Transportation Asset Management Case Studies

Presented by

U.S. Department
of Transportation
**Federal Highway
Administration**

MANAGING AND MAINTAINING ROADWAY ASSETS

The Utah Journey

Clear pavement markings and well designed median separating the four lanes of I-70 on a section through steep mountainous roads.

FRONT COVER PHOTO:
The US189 Transmontane Highway in Provo Canyon that provides an environmentally friendly access through the mountains. To the left of the highway is the Provo River that supplies drinking water to Salt Lake City. To the far left is one of the recreation trails running through the canyon.

Note From the Director

Across the nation, transportation agencies are being chal lenged to find innovative ways to preserve, maintain, and extend the service life of transportation assets. Agencies face challenges from aging infrastructure, demands to improve performance, calls to sustain existing assets, and an imperative to improve highway safety. These demands provide new focus and meaning for Transportation Asset Management (TAM).

The maintenance of roadway assets can be particularly challenging. Assets such as guardrails, pavement markings, drainage structures, shoulders, and signs can degrade rela tively quickly. Tracking their condition and ensuring their maintenance requires nearly constant monitoring and re action by highway agencies. As a result, effective roadway asset maintenance is a crucial feature of a successful high way safety strategy.

Since the late 90's, Utah DOT has been using TAM to effectively manage and maintain its transportation assets. The agency has developed and continuously improved its maintenance management systems and processes. The Utah DOT now has a mature approach to track the condi tion and performance of its roadway assets. This data-driven approach helps the agency demonstrate transpar ency and accountability to the public and also enables it to link the performance and condition of the roadway assets to the day-to-day public driving experience.

On behalf of the FHWA, I am pleased to add the Utah Case study: *Beyond the Short Term, Managing and Main taining Roadway Assets, the Utah Journey* to the TAM se ries. I believe this study shows how mature maintenance and management of roadway assets are critical to ad dressing the traveling needs of the public. I believe these strategies and systems will be helpful to other transporta tion agencies facing similar challenges.

J.B. "Butch" Wlaschin, P.E.
Director of Asset Management,
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Note to the Reader

The TAM case study series is the result of a partnership between State Departments of Transportation and the Federal Highway Administration (FHWA), Office of Asset Management, Pavements and Construction. The FHWA provides the forum and individual states furnish details of their experiences. The case study involves working closely with the transportation agency for researching, reviewing, and compiling information about agency practices, systems and processes in use.

Case study reports rely on the agency's perspective, experience and self-assessment. These case studies are intended to help other transportation agencies understand and learn from the experiences of their peer agencies. Readers should understand that geographical, organizational, and political environments influence the implementation of practices across the nation and customization may be required for specific application.

UDOT building public awareness by reaching out to grade school children.

Executive Summary

As State DOTs across the nation re-examine their strategies on highway and roadside assets, an effort has been put into place to preserve existing infrastructure through efficient systems for maintenance of roadside assets. Without doubt, Utah Department of Transportation (UDOT) has taken this sentiment to heart as they have incorporated department wide reforms to improve the quality and condition of their roadway assets.

With the national focus on performance, accountability, safety and sustainability of transportation assets, it is clear that performance-based asset management and highway safety are critical parts of a DOT's highway management strategy. The conditions of maintenance inventories can change rapidly and the intent of this report is to highlight the challenges and lessons learned in managing such inventories. The report does not go into operational activities such as snow and ice control.

UDOT has proactively implemented initiatives to identify and manage the condition and performance of specific roadway assets critical to highway safety. It has focused attention on high priority roadway assets such as guardrails, traffic signals, signs, drainage, and pavement markings and expects all safety related roadway assets in its state to receive a high performance score of "A-."

The quick change in conditions that can happen to roadway assets, the variability in inspection of the assets and the challenges in maintaining a comprehensive and updated inventory of asset conditions pose major problems to creating an effective maintenance strategy. Since much of this information is utilized to prepare maintenance budgets to effectively allocate future resources, it is imperative that streamlined processes addressing these challenges be implemented statewide.

