Transportation Asset Management Plans

Case Study 2 - Linking Asset Management to Planning and Programming

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Case Study Introduction

This case study is one of seven that captures good asset management practices documented in the 2019 transportation asset management plans (TAMPs) required by 23 U.S.C. 119(e). This series distills many of the good practices and presents them in a convenient format for use by other transportation agencies.

The seven case studies are:

Case Study 1: Asset Management Practices and Benefits

Many of the TAMPs provided comprehensive summaries of their asset management practices and the benefits they received from them. Several examples are highlighted in this case study. These include examples from the DOTs in New Jersey, Pennsylvania, Illinois, and Washington State. These examples illustrate how asset management plans can effectively summarize asset management practices and improvement strategies.

Case Study 2: Linking Asset Management to Planning and Programming

This case study examines how TAMPs documented linkages to the DOT's long-range plan, the State Transportation Improvement Program (STIP), and state planning and programming practices. Examples are selected from the TAMPs in Missouri, Maine, Utah, Ohio, Wyoming, and Montana.

Case Study 3: Supporting Life-Cycle Planning

To develop a life cycle plan, one needs to know how assets deteriorate throughout their life cycle. Several TAMPs were notable in documenting how they manage assets with life cycle plans. Included in this case study are examples from the DOTs in Minnesota, Ohio, Tennessee, and New Jersey.

Case Study 4: Managing Risk to Assets

DOTs embrace risk management to support the long-term performance of assets, and for making risk-based investment tradeoffs. This case study summarizes some of the good risk management practices from Washington State, California, Kansas, South Dakota, Louisiana, Rhode Island, Pennsylvania, Texas, Colorado, and Michigan.

Case Study 5: Developing Financial Plans and Investment Strategies

The financial plans and investment strategies reflect priorities for allocating scarce resources to achieve their highest asset management objectives. This case study examines how several TAMPs described the clear linkages between their asset management objectives, gaps, risks, and investment strategies. Examples are from Kentucky, Michigan, Washington State, New York State, Utah, Vermont, and Illinois.

Case Study 6: Communicating Asset Management Strategies

This case study summarizes examples of communicating asset management strategies with key internal and external stakeholders. Examples are cited from the DOTs in Vermont, California, New Jersey, Washington State, Michigan, Ohio, Colorado, and Nebraska.

Case Study 7: Managing Non-Bridge-and-Pavement Assets

Several State TAMPs included additional assets beyond pavements and bridges. Examples are cited from Minnesota, Connecticut, Utah, and California.

Planning, Programming, and Asset Management

The Federal-Aid Highway Act of 1962 created the State and metropolitan transportation planning process which the Act declared will be "a continuing comprehensive transportation planning process carried on cooperatively by States and local communities…"[1] Since the Act's passage, the planning process steadily evolved to emphasize mobility, safety, public involvement, financial constraint, air quality, environmental justice, and other important factors.

The Moving Ahead for Progress Act in the 21st Century (MAP-21) (Pub. L. 112–141) marked a further advancement of the Federal-aid planning process by enhancing the focus upon performance and asset management. How that enhancement is evolving was evident in many of the 2019 asset management plans, several of which are referenced in this case study. The examples in this study illustrate how State DOTs are strengthening the linkage between their planning and programming processes and their asset management plans.

Maintaining assets has always been a planning and programming priority. What is new is the degree of formality and precision seen in the linking of asset management to planning and programming. As seen in the 2019 TAMPs, State DOTs are increasingly linking long-term life-cycle planning strategies to their planning processes by selecting projects that reflect their TAMP investment strategies. State DOTs are required in 23 CFR 515.13(b)(2) to use their investment strategies to make progress towards achieving their targets for asset condition and performance of the NHS, and to support the National goals in 23 U.S.C. 150(b). Since the 2019 TAMPs were adopted, many long-range statewide transportation plans have not yet been updated. Over time, the statewide long-range transportation plans and the TAMPs influence one another. What is apparent from the examples below is that the TAMPs are already influencing the annual and biennial STIP updates.

The examples below illustrate how State DOTs are linking asset management to the planning and programming processes. These examples summarize only a few from the 2019 TAMPs. All the plans are available on the FHWA website.

