Transportation Asset Management Plans

Case Study 7 - Managing Assets Beyond Pavements and Bridges

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16. Abstract: This is one of seven case studies of practices in the 2019 transportation asset management plans. This case study highlights practices State departments of transportation (DOTs) deployed to manage assets in addition to pavements and bridges.

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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 Risks 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.

Managing Assets Beyond Pavements and Bridges

As practices mature, agencies are taking initiatives to apply the asset management approach to an increasing number of assets. This case study summarizes from the 2019 asset management plans how U.S. transportation departments are expanding efforts beyond pavements and bridges. The 2019 plans include examples of managing culverts, intelligent transportation systems (ITS), signs, signals, buildings, and more. Efforts to manage these assets led to innovations in developing inventories, identifying life cycles, and adopting investment strategies. In addition to bridges and pavements on the National Highway System (NHS), State departments of transportation (DOTs) are encouraged, but not required, to include all other NHS infrastructure assets within the right-of-way corridor and assets on other public roads.

Twenty-two of the 52 plans included all State-managed pavements and bridges rather than only those on the NHS. Four State plans included ITS assets, three States included culverts, three States included signs or overhead sign supports, three included signals, and three included buildings. Other assets that were included in at least one TAMP were lighting, sidewalks and ramps, stormwater tunnels, high-mast towers, pump plants, rest areas, weigh-in-motion facilities, pavement markings, and noise walls.

These case studies summarize only a few of the examples from the 2019 transportation asset management plans. State TAMPs are available on the FHWA asset management website.

Minnesota DOT Strategies Beyond Pavements and Bridges

The 2019 Minnesota Department of Transportation (MnDOT) TAMP addressed assets beyond pavements and bridges that were required by 23 CFR Part 515. In the TAMP, MnDOT included culverts, deep stormwater tunnels, overhead sign structures, high-mast light tower structures, noise walls, traffic signals, lighting, pedestrian infrastructure, buildings, and intelligent transportation system (ITS) components and the State-established performance targets for each. For each asset class, MnDOT established work groups of subject matter experts who were integral in documenting current practices to determine data availability, assess risks, propose mitigation strategies, identify measures and targets, and develop investment strategies.

MnDOT developed a Transportation Asset Management System (TAMS) to help manage asset inventory and condition information. TAMS houses or will house data for signals, lighting, ITS devices, traffic barriers, non-bridge hydraulics infrastructure, noise walls, pavement markings, and signs. TAMS also captures MnDOT maintenance staff labor, equipment, and material investments in those asset classes.

The MnDOT TAMP stated that TAMS maps asset data and historical expenditures that support cost models for life-cycle analysis, maintenance demand estimates, and can be used for evaluating performance and generating reports. Within TAMS, MnDOT is beginning to conduct basic analysis for traffic signals and ITS assets such as assessing their age and condition. The TAMS also include decision trees for culvert maintenance.

For building management and sidewalks, MnDOT houses asset and condition data in separate databases.

Minnesota Culvert and Tunnel Management

All State highway culverts and the deep stormwater tunnels are included in the TAMP. Other hydraulic assets such as driveway culverts, catch basins, and stormwater treatment ponds are not addressed in the 2019 MnDOT TAMP. The MnDOT plan estimated the agency has 40,687 culverts with a replacement value of $1.6 billion, and 73,392 linear feet of deep stormwater tunnels with a replacement value of $372 million. Culvert inspections vary between one and six years depending upon condition and risks, while tunnel inspections occur every two to five years. The deep stormwater tunnels are assessed using the Pipeline Assessment and Certification Program developed by the National Association of Sewer Service Companies.

The State performance measure for culverts was the percent in Poor condition based upon National Bridge Inventory (NBI) inspection standards and MnDOT requirements. Condition levels were assigned during inspections with Poor culverts displaying cracks, holes, joint separation, or loss of surrounding material. The TAMP stated that the condition of culverts was assessed as 2.6 percent Good, 55.9 percent Fair, 14.6 percent Poor, and 6.9 percent were not accessible to be rated. The target for culverts was to have less than 10 percent Poor, so there was a performance gap.

For tunnels, the State performance measure was the percent in Poor condition measured by length. Inspections determined the condition based upon factors such as cracks, fractures, or voids behind tunnel linings. The target was to have less than 10 percent Poor. The inspections showed 19 percent were in Poor condition indicating a condition gap.

The MnDOT TAMP stated the life-cycle strategies for culverts include regular inspections and cleaning as well as corrective actions, as needed, to extend culvert life. Corrective actions could include resetting culvert ends, joint repair, paving the invert or bottom of the culvert, slip lining, and even rehabilitation or replacement as needed. The MnDOT plan indicated that the corrective actions could reduce the annual life-cycle cost per culvert from an average of $507 to $356. The TAMP also indicated MnDOT developed decision trees for treatments based upon culvert size, type, condition, or other "flags" that could support life-cycle planning.

The TAMP included risks for culverts including failure or collapse, flooding caused by a lack of capacity, the inability to manage culverts for the lowest life-cycle cost, and difficulty in managing culverts because of inadequate funding. The only risk rated as "extreme" was potential failure while the risk of flooding caused by inadequate capacity was rated as "high."