UDOT has over many years developed processes to systematically monitor and improve the condition and performance of roadway assets to meet expected targets. It has developed guidelines to ensure consistency in inspection and data collection. The agency's data-driven approach enables asset conditions to be compared to established

standards and maintenance decisions to be communicated logically to decision makers. It also allows the agency to show accountability and be transparent in setting its maintenance priorities.

Effective maintenance strategies are not without challenges and UDOT has developed a knowledge pool that learned from the obstacles it faced. Utah's DOT acknowledges the difficulties encountered when developing a comprehensive inventory of all roadway assets, training personnel in the new system, using flexible decision making in resource allocation, ensuring quality and consistency of measurements, which all require time to perfect and streamline. To aid this process, the DOT established forums where regions that consistently meet and exceed targets can brainstorm with those falling short so that improvements can be disseminated and adopted statewide. Also, UDOT modified its budgeting from an incremental to a zero-budget basis in order to carefully allocate future budgets. Finally, the utilization of Quality Assurance Reviews and multiple inspection teams allows checks and balances to occur, ensuring that the DOT maintains quality and accountability from the ground up.

By using a performance-based data-driven approach in decision-making and setting a high priority for maintenance, UDOT has made great improvements in managing its roadside assets. The agency was rewarded through exemplary government ratings for its attention to the condition and performance of its transportation infrastructure, making it an archetype of effective maintenance and preservation for other DOTs.

Well maintained overhead signs on a protected concrete structure at the junction of I-15 and I-80 in Salt Lake City and a merge sign with slip base that makes replacement easier and safer for the maintenance crew.

BACKGROUND

Our nation's infrastructure is aging and there is a concerted effort by state and federal agencies to focus on preservation and maintenance. Pro-active maintenance and preservation enables states to optimize their investments by effectively extending the useful life of their infrastructure at a lower cost. This document reviews the Utah Department of Transportation's efforts to improve roadway maintenance to enhance safety, improve its infrastructure, and manage its limited resources. It also includes the lessons learned by the DOT as it systematically improved its maintenances processes, practices and roadway conditions.[1]

NATIONAL TREND

Across the nation, the transportation focus has moved from expansion to maintenance and preservation of existing infrastructure. Figure 1 illustrates bridge deficiencies (percentage of deficient bridge area to total bridge area) on the National Highway System (NHS) for all 50 states, The District of Columbia and Puerto Rico. The red bar shows the national average bridge deficiency is about 25% for the entire NHS, whereas the purple bar shows that the Utah bridge deficiency is significantly lower, at about 13%.

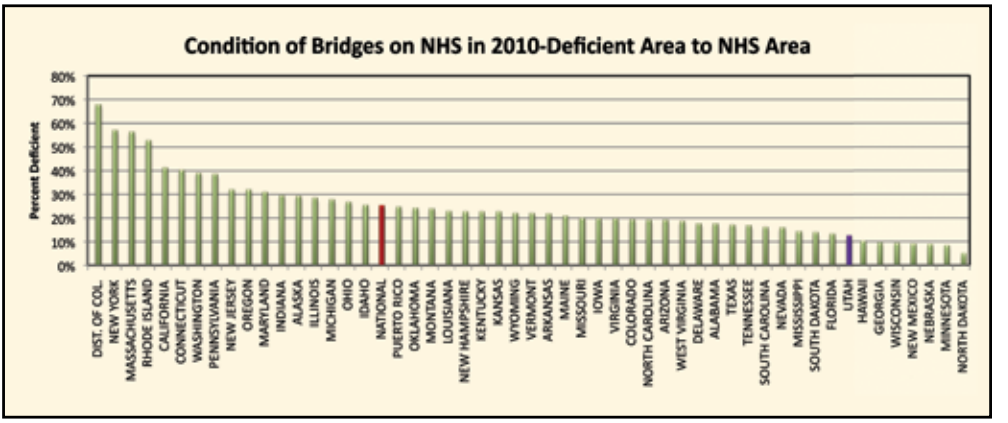

Figure 1: The percentage of deficient bridge deck area to the total bridge deck area on the NHS.