Missouri's Linkage of Its TAMP with Programming

The Missouri Department of Transportation (MoDOT) reported in its 2019 asset management plan that in 2016 the agency's asset management planning evolved from a statewide plan to individual District plans. Since 2016, each of MoDOT's seven Districts maintains an asset management plan for pavements and bridges that directly influences each District's programming. The TAMP reported that the District plans have been developed and updated annually by multi-disciplinary teams including bridge, pavement, mobility, and maintenance experts, and also included input from senior leadership, FHWA, and regional planning partners. MoDOT reported that the 2019 statewide TAMP was developed by summarizing the 2019 District asset management plans, which represents a bottom-up process not commonly seen in other TAMPs.

The 2019 statewide TAMP reported that MoDOT's District asset management plans were developed to align with the agency's performance process which it calls MoDOT's Tangible Results. The TAMP reported the objective is to keep the State's assets in good repair over their life cycle at the most practical cost. The MoDOT plan defined a state of good repair (SOGR) as maintaining pavement and bridge conditions for the six Federal performance measures at targeted levels over the following 10 years. The target levels were:

- Zero percent Poor Interstate pavement.

- 77.5 percent Good Interstate pavement.
- No more than 1 percent Poor non-Interstate NHS pavement.
- 61.1 percent Good non-Interstate NHS pavement.
- No more than 7.1 percent of NHS bridge deck area in Poor condition.
- No less than 30.9 percent of NHS bridge deck area in Good condition.

Targeting for Life-Cycle Performance

The TAMP indicated those State targets cascade down to the Districts and drive their programming, but with an emphasis on using life-cycle treatments and not short-term worst-first solutions. In the past decade, MoDOT has substantially improved Statewide pavement conditions. The TAMP indicated MoDOT now relies primarily on thin treatments to preserve those gains. The TAMP indicated that in rare instances the agency uses full-depth pavement replacements but primarily relies on cyclical preventive maintenance treatments including thin overlays, crack sealing, and pavement repairs.

The TAMP stated Districts are provided with a 10-year funding projection based upon a formula including the amount of highway travel, bridge size, lane miles, population, and employment. Districts use a spreadsheet-based asset management model to develop scenarios of how they will allocate funds over the 10 years to achieve the targets using life-cycle planning strategies. The TAMP indicated the model allows for quick "what-if" analyses of different treatment strategies and funding allocation scenarios to determine the benefit-cost over the life of assets. Each District used the model to recommend optimal programs and implementation schedules to manage its pavements and bridges within the agency's policy and budget constraints.

The TAMP reported that because MoDOT had 7.1 percent of its NHS bridges rated Poor, it still needed to replace some aging bridges. However, it no longer relied only on a worst-first bridge-replacement strategy. The TAMP stated that MoDOT uses a combination of an aggressive repair and replacement program to address Poor bridges and reactive and preventative treatments to prolong the life of Good and Fair ones. District bridge activities include fall and spring bridge washing, bridge joint and deck resealing, and spot painting of bearings and pilings to inhibit corrosion.

The TAMP included an example of a District's bridge condition forecasting result showing specific targets for the square feet of bridge treatments that are needed for the "mix of fixes." The St. Louis District had 898 bridges, 38 of which were in Poor condition and considered to be critical. In Fair condition were 452 bridges shown by route category. MoDOT has two bridge programs, Non-Major and Major. The condition forecasting result indicated that to achieve its target for non-major structures, the District needed to treat on average 30 bridges annually over each of the 10 years of the TAMP. That results in an estimated annual Non-Major bridge program of $20 million.

The TAMP indicated MoDOT is challenged by its major bridges, which are bridges more than 1,000 feet long. They account for only 166 out of 3,557 NHS structures in the State, but represent more than 20.3 million square feet of the entire 55 million square feet of Missouri's NHS bridge deck. The St. Louis Work Plan indicated that the funding was tracked separately for those major structures, as were targets for treating or replacing them. Although the non-major bridge expenditures were similar year to year, the major bridge spending varied annually from zero in most years to $69.8 million one year, $182 million in another, $36.9 million in another and so forth. The specific years in which major bridges were to be replaced or repaired were shown in the 2019 TAMP.

The statewide bridge plan indicated that 22 percent of the programmed work types were for bridge replacements, 10 percent for replacing decks, 28 percent for bridge rehabilitation, and 40 percent for

preventive maintenance. This translated into 55 bridges replaced per year, 25 re-decked, 70 rehabilitated, and 100 treated with preventive maintenance.