For investment strategies, the TAMP estimated that for the 10-year TAMP period, $254 million in planned culvert investment was allocated. To reach the target of no more than 10 percent Poor would require an additional $37 million, which at the time of the TAMP was not budgeted.

For deep stormwater tunnels the investment strategies allocated $2 million over 10 years. An additional $2.5 million was estimated to be needed to reach the condition target.

Overhead Sign Structure Management

For overhead sign structures, the MnDOT TAMP included stand-alone structures only and did not include the condition of the sign panels. It estimated that MnDOT managed 1,858 overhead sign structures with a replacement value of $175 million. The signs are aging with 22 percent of them more than 30 years old and 18 percent of unknown age. The performance measure was the share of overhead signs in Poor condition. Poor conditions were assessed by whether nuts were loose, threads were engaged improperly, the sign supports tilted, grout was present or other defects. Inspections were conducted on a five-year cycle with the results stored in a spreadsheet. The TAMP stated that at the time of its publication the agency's intent was to transfer the overhead sign data to TAMS. The structures were assessed on a 0-9 scale like bridges with those rated 6-9 as Good, 5s as Fair, and 4 and below as Poor. The target was to have no more than 6 percent of them Poor, but 27.9 percent were Poor, and another 38.2 percent were unscored.

The life-cycle planning analysis examined four maintenance and repair scenarios with two scenarios based upon 40-year life cycles and two based on life cycles of between 41 and 50 years. The TAMP stated the current life-cycle scenario involves a 40-year expected life with, annual maintenance structural inspection every five years and with nuts tightened. Major sign rehabilitation is assumed every 30 years. The average annual cost under the current maintenance scenario was $713 per sign per year. Strategies with more frequent bolt tightening increased the per year cost up to $867. Because nut tightening significantly affects the life-cycle cost, the TAMP indicated that MnDOT sponsored a research project on national guidance for nut tightening issues.

Risks for overhead signs included poor construction and installation, inability to manage them for the lowest life-cycle cost, damage caused by man-made events, and others. All the risks were assessed as medium or low.

The investment strategy for overhead sign structures was to allocate $8 million annually. However, to reduce the current percentage Poor to the target level of no more than 6 percent, an additional $33 million annually was estimated to be needed.

Noise Wall Inventory and Management

For noise walls, MnDOT recorded 364 wooden walls for a total of 10 million square feet and a replacement value of $312 million. It also owned another 70 concrete noise walls totaling 1.4 million square feet with a replacement value of $62 million. Condition data on the walls were collected in 2012 and 2019 with inspection frequency up to each district. The TAMP stated the performance measure for noise walls is based on a MnDOT developed Noise Wall Health Index that incorporates defects and their severity. The TAMP reported that the target was to have no more than 8 percent in Poor condition. The TAMP showed that 11 percent was in Poor condition, indicating a condition gap.

The life-cycle strategy for noise walls included conducting reactive maintenance, inspections, and minor rehabilitation. Costs for LCP strategies varied by whether a wall was wood or concrete. The current life-cycle strategy for concrete walls includes annual reactive maintenance, structural inspections every 10 years, and minor rehabilitation after 27 years. Splash zone sealing for concrete walls was considered in one LCP scenario but was not found to be cost effective. The life-cycle analysis for concrete walls extended from 81 to 100 years for an annualized cost of between $2,137 and $3,359. For wood walls, the life-cycle strategy included annual reactive maintenance, 10-year structural inspections, and re-planking every 30 years. The life cycle was estimated to be between 61 and 80 years with annualized costs of between $2,404 and $4,348.

The TAMP indicated that risks to noise walls include not repairing problems that are identified during inspections, not managing walls to the lowest life-cycle cost, lacking a unified data management system, and not inspecting adequately. All of those were assessed as medium risks.

Over the next 10 years, the investment strategy was to invest $97 million in capital and maintenance funding for noise walls but an additional $57 million was estimated to be needed to meet the condition targets. The TAMP indicated that no funds are directed to preventive maintenance and all funds are used for replacement or rehabilitation. The TAMP estimated that up to 10 percent of the noise wall allocation could be used effectively for noise wall preservation activities such as wooden plank repair or concrete sealing.

Traffic Signal and Lighting Management

The TAMP indicated that MnDOT managed 1,295 traffic signal systems with a replacement value of $324 million and 27,147 lighting structures with a replacement value of $217 million. The performance measure for signals and lighting was the percent beyond their 30-year useful life. The TAMP stated MnDOT did not have a consistent inspection frequency for signal structures and lighting with inspection frequencies up to the districts. Electrical inspection data were stored in TAMS as were repair activity costs. The TAMP estimated that 16 percent of the signals were beyond their useful life, while the target was to have less than 2 percent. For lighting, 31 percent were beyond their useful life while the target was to have less than 2 percent.