[1]In this report maintenance refers to addressing roadway appurtenances. The report does not go into operational activities such as snow and ice control.

UTAH PAVEMENT CONDITION TREND

As of 2010, Utah's highway conditions were above national averages. Figure 1 shows that the Utah DOT bridge deficiencies are about half the national average and Figure 2 shows that Utah's pavement deficiencies are relatively low, accounting for less than 147 centerline miles in 2010.

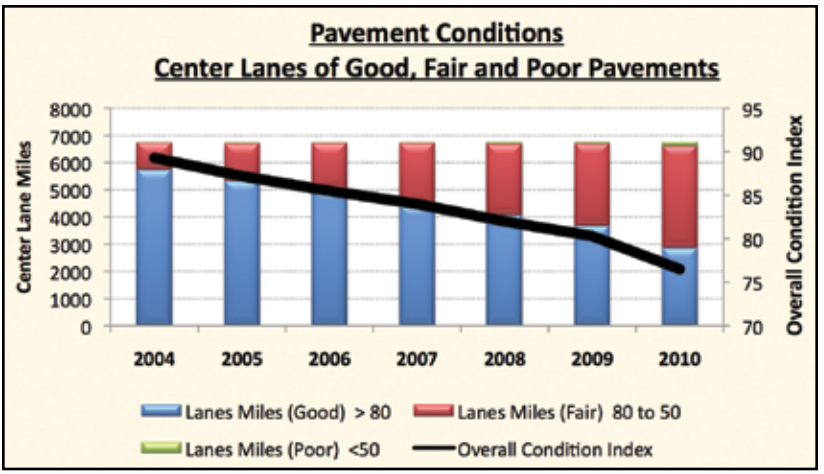

Figure 2: Overall Condition Index showing pavement conditions from 2004 to 2010 for UDOT.

MAINTENANCE AND INFRASTRUCTURE PERFORMANCE

With the national focus centered on the safety, improvement, and sustenance of existing transportation infrastructure, conversation is almost unanimously moving towards performance-based asset management.

Stephen Gaj from the FHWA Office of Asset Management, says, *"Asset management and maintenance activities are critical to preserving and improving asset condition and performance. Maintenance and preservation are important for managing assets for their whole life and optimizing resources as well as enhancing the safety of existing transportation infrastructure."*

Figure 3 shows this link between maintenance activities and performance of roadway assets.

Figure 4 (see next page) shows the importance of maintenance activities in fatality reduction. It shows that maintenance of assets such as shoulder drop-offs, sign maintenance, pavement marking and signals play an important role in highway safety.

Adapting the paradigm shift of maintenance to their own assets, the Utah DOT has identified specific maintenance assets critical to highway safety. With a focused attention to safety, Utah expects all safety related maintenance assets in its state to receive a performance score of "A-."

States are developing strategic asset management plans that focus on maintenance and preservation activities. Several have developed detailed maintenance work plans that allow them to monitor the condition and performance achievements of transportation infrastructure against expected annual targets. Agencies also have annual work plans that allow them to track and