For pavements, similar target-focused and life-cycle driven treatments were captured in the example for the St. Louis District. The example District asset management scenario showed that the St. Louis District had 1,694 lane miles of Interstates, 1,806 lane miles of "other" Major Roads, 2,102 lane miles of Minor Roads with more than 400 average daily traffic (ADT), and 138 lane miles of Minor Roads with less than 400 ADT. The current conditions are shown, as are the planned percentage of Good pavements for each of the major pavement classes excluding the ones with less than 400 ADT. The number of lane miles that need treatment by route type are shown along with the estimated annual spending for those treatments. For example, 180 lane miles of Interstate treatments are planned annually, 203 lane miles of Other Major Routes, and 170 lane miles annually of Minor Routes.

Annual STIP Updates to Track Implementation of the TAMP

The MoDOT TAMP indicated that each year the Districts and regional partners update the STIP using the asset management plans as their guide as part of the State and regional coordination activities described in 23 CFR Part 450. At the end of the programming cycle, MoDOT evaluates the STIP to ensure the projects meet the TAMP objectives. The 2019 TAMP indicated that the asset management plan is a rolling 10-year plan reviewed and refined annually.

The TAMP stated,

> "It's imperative that the asset management plans get implemented in order to keep the system operating in the condition that it presents today. To ensure the asset management plans are implemented, each year MoDOT compares the asset management plan investment assumptions to the actual investment levels proposed to be programmed in the 5-year STIP prior to finalizing the draft STIP. Any significant deviations are reviewed and addressed if deemed appropriate. ….. the investment levels and amount of work in MoDOT's asset management plans is compared to the most recent 5-year STIP and reflects what is shown in the Tracker measures that monitor the implementation success. From the Tracker Measure, you can see that percent difference between the asset management assumptions and the actual investment levels in the STIP have dialed in considerably over the past two years."

The Tracker charts show the difference between the projects that were programmed in the STIP and the projects that were identified by the Districts' asset management plan. Comparisons are made for several key categories such as the number of lane miles treated by Interstate, Major Roads, and Minor Roads as well as the money invested in each of those classifications. Similar comparisons were made between the number of bridges treated by treatment type and what was planned in the Statewide TAMP. The 2019 TAMP reported the comparisons between planned and actual work for 2016, 2017, and 2018.

For example, the first three years of the STIP included 702 lane miles of Interstate pavement treatments compared to the 2019 TAMP assumption that 678 miles would be treated. For Interstate bridges, the first three years of the STIP included 362,009 square feet of bridge improvement compared to 302,910 square feet that the plan estimated needed to be treated.

The Tracker also compared actual to planned unit costs. For a three-year period, the TAMP showed that average per lane mile Interstate pavement costs were $162,217 compared to the $120,500 estimated by the TAMP. Interstate bridge replacement costs were $277 a square foot in the STIP compared to $279 per square foot assumed by the TAMP. The 2019 TAMP reported that for the previous two years, STIP pavement and bridge costs were significantly higher than asset management plan assumptions. Even

though the current STIP costs were updated to reflect earlier price increases, the costs are to be analyzed each year to ensure that the costs in the TAMP and STIP are better aligned.

Results Led to Increased Investment

The 2019 TAMP reported that a 2017 comparison between NHS and non-NHS assets revealed investments were inadequate to keep the non-NHS assets in good repair. After realizing the funding gap, the Missouri Highways and Transportation Commission established an Asset Management Deficit Program in 2017 to ensure adequate funding for the non-NHS assets. The commission acted again in 2019 to align funds with needs. The commission funded categories at the level necessary to maintain the system conditions and renamed the funding categories as Asset Management and System Improvement.

The Performance Summary

Although MoDOT's plan reported no NHS bridge or pavement condition gaps through 2028, the MoDOT TAMP was the only 2019 TAMP that included travel time reliability performance measures to illustrate gaps in other performance areas.

MoDOT reported that because of inadequate resources, it set the State Interstate Travel Time Reliability target for 2019 and 2021 to be less than the baseline reliability recorded in 2017. The 2017 baseline was 91.6 percent of the person miles travelled on the Interstate were under reliable conditions although the 2021 target will be only 87.1 percent. For non-Interstate NHS travel time reliability, the 2021 target was 87.8 percent compared to a 2018 baseline of 92.3 percent. The Freight Reliability Measure for 2021 was set at 1.30 although the 2017 baseline was 1.25. The TAMP stated that:

> "Unfortunately, current available funding leaves a performance gap in system performance for reliability and congestion reduction improvements. MoDOT seeks and implements cost-effective, innovative solutions to close performance gaps, but results in these areas are expected to worsen going forward based on current funding……"

In total, the MoDOT TAMP reported an annual funding gap of $825 million for categories such as non-NHS State bridges, maintenance and operations, Interstate reconstruction, economic expansion projects, and other non-NHS pavement and bridge needs.

