lack of these types of metrics also makes it difficult for the maintenance of roadway hardware to compete for funding among other assets, such as pavements and bridges.

The discussion about national performance goals evoked a lot of discussion, with the state representatives showing some apprehension about the concept. However, the participants generally recognized that the country is moving in a direction that will continue to demand increasing accountability, so they generally favored an approach that provides enough flexibility to accommodate specific state interests while remaining meaningful enough to be used for benchmarking, target setting, and investment planning activities. The participants also pointed out that without standard measures across agencies, at least in key areas, it is difficult for agencies to benchmark with one another or to share standards, models, or analysis tools.

This chapter addresses three different aspects of performance-based budgeting and target setting: establishing maintenance priorities using MQA results, using performance data for budgeting activities, and linking customer expectations to the performance targets that are set.

Establishing Maintenance Priorities

One of the common uses of maintenance performance data among the participating agencies[13] was establishing maintenance priorities so that resources are allocated effectively. For example, NYSDOT reported that maintenance personnel in its state like to mow; however, maintenance managers were able to use their performance data to show that too many resources were being allocated to mowing when compared to other important activities where performance targets were not being met. As a result, they were able to reallocate resources and move them to higher priority activities.

One method of establishing maintenance priorities that several agencies have used is the development of a single maintenance rating. The calculation of the rating varies by state; however, those agencies that have adopted this approach appreciate the simplicity of using a single number to represent the overall quality of maintenance activities. In fact, at least 11 of

the participating agencies[13] combine their MQA results into a single statewide maintenance score with weights to reflect priorities. For example, ODOT uses its survey results to calculate a maintenance organizational performance index (OPI). The department's current goal is an OPI value of 4, using a range of 1 to 6. TxDOT also reports an overall performance index, which is based on the scores and weights related to three components: pavement (55%), traffic operations (25%), and roadside (20%).

Rather than establish a single rating, WisDOT has established a hierarchy of contribution categories to help determine how funding will be spent when budget adjustments are needed due to unexpected events (e.g., snowstorms). WSDOT also has established maintenance priorities, which are published in a report.

KDOT rolls its MQA ratings into a single score for each category. It is moving toward managing each of the categories to approximately the same level. The department tracks maintenance areas that are not meeting their targets, using this data to prioritize maintenance activities for the following season.

Using Performance Data for Budgeting Activities

Traditionally, an agency develops its maintenance and operations budget based on historical budget levels that are increased or decreased to match available funding. However, some of the agencies that participated in the scan have been able to use their MQA results to conduct performance-based budgeting. The participants in the scan meeting primarily use one of three approaches:

- Needs-based budgeting (Arizona, South Carolina, Texas, and Washington)
- Formula- or history-based approach (Wisconsin, South Carolina, Minnesota, Ohio, and others)
- Zero-based budgeting (Florida and Utah)

This section provides information on each of the three approaches that have been used and the challenges that agencies face in this area.

The type of budgeting approach used is likely influenced in part by the types of budgeting tools available to the agency. For example, enhanced maintenance management systems (MMSs) may be needed to conduct needs-based budgeting, and homegrown systems may be all that is necessary when budgets are based primarily on historical trends. Table 3.1 shows the types of systems the agencies that participated in the scan meeting use.

[13] Kansas, Ohio, Wisconsin, North Carolina, South Carolina, Maryland, Iowa, Missouri, California, Florida, and Texas

Agency	Software source	Agency	Software source
ADOT	Inhouse program	NYSDOT	Proprietary software
Caltrans	Commercially available (Microsoft Access)	NCDOT	Proprietary software
FDOT	Inhouse program	ODOT	Commercially available (laptop GPS)
Iowa DOT	Inhouse program	SCDOT	Inhouse program
KDOT	Inhouse program	TxDOT	Proprietary software
KTC*	Proprietary software	UDOT	Proprietary software
MSHA	Inhouse program	WSDOT	Inhouse program
MnDOT	Proprietary software	WisDOT	Commercially available (Microsoft Office)
MoDOT	Commercially available (Microsoft Office)		

*Kentucky Transportation Cabinet

Table 3.1 ***Source of maintenance management software***

Needs-Based Budgeting

An example from ADOT illustrates the importance of being able to link funding expenditures with performance outcomes. At that agency, maintenance regularly requested additional funding from the legislature to address its needs. However, the state legislature indicated that it would not increase the amount of money allocated to maintenance activities until the department could document what it would accomplish with the additional funds. As a result, ADOT initiated a study to develop its maintenance budget system to address this need.

To date, the results from the tool are not utilized fully in establishing budget allocations; however, the system better positions maintenance to defend its budget requests. The maintenance budget system is strictly a budgeting tool that allows it to create a budget year, set inflation rates, and add in any additional lane miles that it expects will be built. The program links maintenance activities with condition information and priority weights that are assigned to each activity. By selecting the amount of backlog it wants to address each year, maintenance can determine the needed amount of funding. It can also set LOS targets for each district and the amount of money required to achieve those targets. The level of confidence in the latter analysis is somewhat limited, however, because ADOT does not collect data on enough samples to be statistically valid at the district level.

SCDOT uses the results of its walking surveys to establish current LOS and substandard areas of maintenance performance. The department uses its MMS to generate the costs associated with maintaining the current LOS and achieving other LOS targets and reports the results to upper management and the public since a gas tax funds the maintenance budget.

TxDOT provides similar types of reports to its upper management. However, the department

notes that it inflates the costs of achieving higher LOS to reflect the higher anticipated contracting costs to conduct the additional work due to agency hiring restrictions.

In both SCDOT and TxDOT, the reports help defend the use of maintenance funds and have helped improve internal and external communication. Both states reported some success at using the information to obtain addition money; however, in South Carolina, the additional funds were targeted to certain high-profile roads. The department anticipates that counties will continue to pass tax increases to ensure that they have good roads, so county influence on road maintenance will likely increase with time. In Texas, the availability of pictures to show the deteriorating conditions was helpful.

WSDOT initiated its MAP in response to the legislature's questions about what accomplishments it could expect from the provided funding. Since the department could not answer the questions, it initiated a study that led to the development of the MAP. WSDOT used the results successfully to identify investment choices and the effects of those choices.

The department has continued to work on enhancements to its MAP to better address maintenance needs. For instance, MAP scores now consider construction activities since large construction projects were increasing MAP scores even though no maintenance was being done. The new, coordinated approach now shows that if construction dollars are not spent, maintenance needs are expected to increase.

WSDOT also looked at backlog needs by establishing the maintenance activities that needed to be done to maintain a base level of work. Starting with signals, it was able to show that the department was performing about 30% of the necessary work. It also showed the improved reliability of the signals in areas where a greater percentage of the needed work was being performed. Because of this information, the legislature awarded WSDOT a significant increase in its budget, with nearly half of the money targeted to signals and intelligent transportation systems.

WSDOT allocated the funds to the regions based on the amount of work they were performing. For example, a region that was performing 94% of the necessary maintenance work on signals got less money than one that was performing 50% of the necessary maintenance. The regions now report their MAP scores and the percent completion of baseline activities that they are performing. The system has been working well not only because it gives regions the ability to manage the use of their funds, but also because there is some statewide control of priorities. It also provided a means of illustrating to the legislature the impact of adding new miles to the network and the resulting reduction in the amount of work that could be accomplished.

Both WSDOT and TxDOT reported that before regions or districts can request additional money to address their needs, the central office checks to make sure that all of the money will be used. In fact, TxDOT requires each district and maintenance section to be within 1% of the amount it was allocated each year. If money is not going to be spent, it is reallocated in other areas based on need so it is not wasted on year-end purchases (e.g., furniture) that do not improve system performance.

NCDOT also conducts needs-based budgeting and reports the results of its analysis to the legislature every other year. For instance, in 2006 NCDOT used its historical cost information to determine the cost of maintaining various LOS for each asset category[14], as shown in Table 3.2. The table shows that the average cost of maintaining low shoulders at a LOS C, for example, is $213,002 per year. The cost to improve the LOS to a B is $159,751 (increasing $213,002 to $372,753). This type of information is very useful for reporting needs and for linking customer expectations to budget requirements.

Road Maintenance Funding Matrix Table
Performance Based Activities

Maintenance Activity	Interstate System			
	TOTAL COST A	TOTAL COST B	TOTAL COST C	TOTAL COST D
Pavements	$ 3,963,032	$ 2,963,032	$ 2,713,032	$ 1,963,032
Subtotal	$ 3,963,032	$ 2,963,032	$ 2,713,032	$ 1,963,032
Shoulders & Ditches				
Low Shoulder	$ 745,507	$ 372,753	$ 213,002	$ 149,101
High Shoulder	$ 842,519	$ 421,259	$ 240,720	$ 168,504
Blocked Lateral Ditches	$ 1,232,217	$ 410,739	$ 273,826	$ 205,370
Subtotal	$ 2,820,243	$ 1,204,752	$ 727,548	$ 522,975
Drainage				
Cross Line Blocked	$ 2,600,742	$ 866,914	$ 650,186	$ 433,457
Cross Line Damaged	$ 508,704	$ 169,568	$ 127,176	$ 84,784
Curb and Gutter Blocked	$ 700,345	$ 280,138	$ 200,099	$ 140,069
Curb and Gutter Damaged	$ 44,395	$ 17,758	$ 12,684	$ 8,879
Basin Blocked (Inlet)	$ 4,081,237	$ 1,632,495	$ 1,020,309	$ 742,043
Basin Damaged (Inlet)	$ 439,999	$ 175,999	$ 110,000	$ 80,000
Subtotal	$ 8,375,422	$ 3,142,873	$ 2,120,453	$ 1,489,232
Roadside				
Mowing	$ 1,439,936	$ 1,199,947	$ 959,957	$ 719,968
Brush & Tree Control	$ 21,973,606	$ 6,278,173	$ 3,662,268	$ 2,585,130
Litter & Debris	$ 5,536,296	$ 4,152,222	$ 2,768,148	$ 2,076,111
Slope Failure	$ 134,323	$ 67,161	$ 33,581	$ 22,387
Guardrail	$ 1,223,500	$ 611,750	$ 305,875	$ 203,917
Subtotal	$ 30,307,661	$ 12,309,253	$ 7,729,828	$ 5,607,513
Traffic Control Devices				
Traffic Signs	$ 2,420,410	$ 806,803	$ 484,082	$ 345,773
Pavement Striping	$ 835,446	$ 417,723	$ 238,699	$ 167,089
Words & Symbols	$ 1,918,717	$ 959,358	$ 639,572	$ 479,679
Pavement Markers	$ 1,198,467	$ 479,387	$ 299,617	$ 184,380
Subtotal	$ 6,373,040	$ 2,663,272	$ 1,661,970	$ 1,176,921
Environmental				
Turf Condition	$ 6,438,273	$ 2,146,091	$ 1,287,655	$ 919,753
Misc. Vegetation Management	$ 8,043,646	$ 4,021,823	$ 2,681,215	$ 2,010,911
Subtotal	$ 14,481,919	$ 6,167,914	$ 3,968,870	$ 2,930,665
Total	$ 66,321,318	$ 28,451,096	$ 18,921,701	$ 13,690,337

Table 3.2 *Interstate maintenance costs for different LOS (source: NCDOT, 2006)*

[14] 2006 Maintenance Condition Funding Needs for the North Carolina State Highway System, NCDOT, Raleigh, NC, 2006, http://www.ncdot.gov/programs/srmu/download/MCAP_Rpt2006.pdf

Some SHAs identified other approaches for using MQA results for budgeting activities. For instance, WisDOT recently developed "maintenance price tags" that are used to estimate the funding required to reduce maintenance backlogs to different LOS based on unit cost data. It also establishes fiscally constrained summer maintenance targets each year, but has not yet established long-term goals based on an ideal funding scenario.

The use of performance data in budgeting activities provides a means of holding field personnel accountable for the results achieved; however, the degree to which they are held accountable varies by agency. For example, WSDOT asks the regions to explain why did not meet their targets, since the information is useful in future budgeting activities. In Missouri, the department showcases the accomplishments of districts that were able to reach their targets and uses that as a way to motivate other districts to change their practices. TxDOT has a focus on pavement that emphasizes spending money on meaningful activities, which is known internally by the slogan "pennies to the pavement." Under this program, people are held accountable for projected conditions that should be achieved with the funds provided.

Formula- or History-Based Approach

The Kentucky Transportation Cabinet (KTC) recently changed its budget allocation process to address district complaints that the prior approach, which was based on lane miles in each district, did not account for variations in cost and performance across the state. The new approach used the results of the cabinet's MRP to identify features in need of improvement, as represented by an MRP score below 70. Districts where the substandard conditions were noted could then apply for a $100,000 bonus to address the deficiencies. Because the revised approach did not work as planned, the process was changed again in 2009. Now, a baseline amount of the budget is distributed to each district based on prior year spending, and the central office makes quarterly allotments of additional funds to address needs when it is clear that the districts are spending their baseline budget as planned and a deficiency exists.