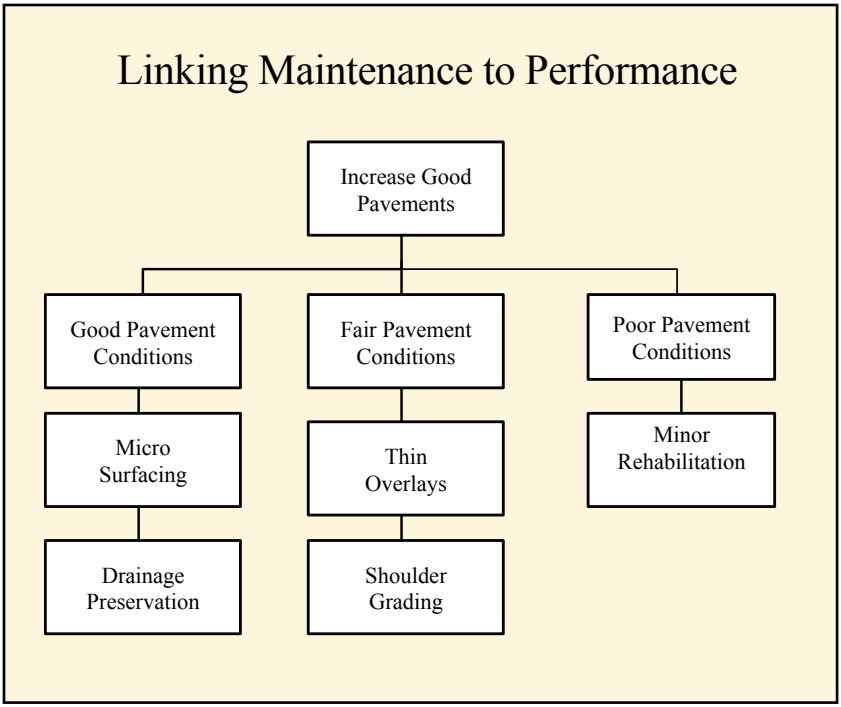

Figure 3: Linking Maintenance to Performance. (SOURCE FHWA)

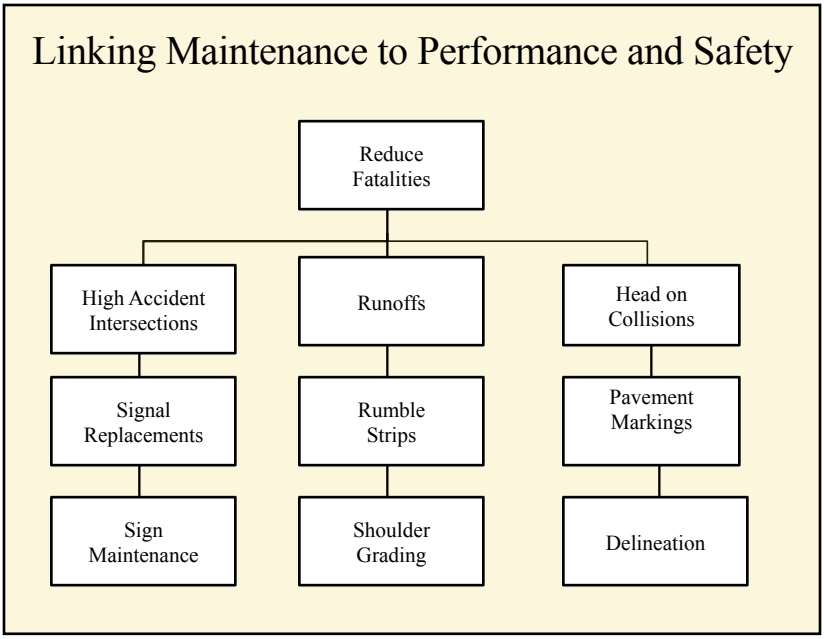

Figure 4: Linking Maintenance to Performance and Reducing Fatalities. (SOURCE FHWA)

compare budgets established versus dollars spent and hours logged versus hours allocated for maintenance and preservation.

The Utah DOT has explored using different technologies including the use of Lidar and High Definition Imagery to get a 100 % baseline inventory of approximately nineteen roadway assets. The information included the GPS location and size of each roadway asset. Some agencies are moving towards 100% inventories of high priority maintenance features such as guardrails, traffic signals, signs, drainage, and pavement markings. Other states use a sampling of inventories to estimate the level of effort needed to sustain the assets in a state of good repair. Many do systematic upkeep of the maintenance assets such as under-drain cleaning, sign replacement, raised pavement markers, and repair and replacement of traffic signal bulbs and controller components. Some use historic trends and budgets to project future budgets while others plan budgets based on information about the condition of maintenance inventories, expected performance, condition targets, and other resource constraints.