Four signal life-cycle strategies were analyzed. Each included annual reactive maintenance but they otherwise varied by frequency of preventive maintenance and by whether they assumed cyclical replacement of light emitting diodes (LED) indications or replacement of electronics. The TAMP showed that the annualized cost per signal could vary from $8,885 to $10,793 depending upon the strategy selected.

Risks identified for signals and lighting included poor traffic signal timing, poor construction or installation, pole failure because of weather or premature deterioration, and a lack of appropriate management leading to premature deterioration. All the risks were assessed as medium.

The investment strategy for signals was to invest $157 million over 10 years which is $78 million less than needed to achieve the condition targets. For lighting, the investment strategy was to invest $125 million over 10 years which is $19 million less than needed to achieve the target.

Sidewalk and Curb Ramps

The TAMP estimated that MnDOT owned 560 miles of sidewalks with 21,000 curb ramps for a combined replacement value of $146 million. The performance measure for these assets was the share out of compliance with Americans with Disabilities Act (ADA) regulations and out of compliance with a MnDOT compliance target. Inspections were conducted when new assets were built. For existing assets, inspections were done every 10 years. The TAMP reported that in 2017, 61 percent of the ramps and 44 percent of sidewalks were non-ADA compliant.

Life-cycle planning activities were largely reactive. Curb ramps were inspected every 10 years. If deficiencies were reported between inspections, reactive maintenance treatments were used such as grinding high slabs, jacking low ones, or removing vegetation that caused slabs to become uneven. The annualized life-cycle cost of ramps was estimated at $232 each.

For sidewalks, inspections were performed every 10 years and the life-cycle strategy assumed that every 20 years repairs such as jacking or grinding slabs would be needed. A 40-year life was assumed. Annualized costs were estimated to be $269 for every 300 feet of sidewalk.

Risks included not meeting the needs of system users and the disabled community, not being Federally compliant, failure to comply with the agency's "complete streets" policy, failing to address funding gaps for these assets, and not receiving local consent agreements resulting in a lack of maintenance of these assets. Not meeting system user needs was assessed as a high risk, and the other risks were assessed as moderate ones.

As an investment strategy for the 10 years of the TAMP, MnDOT expects to expend $250 million on capital and maintenance for pedestrian infrastructure while an additional $104 million was estimated to be needed to achieve the condition targets.

Building and Rest Areas

The TAMP reported on 876 buildings including rest areas, weigh stations, truck stations, salt sheds, storage sheds, office buildings, and nearly 100 miscellaneous buildings for a total replacement value of $1.2 billion. Condition data were collected every three years, and data were stored in a facilities management system.

The performance measure was the share of buildings in Poor conditions based upon a Facilities Condition Assessment as assigned by inspections once every three years. The condition targets varied by type of building, and considered factors such as public visibility, essential services, and whether the building is habitable. For example, the target for rest areas was to have no more than 4 percent in Poor condition while for heated storage sheds the target was to have no more than 10 percent Poor. For salt shelters, the target was no more than 15 percent Poor. The TAMP stated that 12 percent of rest areas are in Poor condition, representing a performance gap. Some categories such as weigh stations faced no current gap but were projected to develop gaps over the 10 years of the plan. No building category was forecast to improve over the 10 years.

The life-cycle planning strategies for buildings varied by type and element. Different treatment types and schedules were defined for different buildings such as rest areas, unheated, and heated sheds. Strategies also were different for walls, floors, and other building elements. No typical life-cycle cost was calculated because of the differences among building types.

Risks included the inability to manage buildings effectively, lack of capital and maintenance funding, increased equipment size that requires larger buildings, and temporary or permanent rest area closures. All were assessed as high risk except for increasing equipment size, assessed as a medium risk.

The investment strategies for buildings was to spend an estimated $261 million over 10 years while an additional $132 million was needed to reach targeted levels.

ITS and Communication Assets

For ITS assets, MnDOT reported 15 classes of components including 703 miles of communication network, 1,343 traffic management system cabinets, 7,733 detector stations or site loops, 734 dynamic message signs, and 1,878 communication devices such as ethernet devices or video transmission equipment. The total replacement value for all 15 classes was estimated at $150.7 million.

The TAMP included a performance measure for the many diverse components within the ITS systems of the share of components that are beyond or are approaching their useful life. Condition is assessed continuously, and complete inspections for each asset range from yearly to every five years. Many of the 15 classes of ITS components did not meet the target. For example, the target was to have no more than 4 percent of fiber communication networks beyond their useful life while 10 percent exceeded the target. The target for dynamic message signs was to have no more than 7 percent beyond their useful life but 15 percent were beyond that age. Some assets exceeded the target. No rural intersection conflict warning systems or road and weather information systems were beyond their useful life. No total summation of what percentage of ITS assets failed to meet target was provided.

The TAMP included life-cycle strategies only for dynamic message signs as an example of how ITS assets are managed; strategies were not reported for each class of components. The TAMP indicated that dynamic signs are inspected annually. The life-cycle strategy includes replacing the fans every four years, the pixel boards every 10 years, and power supplies every 13 years. The estimated per year life-cycle cost per sign was $286 with an expected life of 15 years. That compared to a “minimum maintenance” strategy that replaced the signs every six years for a cost of $8,493.