Maine's 'Plan, Deliver, Measure' Programming

At the core of many performance management processes is the "plan, do, check" cycle. Such a cycle is evident in the Maine Department of Transportation (Maine DOT) asset management plan description of how its STIP projects are measured against the TAMP strategies to determine if the agency is achieving its asset management objectives.

The Maine DOT 2019 TAMP stated that the agency's STIP is the vehicle for implementing the department's asset management plan strategies. The TAMP indicated that each year as the STIP is updated, the TAMP investment strategies are manifested in the projects added to the program which drives the agency's work plans.

The Maine DOT TAMP indicated that the agency used its bridge management system (BMS) and pavement management system (PMS) to identify optimized funding levels and treatment strategies. Those funding levels influenced what it called Asset Management Funding Strategies (AMFS) intended to minimize life-cycle costs for each asset class. Those funding levels led to what it called Resource

Allocation Goals (RAGs) on a network-wide basis. From the resource goals, the agency developed a Work Plan that included the additional projects recommended for the STIP.

The TAMP indicated that Maine DOT used its management systems to conduct a systematic number of scenarios of different bridge and pavement investment levels. For pavements, it analyzed investment levels ranging from $32 million annually to $44 million annually for 20 years. The scenario based on $41 million annually for 20 years appeared to produce optimum conditions with the least cost. Investments beyond $41 million produced diminishing returns and were deemed to be not optimum. Using the $41 million scenario, the TAMP adopted the funding splits recommended by the PMS for the pavement investment strategies. Over 10 years in total, the strategies were to allocate $15 million for preventive maintenance, the largest amount of the remaining funds for preservation, followed by rehabilitation, and the least amounts for reconstruction. Only $35 million was allocated for initial construction.

A similar management-system-based analysis was conducted for bridges. Various funding levels were analyzed and the one selected was to invest $40 million annually for bridges for the 10-year TAMP period. The investment strategy adopted included $20 million for maintenance with the remaining funds allocated approximately equally between preservation, rehabilitation, and reconstruction and replacement. Again, $35 million was allocated for initial construction.

The Maine plan indicated that annually the agency updates its Work Plan to incorporate any adjustments recommended by the pavement and bridge modeling. The TAMP included a version of the graphic shown in Figure 1 to illustrate its "Plan, Deliver, Measure" process that uses the management systems to recommend treatments, the Work Plan and STIP to deliver the treatments, and the data-collection process to continuously assess if the desired results are achieved.

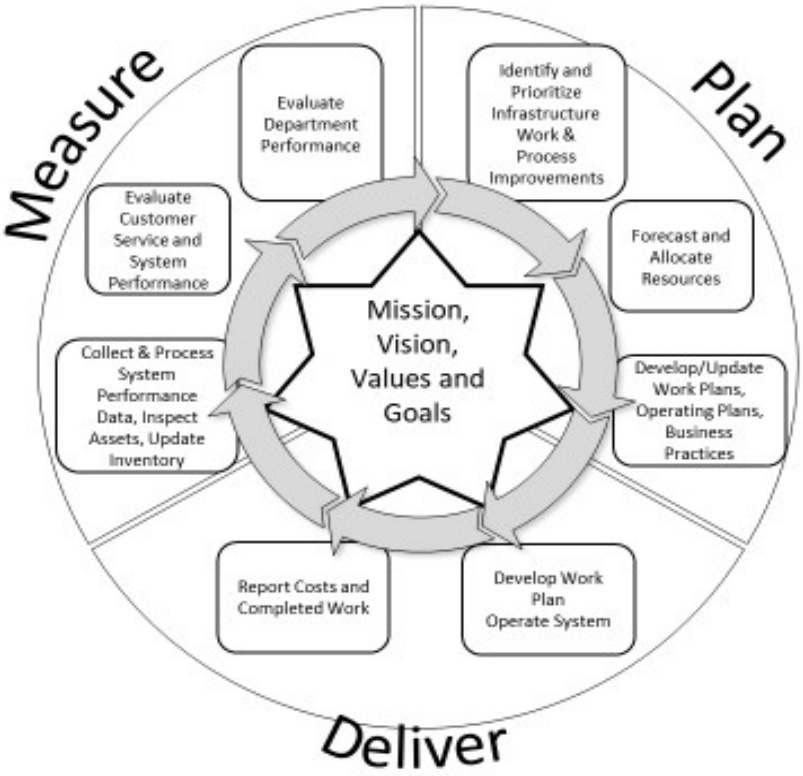


Figure 1. This is the Maine DOT Plan, Deliver, Measure graphic. The colors were modified to enhance the on-line visibility. Source: Maine DOT.