STRATEGIC ALIGNMENT: STATE AND NATIONAL LEVEL

Alignment of priorities between the state and national levels expedites the ability of states to achieve their targets on improving and sustaining the condition of their transportation infrastructure through performance based asset management. Utah DOT's maintenance program is aligned to its strategic goal—***"Taking Care of What We Have"***, something which has enabled it to be ahead of the curve in effectively addressing maintenance activities. The DOT has successfully used the maintenance activity performance information to inform lawmakers on how it effectively utilizes available maintenance funds to take care of the transportation infrastructure under its charge, resulting in the legislature echoing its philosophy that ***"Good Roads Cost Less"***. This strategic alignment and focus on preserving and maintaining its infrastructure resulted in UDOT receiving the highest rating of any state from Governing magazine in 2005 for taking care of its transportation infrastructure.

THE UTAH DOT MAINTENANCE PROGRAM

The Utah DOT has been using Maintenance Management Quality Assurance (MMQA) programs since 1997 to maintain its infrastructure assets, evaluate the effectiveness of its maintenance activities, and make refinements to its processes. The agency has been systematically refining its maintenance practices and processes since incorporating MMQA into the department's activities in 1997. In 2003, this continuous improvement and refinement resulted in an enhanced MMQA program called Maintenance Management Quality Assurance Plus (MMQA+). The MMQA+ provides enhanced decision support including:

- Guidance for feature condition thresholds that trigger maintenance actions;
- Information to help make data and needs-driven projections for allocation of maintenance funds;
- Tools to help communicate maintenance needs and decisions to key stakeholders, and;
- Tools to help measure the Level of Maintenance (LOM) of the highway system.

TARGET SETTING: THE BACKGROUND

UDOT's organizational hierarchy consists of the state, regions and stations as depicted in Figure 5. To work towards a common goal for performance of maintenance activities, statewide targets are set by UDOT for each roadway asset. This includes Shoulder Drop-offs, Pavement Markings, Guardrails, Signs and Posts, and Drainage. The permissible range of performance of each roadway asset is expressed through letter grades A, B, C, D or F. Performance targets are generally set at the state level from A through C and are applied to the regions and the stations. Stations are responsible for multiple segments of a route.

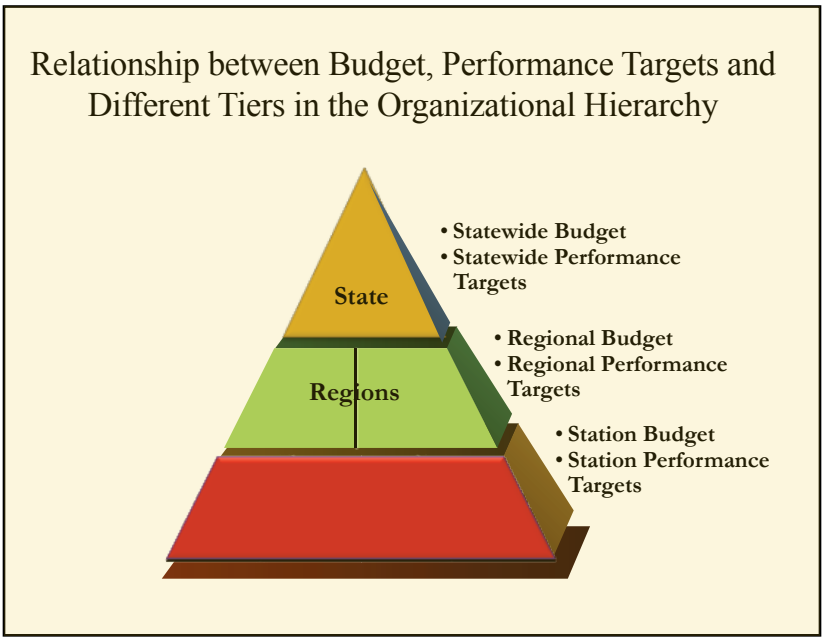

Figure 5: The relationship between State, Regional and Station level Performance Goals and Budgets at UDOT.