KDOT has separate budgets for routine and preservation maintenance. The budget for preservation maintenance activities is allocated to pavement management using inputs from the department's annual network optimization survey. The routine maintenance budget is allocated to the districts, which have a great deal of autonomy in how they spend that money. In the 1980s, the department required the districts to prepare work plans that showed how the money would be used. However, this burdensome, top-down endeavor rapidly fell into disuse. Even 30 years later, the words "work plan" have a negative connotation.

Although KDOT has LOS information available from its manual surveys on approximately 3% of the network, it has had difficulty in correlating costs to LOS for routine maintenance activities. For instance, in low snow years, maintenance crews are able to spend more time on other activities, so the MQA scores fluctuate based on the types and duration of weather events that occur, as illustrated in the following figures. Figure 3.1 illustrates the number of hours spent yearly on each of the six maintenance categories. Figure 3.2 shows a comparison of the number of hours spent on snow and ice removal and the overall MQA score each year.

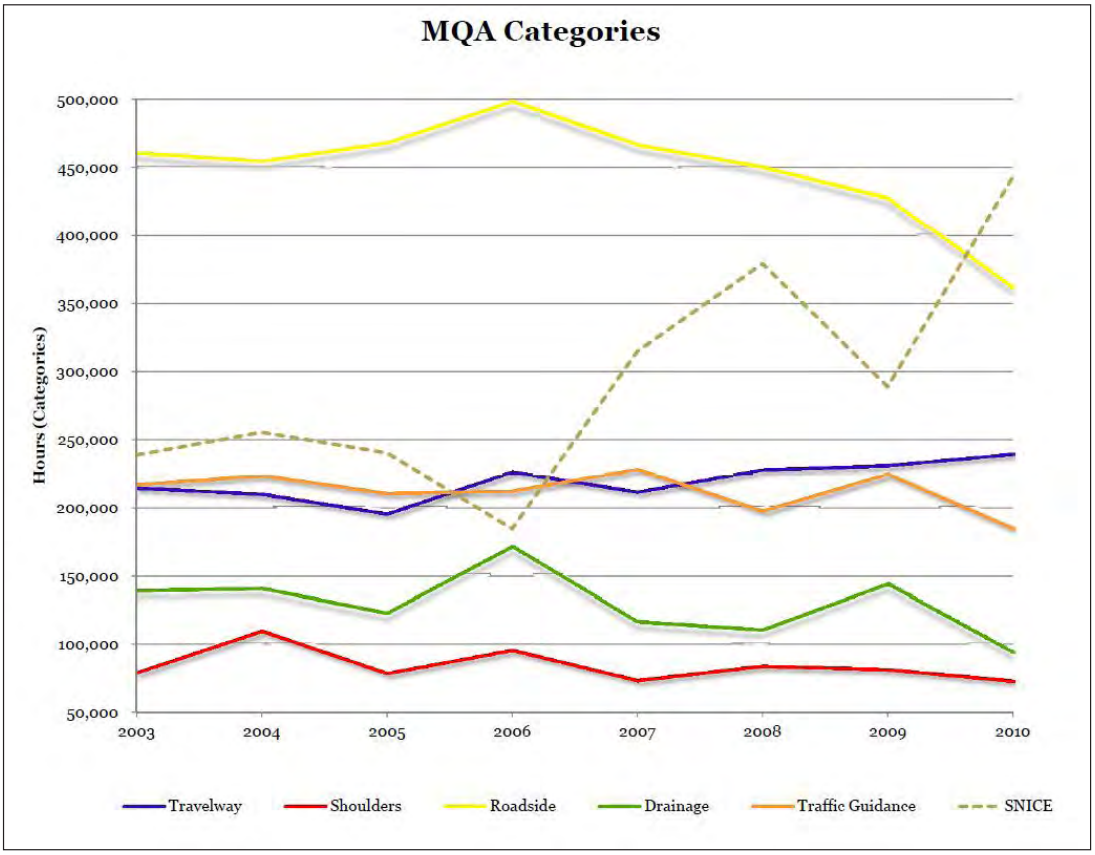


Figure 3.1 *Hours spent on various activities each year (source: KDOT)*

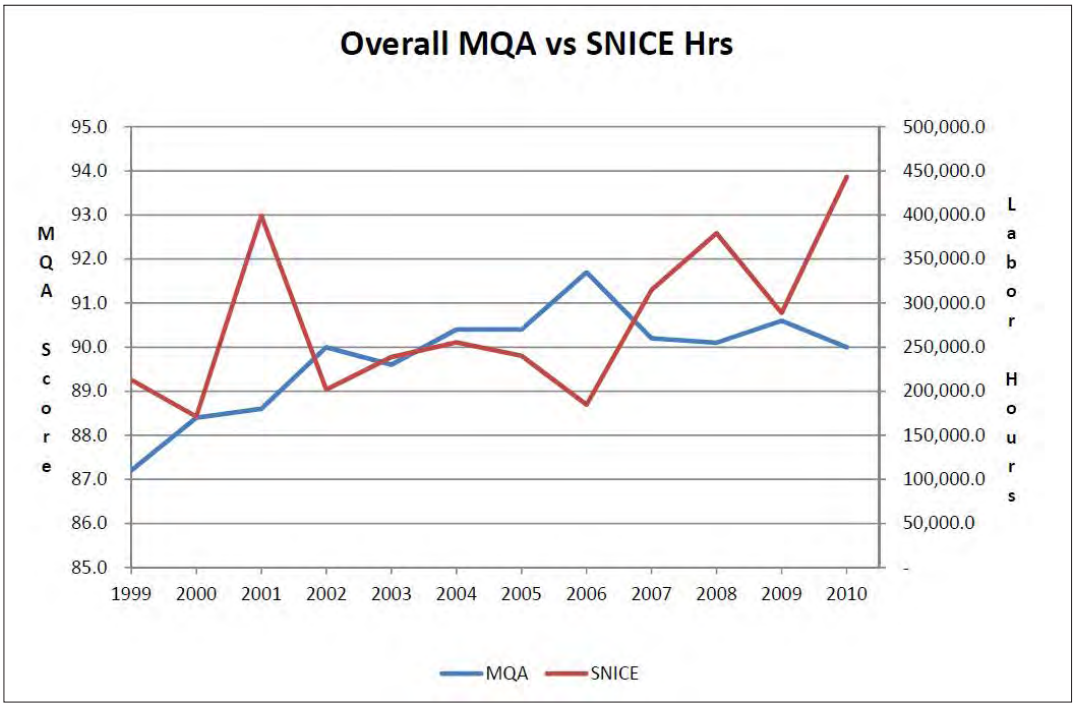


Figure 3.1 *Impact of snow and ice removal requirements on MQA conditions (source: KDOT)*

Zero-Based Budgeting

Florida is a zero-based budget state, which means that every line item in the budget must be approved without reference to previous expenditures. This requirement has impacted the department's use of its roadway characteristic inventory for maintenance budgeting by establishing an overall baseline MRP of 80 that must be achieved.

The department's budgeting tools link workloads to unit costs for each activity to determine routine maintenance funding needs. The unit costs reflect work done by both in-house and contract forces based on a 20/80 split, respectively, reflecting a legislature-mandated split. Of the 80% that is conducted by contract forces, the legislature also mandates that 50% of that be conducted using asset management contracts by an FDOT policy. The budget also includes fixed obligations for items such as rest area maintenance, which are added as a line item with a 2.5% increase in costs applied each year.

Reports showing planned and completed maintenance activities are used to adjust activity formulas used in the budgeting process; however, they are also used to determine if money needs to be reallocated. For example, in one year the department eliminated the additional number of cycles for limited-access mowing, which saved approximately $51 million over a five-year period. The savings were used to reduce FDOT's overall budget request.

Strategies for Addressing Budgeting Challenges

The discussions among the scan participants indicated that agencies face many challenges in allocating maintenance funds. For example, one of the challenges that several agencies mentioned was the use of performance data for budgeting purposes related to relatively labor-intensive activities. For instance, one year when the ADOT maintenance budget was cut, it realized an increase in the LOS for some features (e.g., ditch cleaning) because maintenance staff shifted from one activity to another that required fewer resources. This situation is counterintuitive to some people and can be difficult to explain.

Another issue is that, in some agencies, upper management knows that maintenance holds money to address unpredictable weather events. Attempts to "borrow" this money to address short-term agency needs can have a significant detrimental impact on maintenance budgets if a weather event materializes.

Another common issue among the participating agencies is dealing with field office perceptions that budget allocations reward those individuals who are not doing a good job with maintenance activities. For example, a truly needs-based approach tends to favor a group that allows things to deteriorate; however, a group that applies preventive strategies would not receive as much money.

MSHA offset some of those types of concerns by allocating 25% of the budget based on needs and the remainder of the budget based on the size of the asset inventory. The KTC bonus system has helped address this issue to some degree; however, it also stresses that each district should focus on its contribution to the overall system conditions and not the contributions of other districts.

NYSDOT took a slightly different approach. It implemented an innovation fund using some money that maintenance retained from the distributions made to the districts. This fund pays money for special projects, which are later shared with the other regions.

TxDOT bases 60% of its fund allocation on pavement condition. It posts the condition scores so it is clear to each district how the funds were allocated. Each district is also responsible for submitting a plan for how it will use the money and is held accountable if the anticipated improvements are not met.

The ability to link maintenance accounts with other management systems is another challenge for some agencies. For instance, Iowa DOT representative indicated that the information in the maintenance force accounts and other systems (e.g., their pavement management system) is separated. TxDOT has addressed this issue by making maintenance personnel responsible for developing a four-year pavement management plan that is presented at the central office and compared with the four-year construction plans that are developed by pavement management.

One of the items that makes this topic particularly challenging is that not all maintenance activities are reflected in the pavement management systems, so it can be difficult to coordinate the two functions. In Minnesota, for example, maintenance paving is captured in the pavement management system, but pothole patching is not. Therefore, patching conducted by the maintenance forces is not reflected in the pavement condition ratings generated by pavement management.

WSDOT has incorporated all pavement reporting into its pavement management system, which provides a yearly score (a percentage of pavement in fair or better condition). The purpose of this is to use one data set for reporting pavement condition, instead of separating maintenance and construction, in an attempt to show the correlation between the two programs. Therefore, maintenance is now able to use pavement management condition data for planning purposes and maintenance activities performed are now provided to pavement management to track.

MSHA is reportedly doing something similar to WSDOT. In Maryland, maintenance and pavement management coordinate their activities so that planned maintenance activities can be considered in the pavement management model.

UDOT develops what it calls “A Plan for Every Section,” which is kept in both the maintenance and pavement management areas. Any work done by maintenance or contract forces, or by pavement management (i.e., construction projects) is reflected in the plan.

Linking Customer Expectations to Performance Targets

Performance targets provide a mechanism for an agency to establish its program objectives by setting a specified level of service or performance. Performance targets can be used to determine any gaps between existing and desired conditions and to estimate the funding

levels that would be required to address those gaps. The information can also be used to provide feedback to elected officials and to the traveling public regarding maintenance accomplishments. Because of the close link between performance measures and the interests of the traveling public, many transportation agencies have implemented programs that provide feedback from segments of the traveling public on the degree to which their needs are being met. However, these forums also provide a mechanism for conveying a message to the traveling public so it can better understand the challenges that today's transportation agencies face.

Most of the participants in the domestic scan reported that they had conducted some form of maintenance customer survey in recent years. However, due to funding constraints in many of the participating agencies, several reported that the surveys have been suspended or are being done less frequently.

MoDOT is a very performance-oriented agency, so it has established a number of strategies for obtaining customer input to help ensure that the agency is focusing on what the public expects. The corporate culture supports a performance-based approach, and the MoDOT *Tracker*[15] is used for accountability. MoDOT uses road rallies, customer surveys, and report cards to monitor the degree to which the public accepts the agency's performance. To date, the public's priorities focus on safety and unrestricted access to roads.

Because of the importance MoDOT places on customer feedback, it spends approximately $200,000 each year on its public phone survey and a survey of the media and other partners (e.g., public officials and organizations like the Association of General Contractors). Customer relations personnel generally design the survey mechanism with input from the department on the agency-wide focus areas. One of MoDOT's newer applications is its "Show Me My Buzz"[16] smartphone application (see Figure 3.3), which estimates the user's blood alcohol concentration and provides a direct link to a taxi service. This tool's release was done in conjunction with other public relation campaigns designed to reduce drunken-driving fatalities.