The TAMP emphasized that the STIP is the final process that allows the latest TAMP results to be delivered. The Maine DOT used funding strategies from the management systems to develop the detailed list of projects in the agency's 3-Year Work Plan and the 4-year STIP which it updates annually. As bridge and pavement data are collected, the project results are assessed and fed back into the ongoing analysis of whether investments are achieving the agency's objectives and targets.

Utah's Linkage of Asset Management and Planning

The Utah Department of Transportation (UDOT) 2019 asset management plan listed as an objective the incorporation of asset management into the intermediate and long-range planning processes. Program alignment between the asset management process and the projects that are selected was one of three major initiatives that resulted from an agency asset management self-assessment.

The objectives and the findings from the self-assessment led to an asset management goal to work collaboratively across divisions to develop a unified program that maximizes system performance and funding, while quantifying risks.

The TAMP described the alignment of the asset management analysis with the prioritization of Region projects as a work in progress but one that is an agency priority. The TAMP said collaboration continues between UDOT divisions to complete an information loop from project planning, design, construction, and maintenance. The TAMP said the agency believes completing this loop from planning through design, construction, and maintenance will improve the accuracy and efficiency of each separate process and of the overall UDOT program. It stated that the development of this linkage also will tie the long-range plan to the STIP process, as well as to the asset management plan.

The TAMP stated UDOT uses its pavement management system to develop a five-year set of recommended treatments for each Region based upon the suggested funding level. The Regions consider the recommendations for preservation, rehabilitation, or reconstruction, and incorporate them into their recommended set of STIP projects.

In addition to selecting projects to continue achieving the State-set condition targets, projects are also selected based upon a State-developed Sustainability Index. The index helps assess if the mix of treatments selected will achieve a sustainable pavement level for the entire roadway network. The index is based on the premise that all pavements age one year annually which can be measured in units called Surface Area Years. Different types of projects replace different amounts of surface years, such as a reconstruction project provides more Surface Area Years than does a chip seal. The Sustainability Index is the ratio of work planned to be done divided by the Surface Area Years that will be lost in the District during the life of the STIP. If the District program does not replace as many Surface Area Years as will be lost, then the Sustainability Index will be less than 1.0 indicating that the program will not lead to sustainable condition levels.

The Sustainability Index is what UDOT calls a secondary performance measure. A primary measure is one such as the measures set for the Federal performance management process. A secondary measure focuses on efforts to minimize long-term costs and maximize the service life of each asset.

Each year the Regions' and Statewide STIP projects are reviewed and a new sustainability index is calculated. This index value showed if adequate funding had been invested in the right mix of projects to sustain the NHS and statewide system in Good condition.

A similar process is used for bridges, but instead of a Sustainability Index UDOT uses a UDOT-developed Bridge Health Index. The Bridge Health Index is a composite measure to describe the overall condition of each bridge, and it is used as a structural performance measure to prioritize treatment. The index is made up of three scores, the deck, superstructure, and substructure weighted to underscore the importance of each to a bridge's health. The deck component is weighted at 40 percent, the superstructure 35 percent, and the substructure 25 percent. The score of the deck, superstructure, or substructure component is the score of the elements that make up the component. A health index is

calculated for each element as the ratio of the value of the element in its current condition to the value of the element if it were in the best possible condition.

The component scores are used to prioritize bridges statewide for replacement and rehabilitation while the health indices of individual elements are used to identify preservation needs. Each year, the program of projects is updated following the annual bridge inspections to ensure that the mix of preservation, rehabilitation, and replacement will sustain the bridges at targeted levels. The analysis also results in what UDOT calls a "plan for every structure" that defines each structure's needs for preservation, rehabilitation, or replacement.

Bridge forecasting influenced long-term program funding as well as short-term project selection. A 20-year forecast indicated that although the number of Poor structures was forecast to remain better than the targeted level, the amount of bridge area in Fair condition was increasing. To prevent a long-term risk of more structures being on the verge of becoming Poor, UDOT increased bridge funding from $18.7 million annually to $48 million for three years to "jump start" long-term efforts to reduce the number of Fair structures in the 20-year forecast. The number of structures in Fair condition will continue to increase, but not at the same rate as before the investment increase.