ACHIEVEMENT EXPECTATION

The expectation at UDOT is for each Station to work within the allotted budget to achieve the target performance for each asset and maintenance feature. Station personnel inspect assigned routes and record both the total number of features that need to be maintained as well as the number of deficient features. For example, when measuring Pavement Markings the inspector will check for the following features:

- Lines are retroreflective;
- Lines are free of chipping, fading or wear;
- Lines are not covered by crack sealing, patches or overlays, and;
- Entire line is visible and has uniform color.

The data from the inspection is entered into the MMQA+ software. The system then computes the Level of Maintenance and assigns a score from A through F. Reports generated by the software allow agency personnel at different levels of the organization to review the performance achieved for each maintenance activity. They provide valuable information used to manage the available budget and other resources. For example, these reports allow Stations to prioritize and focus on Station specific activities that address maintenance and preservation of roadway assets.

MEASURING LEVEL OF MAINTENANCE

Station personnel at UDOT can view the performance targets set for each maintenance activity in the station using the MMQA+ system. Based on current conditions of maintenance features, available budgets and target performance, the Station supervisor prioritizes and schedules work activities.

The frequency of measurement varies with the activity. For example, signs and posts are inspected at least bimonthly. Shoulder drop-offs, pavement striping, pavement markings, and guardrails are inspected semi-annually. These inspections mainly involve identifying the percent of deficient features relative to total features. The process of inspection and data collection is methodical and well documented. It also includes a feedback and learning cycle that ensures improvement processes are on-going and refinements occur within each activity cycle.

For each measurement, the MMQA+ manual provides detailed information about:

- Desired conditions;
- Deficient conditions;
- The frequency of measurement to be taken;
- Measurement area;
- How to record total count of feature;
- The number of deficient items, and;
- Comments for clarification.

Based on the number of deficient items identified and entered into the MMQA+ system, the software computes the LOM and assigns a letter grade of A-F.

ENGINEERING JUDGMENT AND SYSTEM KNOWLEDGE TAKES PRECEDENCE IN DECISION MAKING

The granularity of information within UDOT is impressive but the agency also relies on engineering judgment. UDOT has information to compare allocated budgets to expenditure and labor hours allocated to actual hours spent by station,

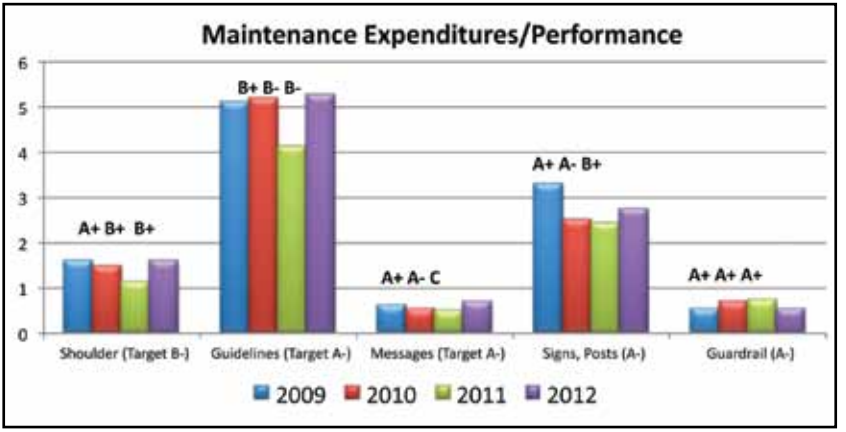

Figure 6: Expenditure and Performance of Maintenance Activities.