Figure 3.3 *"Show Me My Buzz" smartphone application (source: MoDOT*

[15] MoDOT Tracker, http://www.modot.org/about/general_info/Tracker.htm

[16] "Show Me My Buzz" news release, http://www.modot.org/newsandinfo/District0Release.shtml?action=displaySSI&newsId=115900

MnDOT's increased attention to customer feedback is evident. The department employs full-time market research personnel to support its efforts and considers stewardship as a three-way partnership between technical expertise, strategic direction, and customer input. While one factor may carry more weight than another for some features, the presence of all three is important. Customer surveys and focus groups have had a direct impact on the department's performance targets, as evidenced by the snow and ice performance targets that were set at five different levels based on traffic volumes. Figure 3.4 shows the photos that were used for the focus group discussions, and Figure 3.5 shows the targeted conditions that were established.

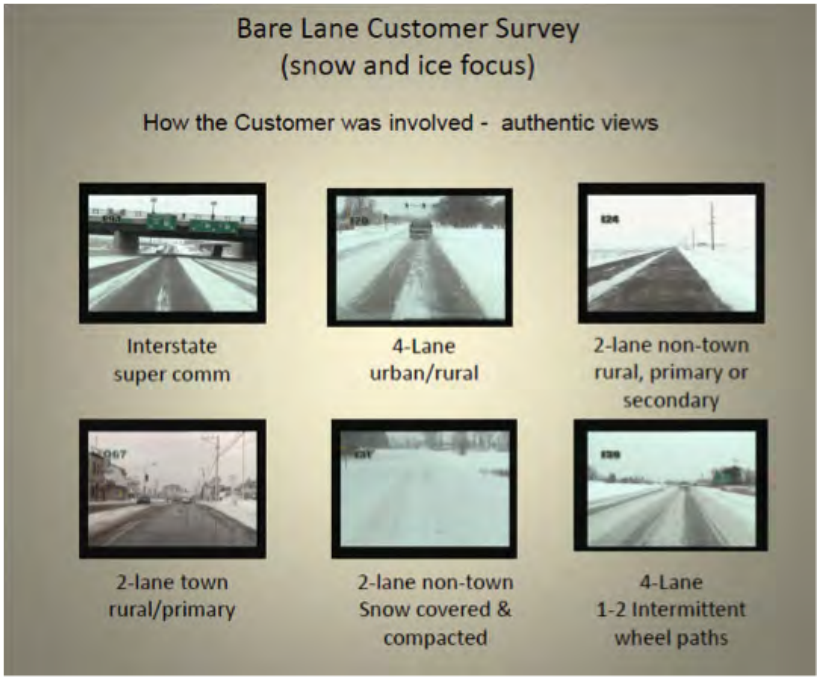


Figure 3.4 *Snow and ice photos used for focus group target setting (source: MnDOT)*

Figure 3.5 *Targeted conditions for snow and ice removal (source: MnDOT)*

One of the early observations that influenced MnDOT's use of performance measures was the public's interest in performance outcomes (e.g., time to bare lanes after a snowstorm) rather than outputs (e.g., number of hours spent on snow removal). As a result, the department's performance measures are very outcome-oriented and focused on items of interest to the public (e.g., snow and ice removal). For example, one of the department's significant uses of the customer performance data regarding snow and ice was a decision to move from a bare pavement policy to a bare lane policy. MnDOT made this change based on customer input that showed customers were most interested in removing snow from the fog line and the centerline. To obtain feedback from agency peers, the maintenance department conducts an annual department-wide survey that has used a consistent set of questions for a number of years. As a result, the information can be used to document trends in performance and compare performance to targets.

KDOT is one of the agencies that suspended customer surveys due to budget constraints. However, it had conducted surveys for approximately 10 years prior to ending the program. Its results indicated that local and national events easily influenced the public's perception of conditions. For example, the Kansas media promoted a particular snowstorm as an extreme event, although the department considered it no more than an average storm. However, because of all the media attention to the storm, the public was very complimentary regarding the department's success at clearing the roads so quickly. The increased interest in bridge conditions following the collapse of the I-35 Bridge in Minneapolis is another example of how special events can influence public perception.

Another challenge with the public perception is that the public is not always aware of the factors that might trigger maintenance actions. For example, one of KDOT's customer satisfaction surveys indicated that the public was "very satisfied" with the condition of guardrails. In reality, many guardrails were too low meet current guidelines. Therefore, the department found that the results of customer surveys cannot be used exclusively to drive maintenance budget allocations.

It is also difficult for the public to differentiate between state routes and local routes, so it can be difficult to know what roads were used as the basis for the opinions provided in customer satisfaction surveys. UDOT and WSDOT try to address this by introducing examples of several state routes at the beginning of their surveys.

The format used for gathering customer input varies. For instance, KDOT reported that its last survey was conducted using letter surveys sent by mail. MoDOT indicated that it uses annual phone surveys; however, ADOT found that it is hard to get people to answer the phone these days. WSDOT recently moved to an e-mail survey. The response rate was lower than it had been for other types of past surveys; however, the responses were higher quality because they were submitted by people who were really interested.

Several DOTs, including KDOT, also have Web sites that provide forums in which the public can express their opinions. Other states use Facebook accounts for this type of information. However, the irony of the situation was not lost on the participants. They pointed out that while many DOTs allow the public to post opinions on Facebook or on blogs, those same agencies typically prevent their employees from accessing the sites for security or personnel management reasons.

In addition to the various forms of surveys that are conducted, several agencies indicated that they conduct road rides with representatives from various stakeholder groups as another method of obtaining customer input. In Kansas, a consultant organizes a group that rides in a van and rates the roads. NCDOT does something similar and pays the participants $30 per hour for their time. TxDOT invited peers from other SHAs to ride in a van with a group of experienced raters from maintenance and a group of inexperienced raters. The department found that the maintenance group tended to rate their own work much more harshly than did the others.

One of the trends identified in the discussions was the use of questions that ask the recipients to rank priorities, rather than merely report whether they are happy with the level of service. Both MSHA and WSDOT report that they have moved toward this type of survey.

When asked whether customer surveys are worth the investment, most participants indicated that they are because they provide information that allows the agencies to respond to legislative requests. The participants indicated that when they are able to tell the legislature that 75% of the traveling public wants a certain accomplishment, it provides a very strong, supportive argument. It also helps the agencies confirm that they are focusing their efforts on the things that are of most value to the public, especially during times when budgets are tightening. However, the feedback needs to be connected to decisions for the value to be fully realized.

Findings

The budgeting discussions led the group to conclude the following:

- Agencies use a variety of techniques for budgeting maintenance activities and for estimating maintenance needs. For example, TxDOT uses a needs-based budgeting approach, while FDOT and UDOT use a zero-based budgeting approach. Several other participants use more of a formula- or history-driven budgeting approach. For the most part, agencies are not using MQA results to manage maintenance funds across districts. Instead, the results are used to make better use of funding within a district. However, WSDOT is moving toward a more integrated needs-based budget.
- Performance-based budgeting helps managers address gaps between targeted and actual conditions. An analysis of the data to determine the factors causing the gap is important to address these concerns. Departments should take steps to help people avoid future gaps in performance when the gaps can be eliminated by

improving the manager's decisions. It is also important for departments to make corrections to high-priority features.

- The use of performance data for needs-based budgeting expands the use of MQA results. For example, WSDOT was able to use the information to show the legislature the impact of new miles on future maintenance needs.
- A key to being able to use MQA data for budgeting is to train district and region staff about the system and the way decisions are being made. The training can help improve the consistency in the maintenance priorities across the state so that the field priorities better match the central office priorities.
- Districts that perform well tend to feel shortchanged when money is allocated based solely on the gap between targeted and actual conditions. None of the agencies has completely overcome the issues associated with budget allocations in which one group feels that those who are doing a poor job of maintenance are rewarded with more money than the group doing a good job. However, processes that provide at least a portion of the budget based on needs seems to help offset some of these concerns.
- Some agencies (e.g., MSHA and KTC) have been able to use their performance data to allocate funds to address their backlog or to address a higher-level (e.g., statewide) need. NYSDOT was able to use the data in a similar fashion for drainage needs. Other agencies, including WSDOT and TxDOT, have used their needs estimates to obtain additional funds.
- To a varying degree, some SHAs are using the results of needs-based budgeting to hold field personnel accountable. In some agencies (e.g., WSDOT) discrepancies must be explained; however, in other agencies (e.g., TxDOT) the degree of accountability is much higher.
- It is a challenge to change the culture of an organization when it needs to approach business processes differently. However, several agencies (including WSDOT) were able to demonstrate their ability to manage this change.

The discussions on linking customer expectations to performance led the group to conclude the following:

- The results from customer surveys do not always match factors used in making maintenance decisions, as evidenced by the Kansas guardrail example.
- In customer surveys, MoDOT and KDOT both found that pavements always come out as the top priority.
- Holding people accountable has made a difference in the success of the MQA programs in several states. MoDOT reported that its staff reports on actions rather than plans for action.

- The DOTs are increasingly using social media to communicate with stakeholders. For instance, MoDOT's "Show Me My Buzz" application and MnDOT's online community illustrate the types of applications that are being used.
- Close working relationships with public information officers and market research personnel have strengthened several maintenance programs. MnDOT reports that it employs full-time market research personnel to help evaluate public response to changes in programs and policies. WSDOT and TxDOT have a public information officer assigned to maintenance to answer phone calls and address complaints.
- Stewardship is based on a combination of technical expertise, strategic direction, and customer input. The weight of any of these factors may vary depending on the item or activity.
- What gets measured can influence behavior both positively and negatively. Therefore, it is especially important that performance measures monitor the conditions that are closely linked to an agency's strategic goals.
- There is a difference between indicators (output) and performance measures (outcome), and MnDOT has found that it is acceptable to use both to address maintenance activities.
- Most of the scan participants report that it is worth the expense to obtain customer feedback as long as the results are used.

4.0 Addressing Institutional Issues

Background

In addition to the technical issues associated with the use of performance data to support maintenance decisions, institutional issues may also need to be addressed, such as those related to factors associated with personnel, organizational structure, or internal policies that may hinder the adoption of new approaches. For example, common institutional issues include individual resistance to change, organizational barriers that prevent interactivity among stakeholders, and shifts in organizational direction due to leadership changes. In some cases, institutional issues can be harder to address than technical issues because they require changes in individual behavior.

A number of institutional issues impact the success of performance-based decision-making. For example, an MMS is dependent on the availability of sound, technical information upon which decisions can be based. In general, responsibility for entering asset inventory and condition information rests with field maintenance personnel who have many other competing priorities. The quality of the data reported by field personnel is strongly influenced by their understanding of how the data will be used to support maintenance decisions. Therefore, building buy in for the program among field personnel is an important step to ensure the success of the program.

Another issue discussed among the participants is improving both internal and external agency accountability. This chapter describes how several SHAs have used performance data to improve the performance of field personnel through accountability enhancement. These strategies range from reports of district or region performance to the inclusion of survey results in individual performance reviews. External communication issues are addressed in the next chapter (see page 60).

Building Buy in Among Field Personnel

It is not always easy to interest field personnel in providing the level of support necessary for a performance-based maintenance approach. Individuals may be resistant to change, especially if they believe that they know what does and does not work and where the priorities ought to be. Other common arguments against an MQA program include workload issues, with most field personnel expressing frustration with the amount of work that needs to be done and the limited resources available to do the work. As a result, it can be difficult to convince field personnel to take on the additional responsibilities that are needed if a performance-based approach is going to succeed.

Many different strategies are being used to build buy in among field personnel. One

approach is to involve the field personnel in the MQA surveys so that they will understand how the ratings are determined and can see what types of events constitute deficiencies. ODOT used this approach, beginning with its county managers. Once all of the county managers had participated in the surveys, the department expanded the program to include interested district personnel. The process helped fight the initial perception among field personnel that the MQA program was only being done for the central office. The department also promotes innovative practices that have been put in place and issues awards at the district level.

TxDOT builds buy in among field personnel through promoting the reasons why maintenance accountability is important. The department conducts presentations at regional meetings, where it focuses on the following reasons:

- Being accountable to taxpayers
- Justifying needs to the legislature and other decision makers
- Identifying opportunities for innovation to improve system conditions

In addition to promoting the reasons behind the program, TxDOT also emphasizes the benefits associated with the availability of this information. It stresses that the program allows field personnel to:

- Have a better understanding of the statewide performance expectations
- Compare their results with their peers and determine where improvements might be needed
- Better estimate the costs that will be needed to make the necessary improvements

TxDOT also reports that field personnel are further engaged through friendly competition between maintenance sections and by recognizing accomplishments at statewide maintenance conferences. The spirit of competition works effectively in Texas because the central office does the inspections, so that the numbers are consistent statewide. Although some participants thought that the competition would result in maintenance sections overshooting their targets, TxDOT has not experienced this because resources are limited, and overshooting in one area tends to bring down the numbers in another area.