Risks to ITS assets included construction or design flaws, inadequate maintenance funding and staffing, uncertainty over parties responsible for maintenance, ineffective vendor accessibility, technology obsolescence, and extreme weather. All were rated as medium risks.

The investment strategy was to spend $41 million over the next 10 years for ITS assets but an additional $67 million was required to achieve the condition targets. The TAMP estimated that $82.3 million was needed only for the metropolitan Minneapolis/St. Paul ITS equipment, and an additional $25.9 million for the remainder of the Statewide ITS network.

Connecticut's Management of Additional Assets

The Connecticut Department of Transportation's (CTDOT) 2019 asset management plan went beyond NHS pavements and bridges to include all State-owned pavements and bridges as well as five other asset classes: traffic signals, signs, sign supports, pavement markings, and highway buildings. CTDOT's asset inventory included:

- 4,017 bridges
- 3,718 center line miles of pavement
- 2,777 traffic signals
- 263,000 signs
- 1,654 sign supports
- 163 million linear feet of pavement markings and 2.2 million square feet of pavement symbols
- 488 highway buildings.

The CTDOT plan also included an indication of the data confidence level for each asset class the plan included. The TAMP included as improvements several steps to continue improving the data and analysis for the asset classes. It also included fact sheets summarizing the conditions and strategies surrounding each asset class. Those are available in Appendix B of the published 2019 CTDOT TAMP which is available online.

Traffic Signal Management

The TAMP stated that CTDOT assessed traffic signal condition based on age. The life cycle for a traffic signal was estimated to be 25 years with interim component replacements at varying intervals. Traffic signals between 0 and 15 years old were considered Good, ones between 16 and 25 were considered Fair, and those older than 25 years were considered Poor. Any signal installed within the past 25 years was classified in a state of good repair (SOGR). CTDOT's plan stated that 35.3 percent of signals were in Good condition, 39.2 percent in Fair, and 25.5 percent were Poor. It also estimated that the asset valuation of its signals was approximately $674 million.

The TAMP indicated that CTDOT's traffic signal inventory contains location, ownership, estimated energy use, pedestrian features, and other limited attributes. This database was developed years ago and was designed to meet operational rather than asset management needs.

For traffic signals, CTDOT included a projected performance at current funding levels of 70 percent in a state of good repair by 2020 and 64.6 percent by 2022. Its 10-year target was to have 80 percent of signals in a state of good repair.

Performance projections for traffic signals were developed based on the current CTDOT procedure for managing this asset. Each year roughly 130 traffic signals that have exceeded their service life would need to be replaced for this asset class to achieve its performance goal in future years. The TAMP indicated that CTDOT replaces each year approximately 60 signals. The TAMP stated additional traffic signals are upgraded each year under other highway projects and encroachment permits by developers. The TAMP forecasted that at current funding levels of $16 million annually, the percentage of signals in a state of good repair will decline from the current 74.5 percent to about 57.4 percent by 2028. The preferred investment level to achieve the target of 80 percent in a state of good repair would be $45 million annually.

Life-cycle strategies include replacing signals after 25 years, replacing based upon customer complaints or malfunction, replacing incidental to other projects, and replacing the light-emitting diodes every 8 to 9 years.

The risk management process identified risks related to inadequate signal inventories, possible inadequate maintenance staff, changes in regulations, and a risk of inadequate coordination between CTDOT work units that share responsibility for signals. Mitigation strategies involved increased resources, more coordination, and better inventories.

The TAMP indicated that traffic signal investment strategies are to:

- Continue efforts to develop and implement a Traffic Signal Management Plan (TSMP).
- Continue planning traffic signal replacement projects based on projected age.
- Continue efforts to develop traffic signal component-based life-cycle planning.
- Seek to improve traffic operations through enhanced signal control systems.

The TAMP also stated that the confidence level for traffic signal data was rated as medium. Process improvements included develop and implement a component and condition based approach to managing traffic signals, improve the capability of the Traffic Signals Database, and complete development and implementation of the Traffic Signal Management Plan.

Sign Condition Management

CTDOT manages signs and sign supports as two separate assets. The CTDOT plan defined signs as the sign panel. The sign support comprises the horizontal members, posts, vertical attachments, and foundation carrying sign panels or variable message boards. The condition ratings were based upon age with those installed within the past 17 years considered to be in a state of good repair. The sign condition rating was based upon the expected life of the signs' retroreflectivity. Signs less than 12 years old were rated Good, those between 13 and 17 years old were rated Fair, and those more than 17 years were rated Poor.

Sign condition was reported in two categories: limited access and non-limited access routes. In the limited access category, condition was reported as 33.3 percent Good, zero percent Fair, and 66.7 percent Poor. For the non-limited access routes, 30.5 percent were Good, 11.7 percent Fair, and 57.8 percent Poor.