region, and state for each maintenance asset or feature for each year. This enables the agency to do sophisticated analysis to support decision-making. Regions have the ability to analyze the needs and performance of maintenance features at a regional or station level. However, the station personnel are closest to the maintenance assets. They have the best knowledge of the condition, performance, location, impact, and importance of a given asset and their feedback is an important component of the decision making process. Using these methods, UDOT allows for the regions to optimize how they use their resources across assets and stations.

Data analysis plays a very important role in providing information to support Utah DOT's decision making process. However, studies and data analysis at UDOT illustrate that engineering judgment is used repeatedly. The agency continues to systematically refine its data collection and inspection processes. Its plan is to continue this refinement until the agency is completely satisfied with the accuracy of its inventory data, its condition assessments, and its inspection process.

ZERO BASED BUDGETING

Many agencies use sampling and historic trends to establish future budgets and targets for performance of their maintenance features. UDOT has a sophisticated "zero-based" budgeting process. Each year's allocation is computed from a zero baseline and though the process involves reviewing historic trends prior to setting the following year's budget and targets, the new budget is not linked to the previous year's budget allocation. Budgeting is a collaborative process linked to expected outcomes. It involves discussions between central and regional offices about the agency's goals, performance and condition expectations, system needs, deliverability, and resource constraints.

GROWING PAINS IN DATA COLLECTION AND INVENTORYING PROCESSES

UDOT is in the process of obtaining 100% inventories for several maintenance assets that are currently incomplete. It also has a systematic and realistic plan to address some of the shortfalls in the data collection process. The agency estimates that it will be two years before a 100% inventory for all maintenance

assets is achieved. This is because many personnel are involved in assessing field conditions, which can result in data variability. The conditions of assets such as shoulders or pavement markings can also change rapidly. Inventory gaps resulting from these have been taken into account while establishing performance targets and budgets.

Often, improving maintenance management processes and systems takes time and can be frustrating. The Utah example illustrates the "growing pains" that an agency experiences and what an agency should be prepared to address as it goes through the process of improving its maintenance management systems. The DOT has devoted considerable effort to the continuous improvement of its inventories, its inspection consistency, and its budget estimates with the long-term objective of improving the condition and performance of its maintenance assets.

CONSIDERATIONS AND LESSONS LEARNED

Listed below are several considerations and lessons learned from the UDOT experience:

Accuracy of Sample Based Inventories:

Inspection and reporting of the condition of various maintenance features involves a large range of transportation assets along state-maintained roadways.

Figure 7: Deep snow being cleared on SR 14 on Cedar Mountain.

Much of the inspection is subjective and time consuming. The performance scores for each maintenance feature also depends on the time of year when the inspection is being conducted and whether the inspection is done on a select sample. For example, in the case of pavement striping, the conditions of the samples that are selected for inspection will influence the scores. It is also important to note that the actual score will depend on the total inventory of the asset that is recorded in the system.

Incremental Versus Zero Based Budgeting:

UDOT's goal is to *"manage resources at all levels such that they are diverted towards activities that are falling short of their targets and away from activities whose targets are being exceeded".* Historically according to UDOT *"budgeting for maintenance program was an incremental process based on historical expenditures, plus a small increase for inflation".* With the implementation of the MMQA+ system, the agency moved to a zero based budget. Each year, the budget for the next year is projected based on system conditions, available funds, and the target of performance that is expected for the projected year. The move to zero-based budgeting allowed UDOT to meet its goal.

Assessing Maintenance Asset Inventory Takes Time:

It can take several years for the full asset inventory to get updated in a system. As the inventory updated in the system gets close to 100 percent, the reports generated will become increasingly useful to decision makers in projecting budgets for future years. The expectation is that after a few years of implementation of the MMQA+, the entire maintenance inventory will be captured into the system. This will allow more holistic reporting of the system's condition and performance. As the historic budget and inventory information gets closer to reflecting the overall system conditions, the agency will be able to more accurately allocate future budgets as well as move budgets across categories.