Improving Performance Through Enhanced Accountability

Another strategy agencies have used to improve performance is to make individuals accountable for the results of their decisions. Depending on the extent to which MQA results are considered statistically representative of conditions at a statewide, district, region, or shop level, the information can be incorporated into employee evaluations and used to compare performance among peers.

ODOT is an example of an agency that includes its OPI in annual evaluations of county managers. The numbers are used primarily as a point of discussion rather than as a method of enforcement.

NCDOT realized a shift in attitude about its maintenance management program once it started incorporating accountability into the system. During the program's first four years, the field personnel did not feel connected to the maintenance management program and generally had the attitude that it was not relevant to their work. However, NCDOT made changes to the program in 2006 and introduced an infrastructure health index. It also introduced accountability measures at the executive level and now reports performance quarterly.

An example of one of the accountability measures is making the transportation network last longer. NCDOT has established specific condition targets for the road network to help achieve this goal, and considers this information in the annual evaluations of agency executives.

As the program expanded down the organization to other positions, the department made further changes to the system to accommodate the needs for individual accountability. For instance, it assigned different weights to performance factors based on an individual's position in the department. While an executive's evaluation may weight infrastructure health as 10% of the evaluation, the number might be much higher for those individuals with more direct responsibility for facility maintenance. Because of the success of the accountability measures at NCDOT, the program was expanded throughout the state government in 2008 and 2009.

Both NCDOT and MoDOT stressed the importance of holding people accountable as a key to changing the organizational culture to adopt and utilize performance-based systems. Until accountability was incorporated into their practices, these agencies reported that field personnel did not realize the connection between the data they were reporting and the decisions that were being made. However, once the methods of evaluating and comparing performance were initiated, the connections became better understood and more meaningful to the individuals in the field.

There was some discussion about the viability of using survey results to evaluate personnel performance. TxDOT does not use the information because it does not believe it has sufficient quantities of data to use it for that purpose, and it would be cost prohibitive to obtain enough data to have a sufficient confidence level. MoDOT disagreed with TxDOT's position, indicating that even partial surveys can be used to evaluate trends in the data.

KDOT takes a slightly different approach by asking managers to set a performance target that is higher than what was accomplished in the previous year. This encourages innovation without requiring field personnel to put too much emphasis on the numbers. TxDOT emphasized that if ratings are used in evaluations or if rewards or incentives are provided based on the ratings, it is especially important that independent individuals who do not have an affiliation with the districts or regions conduct the ratings.

Findings

The quality of the data reported by field personnel is strongly influenced by their understanding of how the data will be used to support maintenance decisions. This session focused on strategies that participating agencies have used to build buy in to help ensure the quality of the data reported in MMSs. The significant findings from those discussions are presented below.

- Many different strategies are used to build buy in among field personnel, including riding with raters, an approach ODOT uses; engaging employees through competition and recognition, as TxDOT employs; and holding employees accountable, as NCDOT employs. Legislation and reorganization have also had a positive impact on gaining acceptance in the NCDOT.
- Holding people accountable was a key to changing the culture in MoDOT and NCDOT. Other agencies report that educating staff about the way the data will be used can also be beneficial. KDOT reported that maintenance training benefitted the agency because maintenance priorities and practices were better understood.
- NYSDOT and UDOT indicated that if the number of samples inspected during the MQA program is not significant enough to report out by maintenance shed or smaller units, then it is easy for personnel to get the impression that MQA is a central office program and not useful for their purpose. This belief can impact the quality of the data field personnel enter.
- TxDOT found that it was better to have people who were not responsible for the maintenance of particular sections conduct the ratings for those sections, especially if the ratings are used in evaluations or if individuals are rewarded with incentives.
- Some, but not all, agencies resist using MQA results to evaluate personnel performance. Others, such as ODOT and NCDOT, use the results in individual performance assessments. Several agencies participating in the scan indicated that the ability to use MQA data for performance evaluations depends on how the program is structured. For example, KDOT uses MQA results to set performance targets for individuals, focusing on actions rather than on overall scores (e.g., increase the number of signs replaced from the previous year).
- The desire to report MQA results at a level other than statewide increases the number of samples that need to be inspected. For example, NCDOT reported that it had to collect 200 samples for statewide reporting, but approximately 23,000 samples if it wanted to report results at the county level.
- MQA programs do not drive policy; rather, they evaluate compliance with policy and the consequences of policies. WisDOT's training emphasizes this difference. NYSDOT has used graphs to illustrate the consequences of new policies this agency is considering.

5.0 Communicating Results

Background

One of the most common uses of performance data for maintenance and preservation of the highway system is to report results and establish accountability with both internal and external stakeholders. The presentation of results comes in a number of different formats, ranging from written reports and report cards to Web pages and dashboards.

The type of information being presented and the format used to present it typically depend on the audience. For example, high-level information is typically presented to the public, the state legislature, and to other outside organizations. For instance, WisDOT presents this group with information such as an executive summary of condition results and a performance dashboard. It also prepares a "highway operations story" that illustrates to the legislature what level of performance can be attained for different funding levels. This story is used every other year as part of the biennial needs assessment package. WisDOT also prepared a brochure on its Compass[17] program for distribution to the county engineers and to the individuals trained as raters so they get a better feel for the program itself. Each month the maintenance managers receive information that is more detailed so that they can make the decisions necessary in the field. An Internet site is also available for this group's use.

NYSDOT considers the results of its MQA surveys to be "targets of opportunity" that help engage field personnel in improving maintenance practices and establishing internal priorities. The information is also useful for communicating maintenance needs with elected officials, although representatives from the maintenance department are not typically the ones making those types of presentations.

This chapter presents some of the different formats that are being used to present information to field personnel, agency management, the public, and elected officials.

Printed Materials

Most of the agencies that participated in this scan prepare some type of written report to communicate the results of their MQA surveys. These reports are most commonly prepared annually; however, some agencies either update the information quarterly or are moving toward reporting the results more frequently. The reports often present a summary of the survey results when presented to the public, while field personnel typically receive information that is more detailed for use in maintenance budgeting and scheduling activities.

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[17] Wisconsin Safety Data Resource Portal, Compass program, http://wisconsinsafetydataportal.org/index.cfm/roadway/roadway-resources/compass/

A common approach to reporting maintenance conditions is to use a report card format, which presents letter grades ranging from A to F. As in a school report card, an A is the highest grade and F is the lowest. It is also common for agencies to present maintenance trends, reflecting changes in maintenance quality due to improved efficiencies, fluctuating budgets, and/or unplanned events (e.g., severe storms).

According to TxDOT, trends are the most important information to present to the legislature to illustrate that funding is not adequate to address all maintenance needs. TxDOT also presents trends to each of the individual districts so they can also see how conditions have changed with time. The district reports show trends for each individual component of the three maintenance categories (i.e., pavement, traffic operations, and roadside), as well as the overall scores for the elements within each category. The department also prepares a report based on information in its Project Tracker database[18] that shows progress toward six strategic, agency-wide goals. The maintenance activities are linked to the third goal, which relates to the maintenance of the system. That section of the Project Tracker report explains the MAP and what the recent performance results show. The report also documents how TxDOT is responding to the conditions and how it anticipates conditions will change with time.

Using pictures for reporting information to elected officials was fairly common among participants. For example, TxDOT presents photographs of conditions to the legislature but not to the public. ADOT pointed out that it is difficult for elected officials to understand the implications of condition changes from one numerical value to another. However, photographs and letter grades can more easily convey the message, as demonstrated in the WisDOT document *Highway Operations (see Figure 5.1).*

Figure 5.1 ***Excerpt from the Highway Operations document (source: WisDOT)***

[18] http://www.txdot.gov/project_information/project_tracker.htm

WisDOT reports the results of its MQA surveys each year in a Compass Annual Report, which documents the region and statewide ratings with letter grades A to F and shows a five-year backlog of trends in the data, as shown in Figure 5.2 and Figure 5.3. In addition, WisDOT reports summer maintenance targets, which reflect the percent backlog and LOS and price tags, which indicate the cost to improve the LOS for a particular feature.

Critical Safety Features

The roadway features considered critical for safety are those that require immediate action, with overtime pay if necessary, to remedy a problem situation.

Feature	2008	2007	2006	2005	2004	Element
Hazardous debris	C	C	D	D	D	Shoulders
Centerline markings	B	B	B	B	B	Traffic and safety devices
Regulatory/warning signs (emergency repair)	A	A	A	A	A	Traffic and safety devices
Drop-off/build-up (unpaved)	F	F	F	F	F	Shoulders

Figure 5.2 *Sample trend data in the 2008 Compass Annual Report[19] (source: WisDOT)*

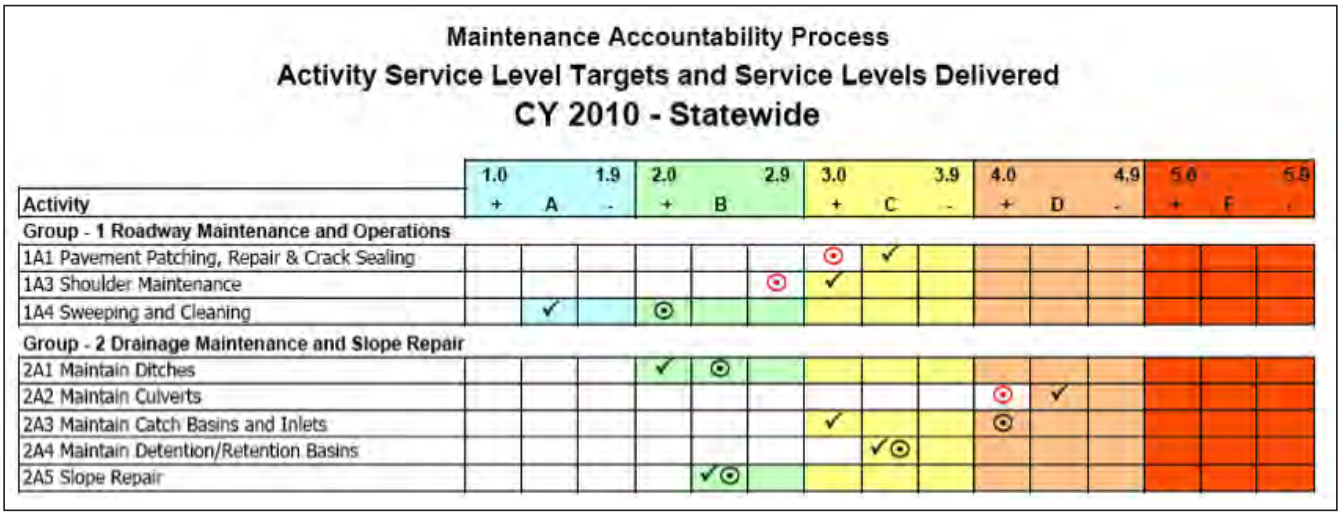
Element	What are we spending? Dollars spent (in millions)[1] FY 04	FY 05	FY 06	FY 07	FY 08	Feature	How much of the system still needs work at the end of the maintenance season? Condition change: 2007 to 2008[2]	% of system backlogged 2004	2005	2006	2007	2008	How well maintained is the system? 2008 Feature grades A	B	C	D	F
						Cross-slope (unpaved)	--	15	14	25	18	18		x			
						Drop-off/build-up (unpaved)	↓	37	36	40	40	44					x
						Erosion (unpaved)	↓	3	3	3	1	2	x				
Drainage	6.5	5.7	5.1	7.2	8.0	Culverts	↓↓	17	18	15	20	28			x		
	7.2	6.1	5.3	7.5	8.0	Curb & gutter	↑	6	7	8	8	5	x				
	0.21	0.18	0.16	0.23	0.26	Ditches	--	2	2	3	2	2	x				
	0.23	0.19	0.17	0.24	0.26	Flumes	↓↓	32	19	27	25	39				x	
						Storm sewer system	↓	9	9	9	11	16		x			
						Under-drains/edge-drains	↓↓	14	20	13	20	30			x		
Roadsides						Fences	↑	4	2	3	2	1	x				
						Litter	↓	70	62	64	60	61				x	
	19.4	20.2	21.9	24.0	19.4	Mowing	↓	40	35	39	36	42			x		
	21.5	21.7	22.7	24.9	19.4	Mowing for vision	↓	26	n/a	2	2	3	x				
	0.62	0.64	0.69	0.76	0.61	Noxious weeds	↓↓	30	29	34	29	38				x	
	0.69	0.69	0.72	0.79	0.61	Woody vegetation	↑	4	3	3	3	2	x				
						Woody veg. control for vision	↑	1	1	1	2	1	x				

Figure 5.3 *Sample condition and spending trends in the 2008 Compass Annual Report[20] (source: WisDOT)*

[19] Adams, T and E Juni, Compass 2008 Data Analysis and Reporting, National Center for Freight and Infrastructure Research and Education (U.S.), 2009, http://trid.trb.org/view.aspx?id=916376

[20] Adams, T and E Juni, Compass 2008 Data Analysis and Reporting, National Center for Freight and Infrastructure Research and Education (U.S.), 2009, http://trid.trb.org/view.aspx?id=916376

WSDOT also presents reports summarizing the results of its MAP. These reports are distributed quarterly to area and regional managers for review and are also presented to the legislature as part of the budget package. In addition, the department incorporates this information into a larger collection of agency-wide performance reports, such as *The Gray Notebook*[21]. *The Gray Notebook* is updated quarterly, with maintenance information reported annually, so the fourth quarter report each year reflects maintenance activities. Figure 5.4 is a sample of a portion of the WSDOT statewide summary, showing both current and targeted conditions. Figure 5.5 is an example from a report prepared by NCDOT for the North Carolina legislature, and a statewide summary report prepared by MSHA is presented in Figure 5.6.