CTDOT currently has a sign inventory that was developed in 2013 that involved capturing the sign locations based on the photolog images. CTDOT has imported that inventory into its linear referencing system (LRS). The TAMP indicated efforts are underway to improve the accuracy and quality of the sign inventory. CTDOT has recently implemented a procedure to capture changes in sign condition and/or location as they occur. Information on work done is being extracted from maintenance work orders and from construction contracts to get more updated sign condition and location information. Replacement of signs is also tracked and entered in to a module of the Maintenance Management System (MMS).

CTDOT's 2-year target for signs on limited access routes was to have 42.4 percent in good repair and for those on non-limited access routes at 41.1 percent. The 4-year targets were 54.5 percent and 43.4 percent respectively. The 10-year state of good repair goal was to have 80 percent of the limited access signs and 70 percent of the non-limited access ones in good repair.

The life-cycle strategies for signs included age-based replacement after 17 years. However, signs also may be replaced because nighttime visual inspections demonstrate a lack of retroreflectivity, corridor replacement efforts, signs replaced during safety projects, or signs replaced incidental to other projects.

The TAMP stated that each year 15,500 signs that have exceeded their service life would need to be replaced for this asset class to achieve its performance target in future years. The TAMP stated that CTDOT replaces approximately 5,000 signs each year that have exceeded their service life. Additional signs are replaced each year under other highway projects but these have not necessarily reached their service life. Funding need estimates include the cost of overhead sign supports and foundations that may not be in Poor condition but require replacement due to sign revisions. The TAMP forecasted that at the current funding level of $28 million annually for limited access route signs, that the performance target of 80 percent in good repair will be met by 2027. For non-limited access route signs, the current funding level of $2 million annually will improve current conditions but will not meet by 2028 the SOGR target. A preferred funding level of $3 million annually would be needed to reach the target of 70 percent.

Risks included safety risks to the public if signs deteriorate, risks caused by incomplete inventories, a lack of maintenance, and if posted signs do not match roadway conditions. Risks to sign supports achieving a SOGR included the lack of an adequate inventory. Mitigation strategies for supports and signs included improved inventories, improved sign sheeting materials, and the potential use of sign-replacement projects.

The TAMP reported that investment strategies for signs are to:

- Continue planning sign replacement projects based on projected age.
- Continue efforts towards replacing signs deemed Poor based on nighttime visual inspections.

CTDOT reported that the confidence level in the sign data was low. Sign management process improvements included to consistently capture date and sign attributes, update the 2013 sign data to reflect current inventory, and implement computer-aided design (CAD) and geographic information system (GIS) solutions based upon successful completion of pilots.

Sign Support Management

Sign support condition data are collected during inspections by the Bridge Safety and Evaluation Unit, typically every six years for full span overhead sign supports; four years for cantilever or bridge mounted sign supports; and two years for any aluminum sign supports, regardless of type. Sign supports in Poor condition are scheduled for more frequent inspections. As part of a sign support inspection, inspectors rate a sign support's condition through evaluation of the main components: (1) signs and illumination; (2) structure; (3) foundation; and (4) traffic safety features. Each sign support was geospatially represented by a single geographic positioning system (GPS) location point within the structure inventory software.

Sign support condition was measured using a 0-9 rating scale like with bridges. If the overall rating was 7 or greater, the sign support was classified as being in Good condition. If it was 5 or 6, the sign support was classified as being in Fair condition, and if it was 4 or less, the sign support was classified as being in Poor condition. The lowest of the ratings for the structure or the foundation determines the overall rating of the sign support. Sign supports with an overall rating of 5 or better are classified as being in Good repair.

The TAMP reported CTDOT has 1,654 sign supports with 41.7 percent in Good condition, 56.9 percent in Fair condition, and 1.4 percent in Poor condition. For sign supports, the 10-year SOGR goal was to have 90 percent in a state of good repair. The 2-year target was 96.6 percent and the 4-year one was 95.2 percent.

The life-cycle strategy for sign supports assumed supports should be replaced after 34 years based upon the assumption that sign panels with a 17-year life would be replaced twice during the life of the support. The TAMP indicated CTDOT was relying on an age-based life-cycle strategy until a deterioration model for sign supports could be developed. The TAMP indicated that sign support replacement is CTDOT's only treatment strategy.

Performance projections for sign supports were developed based on the current procedure for managing this asset. CTDOT used deterioration curves based on a 34-year service life of a sign support. The scenario assumed current funding of $4 million per year and that replacement of 40 percent of sign supports in Poor condition will be included in other types of projects. Based on current funding levels, the TAMP forecasted that CTDOT will exceed its SOGR target for sign supports through 2026 with conditions declining to 84.2 percent after 2027.

For sign supports the investment strategies are to:

- Continue programming sign support projects based on Poor or overstressed conditions.
- Continue efforts to reduce the number of sign supports whenever possible by removing and replacing with signs mounted along the side of the road.
- Increase efforts to maintain sign panel sizes by reducing the legend spacing to minimize the number of unnecessary replacements.
- Overdesign sign supports with a larger safety factor to accommodate larger sign panel requirements anticipated in a future version of the Manual on Uniform Traffic Control Devices (MUTCD) to minimize the number of unnecessary replacements.