UDOT efforts to link programming to the asset management objectives were not limited to pavements and bridges. UDOT's TAMP also demonstrated a programming link to active traffic management system (ATMS) components and to traffic signals. Those two assets were included in the asset management plan, in addition to the required NHS pavements and bridges.

The TAMP included a UDOT condition target of 95 percent of the ATMS system in operational condition. Because the ATMS is made up of many components, the condition of the separate components was averaged into a composite rating. The TAMP estimated that although the overall ATMS network met its 95 percent target, there were more than 1,100 individual components that had failed or were beyond their expected service life. Recognizing the importance of these aging assets, the Utah Legislature allocated an additional $3.9 million each year for device replacement and upgrade. UDOT's plan estimated that within the life of the TAMP the backlog of aging or failed ATMS assets would be eliminated. The TAMP stated that funding needs will be tracked and adjusted as the system expands and as components' life expectancy is analyzed based upon accumulated historical data and technological improvements.

Traffic signals had a UDOT performance measure of the percent in Good or Fair condition based upon annual inspections of the electronics and physical infrastructure. The UDOT target is 95 percent statewide in Good or Fair condition. The TAMP and UDOT's performance dashboard, that is linked to the TAMP, indicated that in 2018 12 percent of the signals were in Poor condition but that was reduced to zero percent Poor by 2019. The percentage rated Fair increased from 39 percent to 57 percent although the percentage in Good condition declined from 49 percent to 43 percent. At the time of the TAMP publication, a life-cycle strategy for signals was under development.

The investment strategies for signals were to conduct regular preventive maintenance to meet the 95 percent State target, implement emergency responses when emergencies occur, and apply established maintenance management processes to minimize failures and downtime. A process was being established to evaluate signalized intersections annually and rate them on a 1-5 scale. The results are published in a Traffic Management Tactical Measures dashboard and the condition reports provided to the Regions. The Regions are to incorporate the cost of the signals rated as a 1 or 2 into their project scoping and cost estimates.

Ohio's Use of Work Plans to Link TAM with Projects

The Ohio DOT's 2019 TAMP emphasized the agency's use of District Work Plans to link the investment strategies with the Districts' capital projects and maintenance efforts.

For pavements, the agency's PMS generated funding needed on a Statewide basis and recommended treatments for each District. The treatments derive from decision trees that emphasize preservation to lower life-cycle costs and to emphasize chip seals on low-volume roads. The Districts developed a pavement Work Plan that matches 75 percent of the PMS recommendations.

While a BMS that includes forecasting modules was under development, a spreadsheet-based tool was used to generate bridge Statewide funding levels and to recommend District bridge projects. The Districts receive a list of structures that should be cleaned, swept, and sealed as part of the bridge preservation program. More extensive improvements are based on an ODOT "general appraisal" analysis which is a form of composite bridge rating using National Bridge Inventory (NBI) component and element ratings.

As with pavements, bridge efforts are incorporated into the District Work Plan that also includes the pavement treatments, and all maintenance activities. Within the larger Multi-Year Work Plan, each District develops a Capital Work Plan that represents the contracted portion of the DOT's long-term plan and which lists the projects that will be awarded over the next six years. In addition to the Capital Work Plan, each District develops an Operations Work Plan that lists the routine and reactive maintenance, preservation, and "ready to pave" projects that are planned for each fiscal year. The Capital and Operations work plans are now part of the Multi-Year Work Plan that are fiscally constrained and which focus upon achieving the agency's condition targets and life-cycle objectives.

Wyoming Closely Links Its TAMP and Program

The Wyoming Department of Transportation (WYDOT) TAMP provided another example of an agency that closely linked its asset management processes to its Districts' STIP projects.

The 2019 Wyoming TAMP explained that the agency relies on its pavement management system to identify the optimal investment strategy that provides the best pavement condition results in future years. To achieve those optimal future conditions attributed to the TAMP investment strategies, each year a minimum number of project miles must be completed using preventive, minor, and major rehabilitation strategies for each of three roadway categories, Interstates, non-Interstate NHS, and non-NHS routes. Those treatments on those systems were identified using the pavement management system during the TAMP development process and then were included in the TAMP as the pavement investment strategies.