Maintenance Accountability Process

Activity Service Level Targets and Service Levels Delivered

CY 2010 - Statewide

	1.0		1.9	2.0		2.9	3.0		3.9	4.0		4.9	5.0		5.9
Activity	+	A	-	+	B		+	C	-	+	D	-	+	F	-
Group - 1 Roadway Maintenance and Operations															
1A1 Pavement Patching, Repair & Crack Sealing							⊙	✓							
1A3 Shoulder Maintenance						⊙	✓								
1A4 Sweeping and Cleaning		✓		⊙											
Group - 2 Drainage Maintenance and Slope Repair															
2A1 Maintain Ditches				✓	⊙										
2A2 Maintain Culverts										⊙	✓				
2A3 Maintain Catch Basins and Inlets							✓			⊙					
2A4 Maintain Detention/Retention Basins								✓⊙							
2A5 Slope Repair					✓⊙										

Figure 5.4 ***Excerpt from a 2010 statewide summary of MAP conditions[22] (source: WisDOT)***

[21] *The Gray Notebook*, http://www.wsdot.wa.gov/Accountability/GrayNotebook/

[22] Maintenance Performance Measures, *http://www.wsdot.wa.gov/Maintenance/Accountability/default.htm*

2010 Report on the Condition of the State Highway System

Roadway			Interstate		Primary		Secondary	
			2010	State Average	2010	State Average	2010	State Average
	ELEMENT	PERFORMANCE MEASURE	Target	Score	Target	Score	Target	Score
DRAINAGE	Unpaved Shoulders	No dropoffs greater than 3 inches and no shoulders higher than 2 inches	95	91	90	89	85	91
DRAINAGE	Ditches (Lateral Ditches)	No blocked, eroded, or nonfunctioning ditches	95	98	90	94	85	94
DRAINAGE	Crossline Pipe (Blocked)	Greater than 50% diameter open	95	87	90	78	85	74
DRAINAGE	Crossline Pipe (Damaged)	No damage or structural deficiency effecting functionality	95	93	90	95	85	91
DRAINAGE	Curb & Gutter (Blocked)	No obstruction greater than 2 inches for 2 feet	95	97	90	96	85	96
DRAINAGE	Boxes (Blocked or Damaged)	Grates and outlet pipes of boxes blocked <50%. Inlets and outlets of boxes are not damaged, and grates are present and not broken.	95	82	90	87	85	85
ROADSIDE	Vegetation (Brush & Tree)	Freeways: 45' from travelway, 5' behind guardrail, not blocking signs; Non-Freeways: Vertical clearance of 15' over roadway and 10' back of ditch centerline or shoulder point	90	90	85	85	80	80
ROADSIDE	Vegetation (Turf Condition)	Areas free of erosion	95	84	90	83	85	86
ROADSIDE	Stormwater Devices (NPDES)	Functioning as designed	90	94	90	94	90	94
ROADSIDE	Landscape Plant Beds	Achieving a score of 2 or higher on the inspection form	90	90	80	90	N/A	N/A
ROADSIDE	Rest Areas & Welcome Centers	Condition Rating of 90	90	96	90	95	N/A	N/A
TRAFFIC	Long Line Pavement Markings	Present, visible	90	93	85	90	80	81
TRAFFIC	Words and Symbols	Present, visible	90	73	85	85	80	77
TRAFFIC	Pavement Markers	Present and reflective	90	84	85	59	N/A	N/A
TRAFFIC	Ground Mounted Signs	Visible and legible	90	94	85	91	85	85
TRAFFIC	Overhead Signs	Visible and legible	92	93	85	80	85	100
BRIDGE	NBIS Culverts	Condition Rating >= 6	85	86	85	86	85	89
BRIDGE	Non-NBIS Culverts	Condition Rating = Good	80	84	80	74	80	56
BRIDGE	Overhead Sign Structures	Condition Rating = Good	95	95	95	93	95	88
	Totals		**91.27**	**89.79**	**87.28**	**86.04**	**84.49**	**85.04**

Red – More than 10% below the target; Yellow – Within 10% of the target, Green – Met or exceeded target; Gray – Element was not rated

Figure 5.5 ***2010 Report on the Condition of the State Highway System[23] (source: NCDOT)***

[23] 2010 Report on the Condition of the State Highway System, NCDOT, Raleigh, NC, 2010, http://www.ncdot.gov/programs/srmu/download/MCAP_Report_2010.pdf

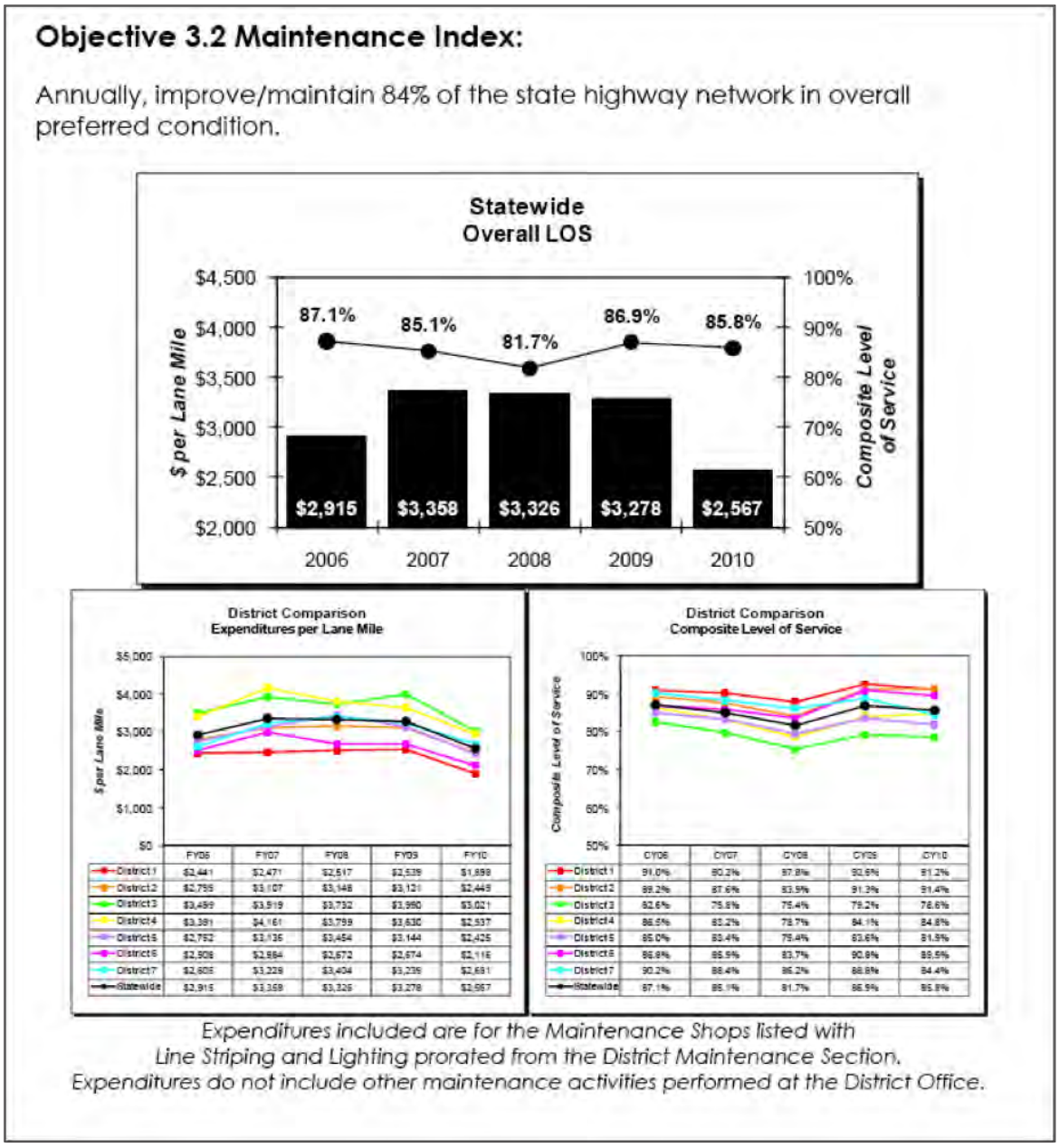


Figure 5.6 ***Sample Quarterly Report[24] (2011) (source: MSHA)***

As shown in Figure 5.7, MnDOT also prepares a performance report that documents the department's goals and its progress toward meeting those goals. The example provided illustrates the department's customer satisfaction goals, its progress toward meeting those goals, and the steps that are being taken to further the department's progress. The performance report also provides a brief summary of the decision process MnDOT uses to select projects.

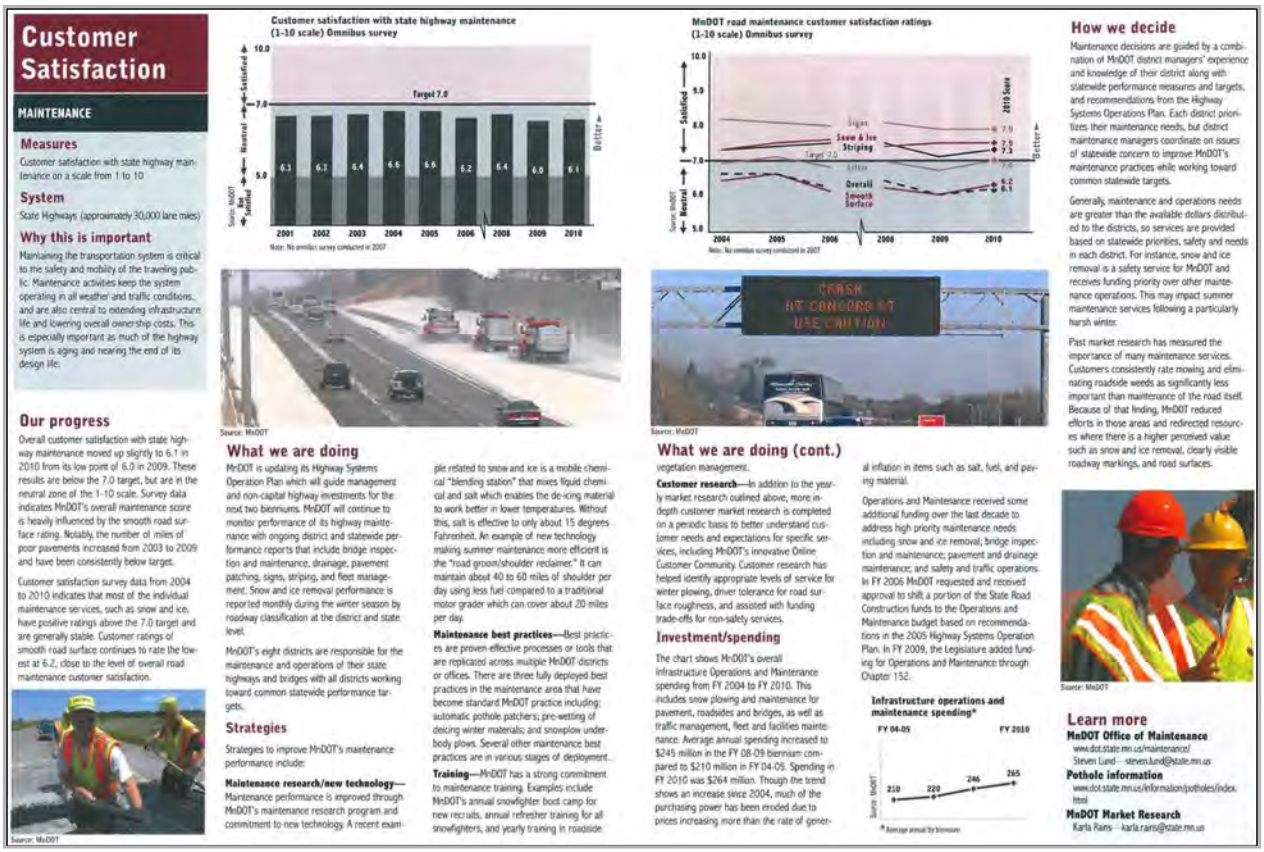


Figure 5.7 ***Excerpt from the MnDOT Performance Report[24] (source: MnDOT)***

NYSDOT prepares a maintenance and operations plan that compiles the planned investment and accomplishments for both in-house forces and contractor forces for the upcoming year. The name of the document was recently changed to *Comprehensive Program Summary* to better reflect the consideration of maintenance in the five-year capital plan. The graphs in the summary show the investment made by all maintenance efforts (both state and contractor forces) and the amount that should be spent to meet the full need.