CTDOT reported that data confidence was low for sign supports. Sign support procedure improvements included to maintain the inspection cycle, complete development of condition-based deterioration modeling, and complete the procedure to allow for tagging of sign supports as assets in projects.

Pavement Marking Management

The CTDOT TAMP organized pavement markings into two categories: line striping measured in linear feet, and symbols and legends (arrows, crosswalks, etc.) measured in square feet. Both categories can be applied as either water-based or epoxy. A state of good repair was based upon whether in-laid epoxy pavement markings were installed within 6 years, epoxy pavement markings installed within the past 3 years, and water-based pavement markings installed within 1 year. These measurements were based on expectation of retroreflectivity life and wear. Pavement markings older than the years identified were classified as Poor. The TAMP stated because of the short life cycle of pavement markings, CTDOT does not include a Fair rating.

Of the line striping, CTDOT reported 27.4 percent was Good and 72.6 percent Poor. For the symbols and legends, 55.1 percent were Good and 44.9 percent Poor. Pavement markings had an estimated asset value of approximately $89.2 million.

The TAMP indicated the life-cycle strategy was to replace the markings at the end of their expected life cycle, replace water-based markings with epoxy markings whenever possible, and replace the epoxy markings on a 3-year cycle. Risks to pavement markings included insufficient staff to replace them on time, uncertain funding, bad weather that restricts application windows, malfunctioning equipment, and insufficient maintenance of traffic protection crews to protect striping crews. Mitigation strategies included increased resources to sustain condition targets.

The TAMP forecast that conditions for both line markings and symbols will remain below target based upon current funding levels. The current funding level of $6.5 million annually for lines will only result in 36.7 percent of lines in good repair by 2028. For symbols, condition forecasts were better but still below target. The TAMP forecast that annual spending of $1.5 million annually for symbols would result in 64.2 percent of the inventory in Good condition compared to a target of 75 percent. The preferred investment levels for lines was $20 million annually and for symbols $5 million.

Pavement marking investment strategies were to:

- Continue efforts towards developing a pavement markings replacement program to obtain a State of Good Repair across the network.
- Continue to invest in epoxy pavement markings.
- Consider increasing investments in grooved epoxy markings where applicable

CTDOT reported that data confidence was very low for pavement markings. Pavement marking procedures improvements included develop a consistent network investment cycle, improve methods to track and maintain pavement marking data, seek alternative contract methods, and investigate the effects of carbon snow plow blades on the life expectancy of markings.

Building Condition Management

The condition of CTDOT highway buildings was based on a combination of age-based and condition-based component ratings. Components with known or industry standard life cycles, such as roofs and boilers, were assigned calculated ratings based on an installation date. Components without known life cycles, such as interior building finishes, were assigned a rating based on a visual inspection.

Individual component ratings were weighted and averaged to provide an overall building score. An overall building score of three or higher on a scale of one to five was rated in good repair. A building with an overall building score lower than three was not. CTDOT’s performance measure was the percent of buildings maintained in good repair.

Buildings were grouped into four tiers. Tier 1 buildings are significant structures from a size, function, or cost perspective and are normally occupied by employees or the public. Tier 2 buildings are like Tier 1 except they are not normally occupied by employees or the public. Tier 3 buildings are much smaller than Tier 1 or Tier 2 structures but are vital to supporting maintenance operations or portable office functions. Tier 4 buildings are tracked as assets but not included in the TAMP.

The TAMP reported that of Tier 1 buildings, 85.4 percent were in a state of good repair. Of the Tier 2 buildings, 96 percent were in a state of good repair and of Tier 3 buildings 69 percent were in a state of good repair. Overall, 331, or 79.6 percent of buildings were in good repair and 85 or 20.4 percent were Poor. The valuation of all Tier 1, 2, and 3 buildings was approximately $858 million.

The TAMP forecasted conditions separately for Tier 1, Tier 2, and Tier 3, buildings. Tier 1 buildings were funded at $43 million annually and conditions were expected to decline from about 85 percent in a state of good repair to 70.6 percent by 2028. For Tier 2, current annual spending of $11 million was expected to sustain conditions above the target of 80 percent. For Tier 3, annual spending of $100,000 annually was expected to result in conditions falling to 39.6 percent in good repair compared to a target of 50 percent.

Risks to buildings included that if the deterioration of the Tier 3 buildings is not addressed, then employees could be injured and equipment damaged. Other risks were a lack of maintenance staff to perform preventive maintenance, and that if CTDOT does not keep condition data current then it will not have a data-driven building maintenance program. Mitigation strategies included prioritizing Tier 3 buildings, replacing maintenance staff as they leave, and implementing a facilities management system.

Investment strategies were to:

- Demolish obsolete highway buildings to eliminate safety hazards.
- Meet regulatory requirements associated with petroleum and chloride storage tanks.
- Focus on maintenance activities that directly improve asset performance.
- Focus on preservation projects to extend assets' life cycle.
- Continue to refine the Highway Building program to achieve and maintain a SOGR across all building tiers.
- Acquire Facilities Management System software.