Develop Flexibility in Decision Making:

UDOT's intent is that station supervisors will be able to review current conditions, established targets and available budgets in the MMQA+ and request that money be distributed across categories within a particular station to effectively address focus areas and best meet established targets. The DOT's regional directors have the flexibility to move regionally allocated funds across various categories within stations and across stations within their region, thus enabling efficient utilization of available resources.

Use Data to Communicate with Stakeholders:

The agency uses the reports from MMQA+ to also communicate with the legislature, the transportation commission and other key stakeholders. The reports have proven unexpectedly valuable in gaining credibility with internal and external stakeholders.

The Role of Quality Assurance:

A Quality Assurance (QA) process for the MMQA+ program involves an annual QA check for each Station. Each Station gets audited on either the monthly and bimonthly measures or on the full scope of measures. The program is coordinated and conducted by the Central Maintenance area. The QA process results in training and improvements in data collection and inspection.

Detailed Documentation Guidelines for Inspection:

Many agency personnel at the station, region or state level will be involved in data collection. It is important to have detailed guidelines to ensure consistency in inspection and data collection.

Document Use of Guidelines:

Performance scores achieved are directly linked to the inspection results, so statewide consistency in inspection is necessary. To ensure consistency, it is important to provide detailed documentation on the desired condition, the deficient condition, and how the deficiency should be interpreted along with examples and photographs of the desired and deficient condition. Information about the measurement frequency, the measurement area, and how to record the total count of each deficiency should also be included.

Consistency in Inspection Across the State:

Important decisions relating to budgets as well as prioritization and resource allocation are based on the reports generated from the inspections conducted and the data entered into various systems. It is important not only to ensure that the inspection is done consistently but also that the data entered is consistent and accurate across the state.

Ongoing Training for Inspection and Data Collection:

Processes and personnel changes occur in every agency. Providing on-going training through a centralized area helps train personnel and promotes consistency in inspection and data collection throughout the state.

Forums to Discuss the Results:

It can take several years of working with processes, inputting data, and discussing performance reports before agency personnel can fully appreciate the power of data entry and develop an understanding of the implications of not entering data into the system. Having a forum to discuss and analyze the performance across stations/counties and regions/districts statewide allows different tiers of the DOT to see the results of the inspection data being entered and also compare and contrast results across the state. It also encourages discussion by stations that show subpar performance with those that have achieved or exceeded targets. This triggers discussion about inspection processes, desired conditions, deficient conditions, data collection, and input differences. Over time, these forums should help with improvement in scores and the consistency with which inspections are conducted and deficiencies are recorded, both of which contribute to variance in final scores.

Random Review of Deficiencies by Externals to Identify Areas of Improvement:

It is necessary to have a different central team (from the team that does routine inspections) do follow-up QA inspections to provide feedback and suggestions on areas of improvement to personnel doing the inspection and data collection.

Give Three to Four Years of Cycle Time for Processes to Improve and Data to be Accurate:

Because there is no automated way of inspecting and grading all the maintenance features, the system is dependent on personnel expertise, experience, and the overall process maturity. Generally it takes anywhere from two to four years for all aspects of the inspection and data collection to mature and become integrated into routine work. The agency receives valuable information from first year inspection data, but the confidence in the data increases with each additional year of inspection and data collection.

CONCLUSIONS

By prioritizing and implementing performance-based asset management, the Utah Department of Transportation has made significant progress towards achieving its strategic goal of ***"Taking Care of What We Have".*** The agency has done so in a systematic, disciplined, and sustainable manner and now has one of the "best-in-class" programs in the country for managing and maintaining its transportation infrastructure assets by making optimal utilization of available resources.

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