MoDOT meets with its regions quarterly to share results and communicate program priorities. The meetings also provide a forum for sharing information from regions that have met or exceeded goals so that underperforming regions can improve their performance.

WSDOT indicated that results have allowed it to communicate with field personnel how activities might be done differently. For example, many of the regions were striping roads annually; however, performance data were used to show that some products, under specific conditions, could last longer than a year. Therefore, the data could drive a cultural shift in the way maintenance activities are being conducted.

[24] Annual Minnesota Transportation Performance Report, http://www.dot.state.mn.us/measures/pdf/2010pm10-6.pdf

Online Materials

NCDOT introduced the use of dashboards[25] to state government. It uses both public-facing and private-facing dashboards to display relevant information to each stakeholder group. For example, the private-facing dashboards monitor the five agency-wide goals. The department is moving toward reporting progress quarterly; it is also beginning to solicit the public to provide feedback on the public-facing dashboards. NCDOT views its dashboards as an important tool to drive innovation and to improve organizational transparency. Figure 5.8 is a screenshot from the Infrastructure Health dashboard[26].

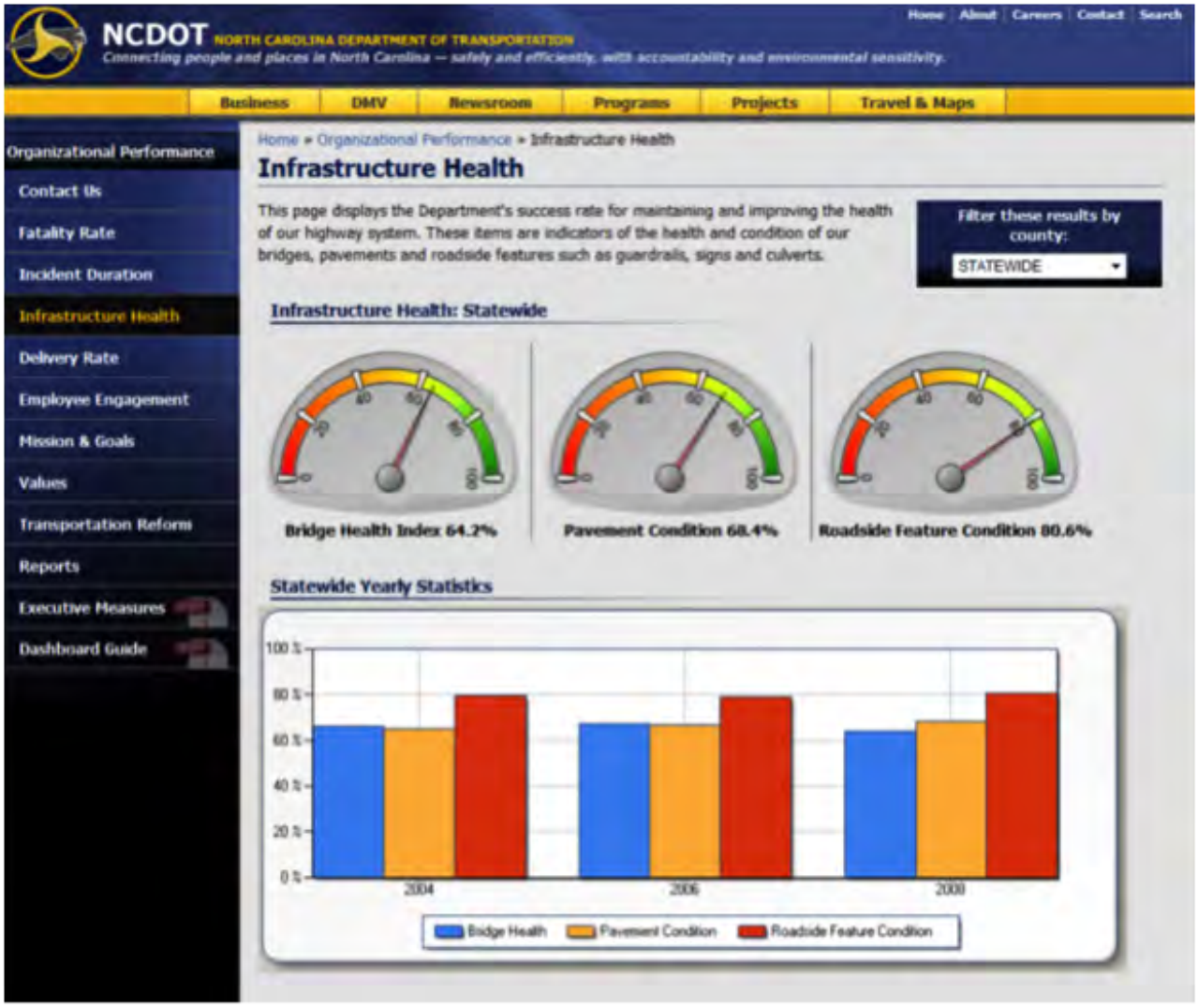


Figure 5.8 *NCDOT performance dashboard (source: NCDOT)*

[25] Organizational Performance, https://apps.dot.state.nc.us/dot/dashboard/

[26] Infrastructure Health, https://apps.dot.state.nc.us/dot/dashboard/InfrastructureHealth.aspx

WSDOT provides a public Web site on maintenance performance measures. It describes the department's MAP program and includes information about MAP targets, how data are collected, results from customer surveys, and so on. It also includes service level reports. Figure 5.9 is a screenshot of the Maintenance Performance Measures page[27] of the Maintenance Operations home page[28].

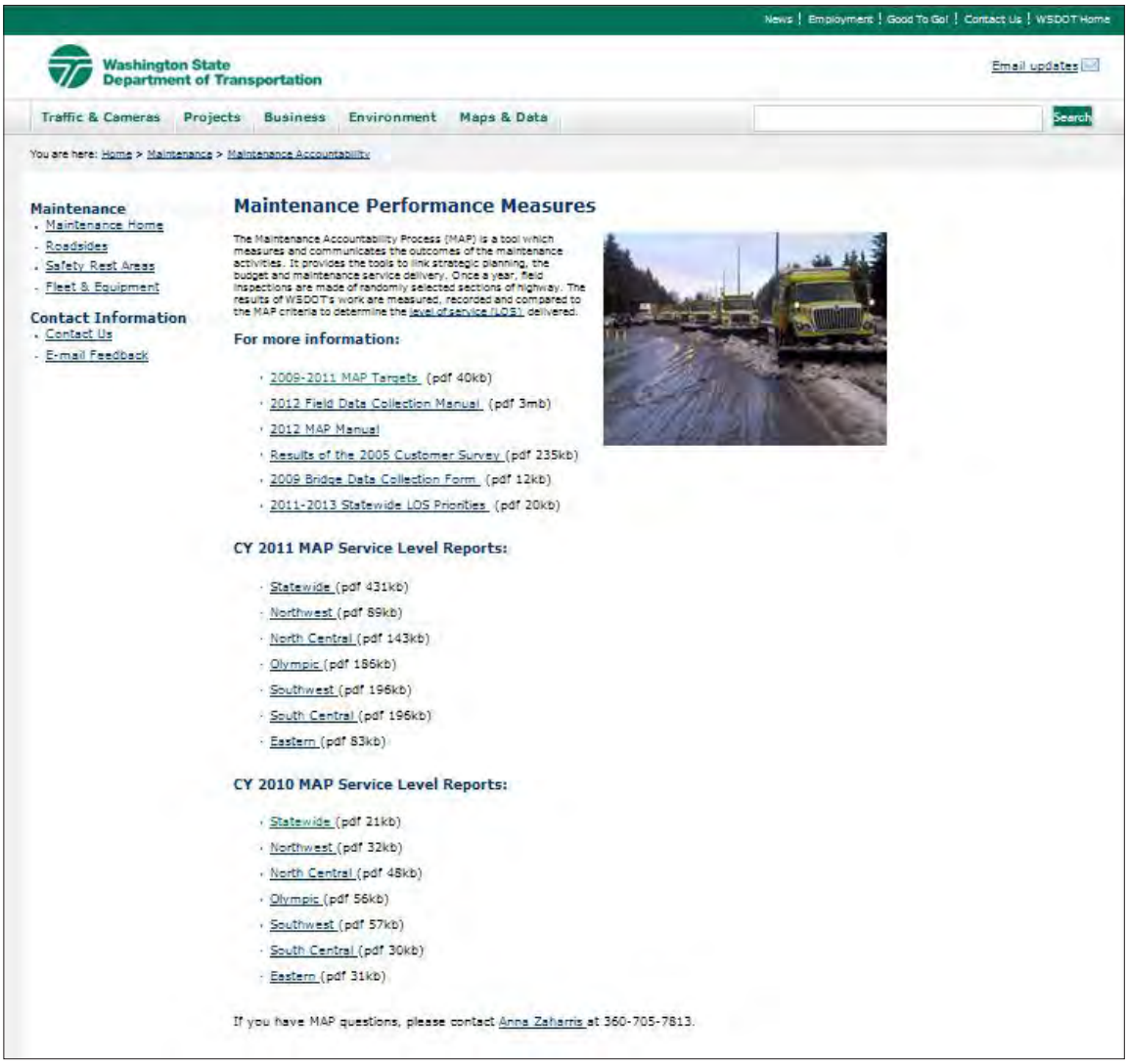


Figure 5.9 ***WSDOT MAP public website (source: WSDOT)***

MnDOT has taken online communication to another level with its Mn/DOT Talk Web page. This page, which is shown in Figure 5.10, provides an online method of reaching out to select stakeholders, surveying their habits, and providing a discussion forum. New surveys and discussions are added to the site each week. The site is not open to the public.

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[27] Maintenance Performance Measures, www.wsdot.wa.gov/maintenance/accountability/default.htm

[28] Maintenance Operations Home, http://www.wsdot.wa.gov/Maintenance/

Figure 5.10 *Mn/DOT Talk home page (source: MnDOT)*

Emerging Technology

Throughout the discussions on presenting results, several agencies identified innovations or new technology that impacted their ability to use and report results. Some of the key issues that emerged from the discussions are listed below.

- Data integration is very important to the success of an MQA program. Geographic information systems (GISs) are becoming the most common way of integrating data. Even though TxDOT still uses reference markers, the existing management system can convert data so it can be reported in the GIS.
- In general, agencies that want to conduct ad hoc queries of data currently require that individuals have the skills necessary to develop the queries. Participants indicated that it would be helpful to have software tools that enable more automatic data analysis without relying on individuals to create the queries.
- The creation of data warehouses is a very time-consuming activity requiring strong IT support. However, efforts to increase the accessibility of data within a DOT are generally beneficial.
- There is a need to better leverage maintenance data with other internal and external users.
- Graphics are a helpful way to make visible, meaningful connections to the data.

Findings

While agencies are using many different approaches to present maintenance conditions and needs, several consistent findings emerged from the discussions. Some of the key findings from these sessions are provided below.

- Maintenance has traditionally been behind other modes of transportation in "telling its story." Scan participants have found that MQA programs have enabled maintenance to communicate needs and trends better, while also improving accountability and decision-making.
- Maintenance personnel do not always understand the need for MQA programs. However, by promoting these tools as methods of communicating needs, agencies can begin to establish buy in from these groups.
- Agencies that do not have legislated programs or strong executive support have used MQA data as "targets of opportunity." In other words, they look for opportunities to show how the data can be used.
- Maintenance serves a large number of stakeholders, and each has different interests and different levels of knowledge. To be most effective, messages must be tailored to each group.
- MQA results typically are reported annually. WSDOT's *The Gray Notebook*, for example, is a department-wide report that is produced quarterly; however, the maintenance measures are only reported once each year, in the fourth quarter report.
- Trends sometimes show a lot of variability in the data, so TxDOT uses two-year averages in the data to smooth out these trends.
- One way to establish buy in to the program is the ability to link results to the reasons behind the trends. For example, a NYSDOT gap analysis shows that the largest gap in funding occurs at the level just before assets fail due to the amount of deferred maintenance.
- Until a program is institutionalized into the decision process, there is a strong reliance on champions. The program may be vulnerable if the champion is promoted or leaves the department.
- There are opportunities to institutionalize MQA programs in agencies that are establishing comprehensive asset-management programs.
- There is a need to speed up the application of new technology in DOTs.