During the development of the TAMP investment strategy, the pavement management system produced a network-level analysis that accounted for the current STIP projects and budget projections. The analysis also incorporated inflation, preservation treatment types, and current road conditions to forecast 20-year conditions. The analysis also broke down to the District and project level. It provided recommended pavement funding strategies for optimizing funds for the treatment candidates in each District to aid District managers in selecting STIP projects. The recommended pavement funding strategy suggested mileage counts for each District and functional classification that should be met on a rolling average for the six-year STIP. Those recommendations led each District to program a minimum number of miles per year with the recommended preventive maintenance and major rehabilitation strategies that were derived from the management system's decision trees and benefit-cost analysis.

The TAMP stated that the programming of projects by the Districts began with taking the recommended management system treatments that led to the TAMP investment strategies and programming them as projects into the STIP. Because the recommended treatments linked to the TAMP investment strategies are generated by the optimized PMS scenarios, the TAMP stated it is critical to strictly track the projects to ensure delivery of the recommended miles of pavement treatments. The TAMP indicated that performance is not based on dollars spent but upon work performed and the resulting changes to the system conditions.

The Districts used the list of candidate treatments recommended by the management systems and the guidance on the mileage to be treated. The TAMP indicated that if the District engineers select projects from the candidate list and apply the treatments indicated, they will achieve their pavement targets. As projects progress through the design and construction processes, the asset categories being treated are tracked and updated as changes occur. The TAMP stated the tracking is done to monitor and update the asset management recommendations which relate to the TAMP investment strategies. If project costs increase for one category, funding is decreased in another.

While the District engineers are held accountable for applying the needed treatments, the Programming Section tracks the treatment types and quantities that each District programs into the STIP. The TAMP stated that the Programming Section provided the District engineer with a report that compared the previously determined required treatment quantities to the actual work programmed in the STIP. Districts can group treatment types into one or two years of the six-year STIP to more effectively use their resources and do not have to deliver the needed treatments in a given year. The cumulative treatment amounts are tracked. The Programming Section tracks the estimated cost per treatment to allow adjustments if unit prices fluctuate during the project-development process.

The feedback loop between planned and actual work occurs by the management systems tracking the treatments over time to ensure that they are providing the projected benefits, and to adjust treatments, if necessary. The tracking may show that construction techniques need to be modified or that the management systems need to be adjusted.

Maintenance Viewed as Critical to Pavement Objectives

Although not part of the STIP, Wyoming DOT's pavement maintenance activities also are linked to the asset management strategies. The Wyoming TAMP indicated that in-house and contracted pavement maintenance activities are captured and their benefits are factored into the PMS forecasts. Maintenance work includes crack sealing, short patches that are less than a section's length, chip seals, slab repairs or slab replacement. The TAMP indicated that without this work, pavements would have shorter lives and deterioration models would need to show steeper curves. The TAMP indicated that Wyoming DOT considers its maintenance budgets to be critically important to achieving its pavement targets. Districts provide a list of their chip seal, patching, and slab-replacement efforts. Those are reviewed by the Materials Program and depending upon the type of treatment and the length of the pavement sections that are treated, some proportion of the completed maintenance work is credited in the PMS. Those efforts are factored into the management system forecasts and they influence the deterioration curves applied to the sections that were maintained.

Using Bridge Management Systems to Support Programming

As the TAMP described for pavements, the bridge management process in Wyoming also influenced the programming process. Once the bridge management system (BMS) identifies needs for preservation, repair, rehabilitation, or replacement, candidate lists are developed for each District. The candidate lists are developed within the parameters of Wyoming DOT's targets which are to maintain State-owned

bridges on and off the NHS so that at least 10 percent are in Good condition and less than 10 percent are in Poor condition.

An optimization algorithm in the BMS compares deterioration rates to treatment actions and their costs. The algorithm set targets for the percentage of the budget that should be allocated to preservation, rehabilitation, or replacement. Then, headquarters provides the Districts recommended treatments that Districts should consider programming into projects. The algorithm prioritizes actions on Poor structures but as the amount of Poor square footage declines in a District, the algorithm concentrates more on preventive maintenance and preservation.

As was described for the pavement analysis, once bridge projects are programmed, the delivery of those projects is tracked to ensure that the amount of treatment by type is achieving the intended bridge conditions. The tracking process compares the "mix of fixes" in the STIP to the percentage of treatment types recommended by the management system. The tracking ensures that over the life of the STIP, the balanced mix of preservation, rehabilitation, and replacement that is needed to achieve the life cycle strategies is delivered.

Montana's Plan Focuses on 10-Year Objectives

The Montana Department of Transportation's (MDT) 2019 TAMP identified current condition gaps that it plans to close over 10 years by focusing upon a life-cycle based program of projects.