CTDOT reported the confidence level in the building data was medium. Process improvements included refine the building scores, refine the building inspection report formats, and implement a facilities management system.

CTDOT Strategies for Managing Assets

One of the concluding TAMP statements was that the life-cycle planning process helped CTDOT consider the costs of maintaining an asset throughout its life. LCP also helped the DOT identify the optimal strategies for preserving asset condition while minimizing costs. CTDOT's LCP approach for bridge and pavement assets was relatively advanced. It analyzed component condition ratings using management systems and developed management strategies. Life-cycle planning for traffic signals, signs, sign supports, pavement markings, and highway buildings were less mature processes. CTDOT used age-based replacement for these assets and was starting to invest in and improve modeling capabilities. The results of the life-cycle planning processes were used to define the TAMP financial plan and investment strategies.

Utah DOT's Managing of Additional Assets

The Utah Department of Transportation's (UDOT) asset management plan included numerous assets besides pavements and bridges, categorized in tiers based upon their asset value and the complexity of the assets' management processes. UDOT Tier 1 assets were all NHS and State pavements and bridges, advanced traffic management system (ATMS) assets, and signal devices. The TAMP categorized them as "performance-managed" assets. The UDOT plan stated that Tier 1 assets have the highest asset value combined with the highest risk of financial impact if poorly managed. These assets are very important to

UDOT performance and are recommended for a significant and separate dedicated funding source. Tier 1 assets were managed with:

- Accurate and sophisticated data collection.
- Targets and measures set and tracked.
- Predictive modeling and risk analysis.
- Dedicated funding through UDOT's annual STIP process.

For illustrative purposes, the TAMP included information about the Tier 2 and Tier 3 assets. Tier 2 assets included:

- Pipe culverts.
- Signs.
- Walls
- Rumble strips.
- ADA ramps.
- Barrier.
- Pavement markings.

The UDOT plan stated that Tier 2 assets are of moderate value and substantial importance to transportation system operation. The TAMP categorized them as "condition-managed" assets. The TAMP stated these assets have a moderate risk of financial impact if poorly managed. As with Tier 1 assets, these assets have separate funding sources. Tier 2 assets are managed with:

- Accurate data collection, less than annually.
- Risk assessment primarily based on asset failure.
- Condition targets.
- Management strategy based on condition.

The TAMP noted that Tier 3 assets were:

- Cattle guards.
- Interstate lighting.
- Fences.
- Rest areas.
- Curbs and gutter.
- Trails.
- Bike lanes.
- Surplus land.
- At-grade railroad crossings.

The TAMP categorized Tier 3 assets as "reactive-managed" assets and noted that Tier 3 assets are managed primarily upon failure, general condition analysis, and repaired or replaced when damaged.

They were described as having the lowest asset value with the lowest risk of negative impact for poor management or asset failure. Management of them included:

- Risk assessment based on asset failure.
- General condition analysis.
- Reactive management involving repair or replacement when damaged.

UDOT's Emphasis on the Asset Register and Asset Valuation

The Utah plan emphasized the importance of an asset register and asset valuation. The value of the assets and their importance to the operation of the system determined their categorization into the three asset tiers. The value also played a role in assessing risks to their performance which will be described below in the risk management section. The TAMP stated that UDOT used several data-collection methods such as the visual inspection of bridges, machine-collected pavement data, and the use of Light Detecting and Ranging (LiDAR) technology for assets such as barriers. It stated that the assets were organized into inventories based on number, location, and condition. The TAMP showed the replacement value of each asset class based upon bid item values and other means to establish the replacement cost. For example, although the number of assets was not identified because of the many component elements, the value of ATMS devices was shown to be $479 million. For signals, the TAMP identified a replacement value of $314 million.

The Role of Risk Analysis in Developing UDOT's Asset Management Tiers

The risk analysis effort contributed to the allocation of the assets into the three tiers. The tiering allowed the allocation of the greatest resources to the asset classes that presented the greatest risk. Risk to the UDOT program is evaluated by asset in four programmatic areas: financial, information, operational, and safety.

Risk probability and consequence were identified to assess risk severity and used to determine if risks to the asset class were high, medium, or low. Risks were assessed for bridges, pavements, ATM assets, and signals. Based upon the risk to an asset class and to the value of the asset class, each class was assigned to one of the three tiers.

Pavements, bridges, ATMS assets, and signals were assigned to Tier 1 because they faced the highest overall risk to system performance, and they had the highest value. Walls had much higher asset values than did ATMS assets and signals, but walls were assessed as facing lower risks and so were categorized in Tier 2.

The UDOT plan included the following strategies and policies to mitigate each category of risk.

- Financial risk was mitigated first by focusing resource allocation toward accomplishment of UDOT Strategic Goals. Short-term financial risk was mitigated by maintaining Tier 1 assets in good condition so that potential years of reduced funding do not create critical conditions for these assets. Financial risk was also mitigated by transparent and data-driven spending, which builds trust with State leaders and taxpayers.
- Information risk was mitigated by using advances in technology to collect data more regularly, accurately, and completely at reasonable costs. These data were stored and mined to create information trends and history for roadway assets. Technology advances were continually monitored and implemented to improve data collection efficiency and accuracy.