6.0 Key Findings

Based on the information presented during the scan in each of the topic areas, several significant conclusions can be made. These findings represent the current state of the practice in the use of performance measurement for highway maintenance and preservation activities.

- Performance-based data (e.g., the inputs to MQA programs) provide the foundation for assessing maintenance needs and for reporting results in all of the participating agencies. Several of the participating agencies have successfully used their MQA results to secure additional funds and to improve communication with both internal and external stakeholders.
- The most successful agencies have established organizational cultures that support the use of performance data to drive maintenance and preservation decisions. Some of the participating agencies have been able to change their organizational cultures by holding people accountable for the decisions they make. Other agencies have used training programs effectively to help change the culture in support of performance-based programs and to build buy in among field personnel.
- No single approach represents best practice in the use of performance-based data for highway maintenance and preservation. In practice, the intended use of the data drives the system requirements and the amount of data needed.
- The quality of the data used in performance-based decision-making is critically important. Therefore, the agencies represented by the scan participants have developed strong QA programs to help ensure the data's reliability and completeness.
- Technology has had a significant impact on the efficiency with which data can be collected, integrated with other programs, analyzed, and reported. SCDOT, for example, reported that it doubled the productivity of its surveys and improved data accuracy by incorporating innovations into the data-collection process. In a pilot study, UDOT found that data could be collected using semi-automated or manual means and handheld devices as quickly and as accurately as with automated data-collection vans, demonstrating that data can be collected very cost-effectively.
- Most of the scan participants combine their MQA results into a single statewide maintenance score with weights to reflect their agency's priorities.
- Some standardization in commonly used performance measures would facilitate the exchange of information among agencies and simplify the startup activities in agencies that are just beginning to build their performance-based programs. The

availability of guidelines and training in this area would benefit the industry.

- The cost of collecting data for MQA programs is insignificant when compared to the impact the results can have on maintenance budgets. UDOT, for example, spends less than 1% of its maintenance budget on these activities, even while performing a 100% survey for most items each year.
- It is important that links be established between the performance data and budget changes. For instance, changes in budgets or standards should have a corresponding change in the LOS that can be achieved. This link establishes a connection between the performance data and agency decisions that is important for building buy in and justifying maintenance expenditures.
- Additional efforts are needed to improve the methods used to report the results of performance-based programs to both internal and external stakeholders. Most of the participating agencies would welcome guidance on more-effective strategies for reporting needs that will resonate with politicians.

7.0 Recommendations

The scan team developed recommendations for each of the topic areas explored during the scan. The team organized the recommendations into six activities that will promote and facilitate the use of a performance-based, customer-oriented approach for estimating maintenance needs and budgets, communicating with various stakeholder groups, improving the transparency of maintenance activities, and allocating resources effectively. The team also identified suggested actions within each of the six activity areas. The six activities and the action items include the following:

- **Measure**—Recognizing the national trend toward performance measures, initiate and lead activities that identify common performance measures that align with and contribute to high-level goals, such as safety and pavement/bridge condition
  - Elevate the importance of maintenance by establishing a link to the agency's asset-management framework and strategic performance measures
  - Charge the AASHTO Subcommittee on Maintenance (SCOM) with identifying commonly used performance measures in the areas of safety, asset preservation, environment, and mobility to support the development of national performance measures that "measure what matters"
- **Report**—Identify communication and analysis tools that enable maintenance agencies to better "tell their stories" and move the industry towards an open-architecture platform
  - Conduct a study to evaluate the impact of maintenance performance measures on national strategic goals
  - Develop methods of using technology and innovation to produce timely and actionable data or reports
  - Promote mechanisms for sharing technology that establish stronger collaborations between industry and the maintenance community and accelerate the application of technology in transportation agencies.
  - Initiate research to develop deterioration models and/or life-cycle models for key maintenance assets, and identify reciprocal relationships between capital investments (for preservation and expansion) and maintenance requirements
- **Improve**—Develop strategies that improve the quality of data used for performance-based maintenance programs, including strategies that accelerate the use of new technology and innovation

- Document the benefits of MQA data-collection activities to support the agency's maintenance, preservation, and asset-management needs
- Charge the SCOM with developing guidelines for data collection at various levels of sampling to ensure the statistical validity of the data and to evaluate under-represented assets appropriately
- Given that performance-based contracting for maintenance is becoming more widely used, develop the means to use MQA tools to manage such contracts and help compare the costs of contract forces to the costs to achieve the same LOS using in-house forces

- **Train**—Develop and conduct training programs to support performance-based maintenance programs
  - Review existing training programs and needs, assess gaps between the two, and support the development of new or modified training initiatives to address those gaps
  - Encourage federal support for sponsoring training and technology-transfer activities to promote performance-based maintenance programs
- **Share**—Develop a sustainable mechanism for sharing performance-based maintenance practices and experiences in SHAs
  - Update and maintain the MQA Web site maintained by the Midwest Regional University Transportation Center at the University of Wisconsin[29]
  - Develop guidelines illustrating how agencies can use MQA data to improve performance, support budgeting activities, build buy in, and hold people accountable
- **Promote**—Actively promote the use of performance-based maintenance programs among SHAs and develop strategies to increase the number of agencies using these programs
  - Promote the best practices from this scan to SHAs and other transportation agencies and the transportation industry in general
  - Document the contribution of performance-based programs to support the agency's asset management and pavement preservation programs and demonstrate how agencies have successfully built collaborative programs
  - Disseminate the results of current NCHRP research on promoting the benefits of maintenance
  - Develop marketing material that agencies can use to promote and sustain the use of performance-based programs to decision makers

[29] http://www.wistrans.org/mrutc/events/maintenance-quality-assurance/

8.0 Implementation Strategy

The scan team also developed an implementation plan that will help promote the findings and advance the recommendations from the scan. The plan includes the following types of activities.

- **Advance findings and best practices**—The advancement of the scan findings will be accomplished through the following activities:
  - **Update the MQA Web site**—The MQA Web site, maintained by the University of Wisconsin, has not been updated since 2009, and the University is moving the site to a new platform. The scan team recommends that the site be updated with current information provided by scan participants and that the functionality of the site be improved to facilitate searches and other types of inquiries by practitioners.
  - **Conduct a series of webinars on best practices**—With support from the FHWA, the scan team intends to organize a minimum of two webinars during the 2012 calendar year to promote the scan's findings and recommendations.
  - **Present findings at technical meetings and conferences**—A number of technical meetings and conferences are coming up at which the results of this scan can be presented. Individual members of the scan team were assigned responsibility for presenting the scan results at the Annual Meeting of the Transportation Research Board, various AASHTO meetings, the Maintenance Management Conference, the Transportation Asset Management Conference, the National Conference on Pavement Preservation, and the National Pavement Management Conference. Some funding to support travel to these events will be provided using project funds.
- **Support the implementation of recommendations through AASHTO and FHWA**—One of the most important ways to advance the recommendations from the scan is to promote the research and technology transfer initiatives through AASHTO and the FHWA. Therefore, scan team members were assigned to work with various AASHTO committees and subcommittees. These efforts will help build support for the recommendations with AASHTO leadership and will promote research needs with the Standing Committees on Highways and Research.
  - **Develop plans for a technology exchange in 2013 or 2014 that demonstrates the use of technology and promotes a peer exchange**—The

scan team intends to promote the conduct of a peer exchange that encourages the use of technology in support of MQA programs and that further supports the sharing of practices among state maintenance personnel. The team will request funding support from FHWA and other industry partners and will seek the support of the AASHTO Subcommittee on Maintenance.

- **Investigate the development of common performance measures for preservation, environment, mobility, and safety through the AASHTO Subcommittee on Maintenance**—Indications are that future legislation may include national performance targets for highway preservation, environment, mobility, and safety. In anticipation of this, the scan team is interested in initiating discussion with members of the AASHTO Subcommittee on Maintenance to determine the consistency of performance measures currently being used for reporting maintenance conditions in these areas.
- **Initiate evaluation of available training programs and needs and develop training to address gaps**—Although a number of training programs are available to assist agencies as they move forward with the development and implementation of performance-based maintenance programs, the options are not well known and gaps in coverage exist. Therefore, FHWA will be asked to summarize the training currently available and identify any training gaps so that high-priority training needs can be addressed.

Appendix A:
Amplifying Questions

General Information About the Agency

(Please provide this information PRIOR to the start of the domestic scan. It will be compiled into a book that is distributed to participants in advance.)

1. Please provide a brief overview of your organization, including the following:
    a. The number of total miles in your network
    b. The number of districts, divisions, or regions
    c. The type of decision process that exists (e.g., centralized, decentralized, or mixed)
    d. Funding levels available for maintaining and improving the highway network
2. Please provide the following information about your Maintenance Quality Assurance (MQA) program:
    a. Description of the MQA program (purpose and history)
    b. Program status
        i. How long has your program been active?
        ii. What motivated your agency to develop your program?
        iii. Who was involved in the process and how long did it take?
        iv. What have been recent changes to your MQA program?
        v. How do you review and enhance the MQA program?
    c. Program measures
        i. How were the measures selected?
        ii. How was a rating system for the measures developed?
        iii. Is your rating system a pass/fail (P/F) method or a level of service (LOS) approach?
    d. Categories and features included
    Is your MQA program equally strong for each of the following asset categories?
        i. Drainage structures (e.g., culverts, ditches, drop inlets)
        ii. Roadside (e.g., fence, grass, litter)
        iii. Pavement (e.g., paved shoulders, paved travel lanes)
        iv. Bridges and other structures
        v. Traffic (e.g., signs, pavement markers, impact attenuators)
        vi. Special facilities (e.g., rest areas, tunnels)

e. Data-collection processes

   i. Frequency?

   ii. 100% or sampling? If sampling is used, what size samples?

   iii. How do you determine the number of samples to inspect?

   iv. How much time and money are spent on the data-collection process?

   v. How do you ensure consistency in the ratings on a statewide basis?

f. Software
   Are you using a computerized maintenance management system (MMS)? Was it purchased (licensed) or developed in-house?

g. MQA reporting

   i. Who are your customers for reports?

   ii. How do you report?

   iii. What information do you report?

h. Budgeting
   How do you relate MQA information to the budget?

3. Does your agency have a formal preservation program in place? If so, is the program administered by Maintenance and Operations or by some other group within the DOT?

4. What maintenance and operations activities are performed by in-house crews and what work is outsourced?

Note: The information you provide in response to this request may be useful for updating the MQA website maintained by the University of Wisconsin. You can access the website at www.mrutc.org/outreach/MQA.

Amplifying Questions to Be Discussed During the Meetings

The meeting will include several structured sessions in which a particular aspect of maintenance performance measuring will be discussed. During each of these structured sessions, three to four agencies will be asked to provide a 15-minute presentation on the topic area. Following the presentations, a facilitated discussion will take place, using questions submitted by the audience.

In addition to the structured sessions, an open session will be scheduled on the last day to discuss selected topics. During the open session, specific questions will be asked to help initiate discussion among all participants on key topics.

The draft schedule for the meetings and the state agencies that will participate as panel

members for each session are shown in the following table.

	Day 1	Day 2	Day 3
Morning Sessions	Opening Session	Session 4 – Use of MQA Data for Maintenance Budgeting & Resource Allocations **Arizona, Kentucky, South Carolina, Washington State**	Session 7 – Presenting & Selling Results **Texas, Wisconsin, Washington State**
	Session 1 – Advantages & Disadvantages to Pass/ Fail and LOS Approaches **Florida, New York, Wisconsin**		Open Session
	Lunch	Lunch	Lunch
Afternoon Sessions	Session 2 – Impact of Agency Approach to Sampling on Quality, Cost, and Use of Data **Iowa, North Carolina, Utah**	Session 5 – Linking Customer Expectations With Performance Targets **Kansas, Missouri, Minnesota**	Open Session (continued)
	Session 3 – Use of Innovations in Data Collection **North Carolina, Ohio, Virginia**	Session 6 – Strategies for Building Buy in and Accountability Among Field Personnel **Maryland, North Carolina, Ohio, Texas**	
			Wrap-Up and Closing Session

The types of questions that should be incorporated into the presentations by the panel members are listed in this document. The questions are organized by session.