The plan noted that the agency faces condition gaps in its non-Interstate NHS pavements and in its NHS bridge deck area. The 10-year state of good repair State target for non-Interstate NHS pavements is to have a ride index of 76 whereas the index currently is at 72.6. For NHS bridges, the state of good repair target is to have 25 percent of the inventory by area in Good condition per the 23 CFR 490.409 performance measures whereas 17.4 percent is Good as of 2019. However, by focusing its pavement projects on its management system's recommendations and by relying on dedicated bridge preservation funds, the agency forecasts that its STIP projects will over the 10 years of the TAMP bring pavements into a state of good repair and nearly eliminate the gap in NHS bridges.

The MDT plan emphasized the agency's tracking of how projects and treatments influence condition so that the agency can hone the predictive ability of its management systems and processes. The TAMP indicated that MDOT allocates funds based on scenario analysis that seeks to achieve a state of good repair with life-cycle strategies. Funding is distributed to Districts by highway system and work types. As the Districts develop projects, the results of the projects are assessed to ensure progress toward the state of good repair.

The Montana TAMP included Figure 2 to illustrate the long-term, continuous process of identifying pavement needs, designing and then building pavements, and then maintaining and monitoring them over their life cycle. Eventually, the pavements are replaced and the cycle begins again.

The treatments to achieve the pavement conditions with the lowest life-cycle cost are identified by MDT's pavement management system. It bases the recommended treatments upon decision trees and an optimization tool that considers conditions, deterioration rates, pavement type, project histories, traffic levels, and other factors. The recommended treatments are given to the Districts who incorporate them into their project lists that lead to the STIP. As projects are designed, headquarters and District staff work together to refine the scope to address the observed pavement distresses and other roadway needs.

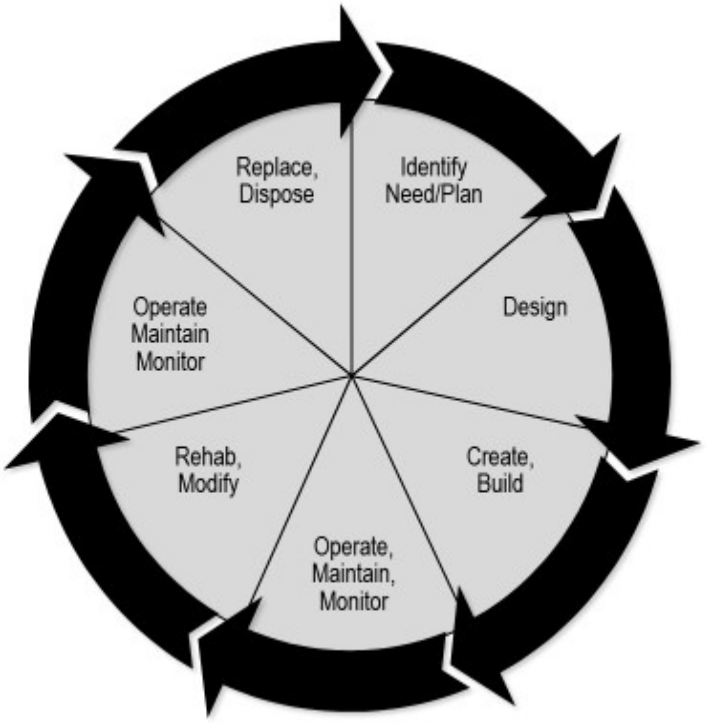


Figure 2.Montana's cycle to maintain pavements over their life cycle. Source: Montana DOT.

For its bridges, MDT increased its annual bridge investments from $25 million annually to $40 million with a 10-year strategy to program the needed replacement and rehabilitation projects in the first five years along with an increase in preservation. It identified a structured sequence of preservation projects that it will consider for the newly constructed bridges to lower their life-cycle costs and to keep them in a state of good repair. Those treatments include preservation at approximately years 10 and 20, along with joint replacement at year 20. Preservation is repeated in year 30 followed by deck replacement and joint repairs in approximately year 40. The cycle of preservation, deck replacement, and joint repairs are repeated until year 100 when replacement is assumed.

The MDT TAMP concluded that by focusing its STIP projects upon the mix of maintenance, preservation, rehabilitation, and replacement called for by its management processes, it will make progress toward its State-defined state of good repair. Key to the achievement will be the enhanced focus upon bridge and pavement preservation emphasized in its asset management plan.

[1] Public Law 87-866-Oct. 23, 1962, Sec. 134