Advantages and Disadvantages of Pass/Fail and LOS Approaches

1. Does your agency use a P/F or LOS approach as part of your MQA program? Why was that approach selected?
2. Has your agency changed its approach to data collection over the years? If so, what changes were made and why? What have been the results of those changes?
3. What do you think are the biggest advantages and disadvantages to the approach used by your agency?
4. Are there any limitations to what you can do with the information you have available that are caused by the methodology your agency selected?
5. What factors would cause you to change from the approach you currently use to another approach? For instance, if you're using a P/F approach, what would convince you to change to an LOS approach?
6. Would you advise an agency just getting started with an MQA program to adopt your methodology? Why or why not?

Impact of Agency Approach to Sampling on Quality, Cost, and Use of Data

1. Does your agency use windshield surveys or do inspectors get out of their vehicle? If you do windshield surveys, how do you inspect assets that are difficult to see from the road, such as pipes?
2. How did your agency decide whether to use a sampling approach or not? What considerations were taken into account in making the decision? If given the opportunity, would you change your approach now?

If your agency does not do sampling, answer questions 3 through 5. If your agency uses a sampling approach, answer questions 6 through 10.
Questions for agencies that do NOT sample:

3. What advantages does your agency realize by inspecting 100% of your network? For instance, can you do more with the data than agencies that use a sampling approach? Does the quality of the data, or your confidence in the data, differ?
4. How has your agency addressed the trade-offs between the resources needed for a high degree of confidence in the data and the cost of collecting that data?
5. As agency budgets tighten, do you anticipate any changes in the amount of data you'll be able to collect? How will you address this issue if it arises?

Questions for agencies that DO sample:

6. How did your agency determine the number of samples to collect as part of the MQA surveys?
7. How do you account for inspection units that do not include all assets? For example, if the sample does not include guardrail, how do you handle this?
8. Do you feel the number of samples currently being inspected is representative of statewide conditions? Why or why not?
9. How has your agency addressed the trade-offs between the number of samples needed for a high degree of confidence in the data and the cost of collecting that data?
10. As agency budgets tighten, do you anticipate any changes in the number of samples you will inspect? How will you address this issue if it arises?

Use of Innovations in Data Collection

1. How has your agency incorporated new technology into the MQA program? What have you done and how has it been used?
2. Have there been any unexpected benefits or consequences associated with the changes in technology? What are they and how have they been addressed?

3. How have you addressed the training needs of agency personnel so they can fully utilize the new technology?
4. Have you had to justify investments in new technology to support your program? If so, how have you approached this issue?
5. Did your agency encounter any IT issues associated with the new technology? If so, what were the issues and how were they addressed?
6. What innovations do you anticipate using in the future?

Use of MQA Data for Maintenance Budgeting and Resource Allocations

1. How does your agency use MQA results for the following purposes:
    a. Setting budgets
    b. Documenting performance trends in the data
    c. Allocating resources
    d. Justifying needs
2. Do you have a computerized MMS in place? If so, how does your agency use the software to allocated maintenance resources?
3. How has your agency established links between the performance targets and the resources needed to provide that LOS?
4. Have you had to justify the expenditures for your MQA program? How have you (or would you) approach this issue?
5. How did your agency establish the prediction models that are used to forecast conditions under different budget scenarios?
6. What degree of confidence do you have in the cost data used for performance-based budgeting activities? What steps has your agency taken to improve the degree of confidence in this information?
7. How do you link the work conducted in the field with the corresponding impact on the agency's performance measures? For instance, do efforts to repair guardrail reflect on the agency's safety measures?
8. In your opinion, do the agency's performance measures adequately monitor the right maintenance and operations activities? If not, what changes would you recommend?
9. How do you determine the success of your agency's maintenance and operations program?
10. What adjustments do you have to make to account for changes in outcomes when you have natural disasters or other emergencies?
11. Has your program survived intact, even with changes in agency administration? Why or why not?

Linking Customer Expectations with Performance Targets

1. How did your agency make the transition from measuring outputs to outcomes?
2. How do you obtain feedback on performance expectations from various stakeholder groups (e.g., surveys, focus groups)?
3. How much of an influence do customer expectations have on your agency's performance targets?
4. How do you calibrate your performance measures based on public expectations?
5. How does your agency use MQA results to monitor customer satisfaction?

Strategies for Building Buy in and Accountability Among Field Personnel

1. How did your agency establish buy in for the program with field personnel?
2. How do you engage maintenance workers in addressing activities that are important to the agency's strategic initiatives?
3. Have you linked MQA results to individual performance evaluations? If so, what has been your experience?
4. What programs have you established to recognize the "best maintenance practices" within your agency?

Presenting and "Selling" Results

1. How did your agency establish buy in for the program with upper management and elected officials? How much time did it take?
2. How does your agency present the MQA results to senior management, elected officials, and the public? How important has this information been in establishing credibility with these stakeholder groups?
3. Do elected officials understand the differences between LOS levels sufficiently to recognize the funding requirements at each level? If so, how have you conveyed the information in a way that resonates with them?
4. What are the most significant benefits your agency has realized as a result of your MQA program?
5. How did your agency move from using MQA results for tracking, budgeting, and resource allocation decisions to using the information to influence decisions at a higher level within the organization? For instance, has your agency successfully used the MQA information to increase or defend the funding allocations for the maintenance and operations program? How were you able to do this?
6. What were the key components to your agency's success in performance-based management? What are the biggest factors limiting your success?

7. What advice would you offer to an agency just getting started in developing an MQA program?

Open Session Questions

1. Do agencies need MMS software to allocate maintenance resources? If so, how could (or has) the software been used for this purpose?
2. How does your MQA program influence your agency's preservation program? Are maintenance activities coordinated with preservation activities?
3. How does your agency determine trade-offs between maintenance and capital? How do you share or link data to do this?
4. How can agencies compare (or benchmark) their performance?
5. How do you tie your MQA program to your agency's asset-management activities?
6. What is the expected role of MQA programs in future legislation?
7. What technical issues must be addressed to benefit your MQA program in the future?

Appendix B:
Scan Team Contact Information

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Appendix C:
Scan Team Biographical Sketches

RUSS A. YUREK (AASHTO Chair) has had a distinguished 34-year career with the Maryland State Highway Administration (SHA). He began his a career as a maintenance worker and worked various levels within a maintenance shop. He was the resident maintenance engineer for Harford County, the assistant district engineer of Maintenance for the Baltimore Metropolitan District, and has been the director of the Office of Maintenance for past 14 years. Yurek also chaired the Maintenance Management System Task Force and was the vice-chair of the Sub-Committee of Maintenance for AASHTO. He is currently Maryland's delegate for the AASHTO Subcommittee of Maintenance. Yurek has led multiple teams that have been recognized at the state and national levels, including AASHTO Pathfinder Awards for the Rest Area and Peer Review Teams; AASHTO Trailblazer Award, Maintenance Activity Guidelines Team; SHA Quality Conference Team of the Year Award, Rest Area Team; and SHA Quality Conference Customer Award, Rest Area Team.

NANCY ALBRIGHT is the director of the Division of Maintenance of the Kentucky Transportation Cabinet. In this role, she oversees the day-to-day operations of the division, manages the maintenance budget for the cabinet, develops and applies maintenance policies, and ensures coordination with other divisions within the cabinet and with external agencies. Before coming to maintenance in 2000, she worked in other areas of the cabinet, including the Division of Planning, developing long-term corridor development plans; the Division of Traffic Operations, developing the cabinet's Intelligent Transportation System; and the Division of Program Management, assisting in the development of the Six-Year Highway Plan. Albright received bachelor's and master's degrees in civil engineering from the University of Kentucky and is a licensed professional engineer in Kentucky.

JENNIFER BRANDENBURG is the state road maintenance engineer for the North Carolina Department of Transportation (NCDOT). In this position, she is responsible for monitoring the performance of the department's maintenance program through the setting and measuring of maintenance and operations performance measures. This role includes the administration of the department's Maintenance Management System and Maintenance Condition Assessment Program. In her 24 years with NCDOT, she has held various maintenance and construction positions monitoring both contractor and employee performance and communicating results to senior management, legislators, and the traveling public. In addition to various national research committees, Brandenburg currently serves on the AASHTO Subcommittee on Maintenance as vice-chair of the Pavements Technical Work Group. She is the past chair of the Performance Measures Focus Group, which coordinates the Maintenance Quality Assurance document library Web site for benchmarking of common maintenance measures. Brandenburg is a graduate of North Carolina State University with a bachelor's degree in civil engineering and is a licensed professional engineer in North Carolina.

MATT HAUBRICH currently serves as asset manager and performance measurement administrator in the Office of Maintenance for the Iowa Department of Transportation (Iowa DOT). Haubrich administers the Maintenance Quality Assurance (MQA) program for the Iowa DOT, coordinating the annual collection and reporting on maintenance quality for more than 5,500 sample road segments representing Iowa's 24,000+ lane-mile primary road network. He is also tasked with supporting and growing the DOT's nascent asset-management efforts. Haubrich has been with the Iowa DOT since May 2010 and has served in various other roles in Iowa government, most recently as bureau chief for Research and Statistics at the Department of Human Services. He has more than 15 years of experience in performance measurement, survey research, and statistical analysis. Haubrich holds a bachelor's degree in statistics and a master's degree in business administration from Iowa State University and is a certified public manager.

LONNIE HENDRIX is the assistant state engineer for Maintenance for the Arizona Department of Transportation (ADOT). His group is responsible for oversight of the state's highway maintenance program, including budget, policy, contracting, permits, maintenance management, and emergency management. He assisted in the development of ADOT's level-of-service and performance-based budgeting system. Hendrix has served in his current position for seven years and in highway maintenance for more than 14 years. He has been an active member of the AASHTO Subcommittee on Maintenance and TRB Committee AHD10 on Maintenance and Operations Management for more than 10 years. Hendrix is a graduate of the U.S. Air Force Academy with a bachelor's degree in civil engineering and holds a master's degree in civil engineering from Arizona State University. He is a licensed professional engineer in Arizona.

DON HILLIS is the director of system management for the Missouri Department of Transportation (MoDOT). In this position, he directs the statewide efforts for the Divisions of Maintenance, Highway Safety, Traffic, and Motor Carrier Services from MoDOT's central office in Jefferson City. He has served in his current position for 10 years. Prior to that, Hillis served as state maintenance engineer and transportation planning director, and assistant district engineer in the Northwest District in St. Joseph. He was involved in the development of MoDOT's maintenance performance indicators and the department's Tracker performance measuring tool. He began his career with MoDOT in 1984 after graduating from the University of Missouri–Rolla with a bachelor's degree in civil engineering. He is a registered professional engineer in Missouri and a member of the AASHTO Subcommittee on Maintenance.

LUIS M. RODRIGUEZ is a senior pavement and materials engineer and team leader of the Federal Highway Administration (FHWA) Resource Center–Pavement & Materials Technical Service Team. He provides technical assistant to state and local highway agencies and FHWA field offices in the areas of pavement management, preservation, and smoothness and transportation asset management. Before moving to the FHWA Resource Center in 1999, Rodriguez worked as a pavement management engineer at the FHWA

Office of Pavement Technology in Washington, D.C., for seven years. He also had field assignments in the Alabama and Georgia FHWA Division Offices. Rodriguez was one of the developers and instructors of the FHWA Pavement Management Multiyear Prioritization training course. He received his bachelor degree in civil engineering from the University of Puerto Rico in 1983. He is a registered professional engineer in Georgia and a former member of the Transportation Research Board Committee on Pavement Management Systems (AFD10).

KATHRYN A. ZIMMERMAN (Subject Matter Expert) is the president of Applied Pavement Technology, Inc. (APTech), a company she founded in 1994. Throughout her career, Zimmerman has worked with both state and local agencies to address the organizational and technical enhancements needed to support the use of asset-management principles for making investment decisions for pavements and other roadway assets. She has led Federal Highway Administration (FHWA) and National Cooperative Highway Research Program (NCHRP) projects, including the development of a 10-year road map for pavement management and a *Guide to Maintenance Condition Assessment Systems*. She developed a training course on maintenance management systems for the National Highway Institute and currently serves as the lead instructor for the course. Zimmerman serves as the chair of the Transportation Research Board (TRB) Committee on Transportation Asset Management, as a member of the TRB Maintenance and Operations Management Committee, and as a panel member for NCHRP Project 14-25: Guidelines/Methodology for Developing Cost Effective and Cost Efficient Levels of Service. Zimmerman is a graduate of the University of Illinois, where she earned both bachelor's and master's degrees. She is a licensed professional engineer in Illinois and 29 additional states.

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Host Agency Key Contacts

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