- The plan for mitigating operational risk was to institute an intermediate-level planning process across the State. The sections on system risk below further explain this plan.
- Safety risk mitigation was the focus of the Zero Fatalities, Crashes and Injuries strategic goal. This goal focused project planning and funding of design and construction elements that will increase safety within project limits.

In addition to the programmatic risks, UDOT addresses the operational risks using a system or corridor level approach. UDOT completed a data-driven risk analysis of portions of I-15 and initiated a second pilot project to refine the approach and establish a standard workflow that can be implemented system wide. The risk assessment served as a pilot that examined I-15 in terms of its capacity to serve demand and its ability to withstand environmental threats. UDOT called this a Risk and Resilience (R&R) pilot. The pilot demonstrated the benefits of examining a highway corridor from both its capacity and its risk from environmental events such as slides, floods, or seismic events.

The TAMP stated the current plan is to expand the data-driven risk analysis to other corridors and over time to the entire NHS. The results of this analysis will be captured on GIS maps and made available to all UDOT functions. The TAMP indicated that with this knowledge, UDOT can more thoroughly address risk in project planning and construction.

Performance Measures and Life-Cycle Planning for the ATMS

The Utah TAMP included State and Federal performance measures for the Tier 1 assets. For ATMS components, the performance measure was the percent of devices in operational condition. The TAMP stated the ATMS assets are composed of several types of devices and the measure and the target are tracked separately and reported monthly for each type of device and averaged into a composite score. The target is to have 95 percent of the system in operational condition. A performance trendline indicated that in 2010, 90 percent of devices were operational; by 2018, conditions rose to 98 percent operational. Performance declined slightly to 97 percent by 2019.

The TAMP indicated that while overall the devices exceeded the 95 percent performance target, various components within the ATMS assets were beyond their expected life and were not operational or were not fully operational. The TAMP reported a backlog in replacement of some network components, including road and weather information system components, communication switches, closed circuit television (CCTV) components, or freeway operations system components. The TAMP indicated that based upon the reported backlog, the Utah Legislature allocated $3.9 million annually for device replacement and upgrades. The TAMP reported that over the next few years, the backlog will be eliminated and critical devices replaced as they reach the end of their life, or before they are projected to fail. This effort was supplemented by devices that are replaced as part of other projects.

The TAMP stated that UDOT has determined that the most effective ATMS management strategy is to consider the entire life cycle of each device type. Like the long-term strategy used for pavement and bridges, the DOT implemented a “Plan for every ATMS device” that addressed the device from cradle to grave. As part of this plan development, UDOT Traffic Operation and region staff participated in a workshop to determine the perceived relative value of the ATMS devices. The workshop resulted in a prioritization of devices and determination of which should be replaced on schedule and which should be allowed to fail before replacement. The highest priority devices were the communication network, ramp meters, express lanes, roadway weather information systems, closed-circuit television, variable message signs, and variable speed limit devices. The plan for each device was to:

- Estimate the year that each device will fail by projecting the expected service life from the installation date.

- Assign the replacement year based on the estimate and the relative importance of the device as determined in the earlier workshop.
- Determine which devices will fall into each construction year and include them in the project scope and funding.
- Replace the highest priority devices first in each funding year.

At the time of the TAMP publication, the life-cycle strategy was under development but the immediate strategy that the TAMP reported was to:

- Give top priority to system-critical elements such as those that would shut down the signal system, if they failed.
- Give second priority to electronics at or near the end of their estimated 10-year life.
- Further priority consideration is a shift in technology that creates benefits to capacity, preservation, or safety, and which has benefits greater than the cost.

Performance Measures and Life-Cycle Planning for Signals

For signal system performance, the TAMP included a State performance measure of the percent of signals in Good or Fair condition based on annual inspection of all electronics and physical infrastructure associated with the signals. The target was 95 percent in Good or Fair condition.

The TAMP reported that the signal system condition was and had been historically below the target. Minor repairs are made throughout the year with maintenance money. Replacement and installation of new signals is funded through projects. The TAMP included the following management plan to reach the signal condition target.

- Update the signal assessment process to make it more objective and consistent across the State.
- Map signal conditions in UDOT's interactive mapping platform called UPLAN.
- Communicate signal replacement and upgrade needs to the regions so they can incorporate the costs into the project scoping and construction estimates for projects.
- Replace the highest priority locations first with the available money.

The TAMP stated that signals will be replaced or installed within project scopes based on funding availability and the expected contribution to system operations.

Financial Planning and Investment Strategies for Non-Pavement and Bridge Assets

The financial plan included not only NHS and State pavements and bridges, but also 10-year annual estimates of program amounts for the ATMS and signal assets. Programming fund amounts for those two categories were further divided by NHS and non-NHS amounts. For example, the TAMP included NHS funding for ATMS assets of $4.5 million annually through 2027 and $3.5 million annually for NHS signals. For non-NHS ATMS assets, the funding is at $200,000 annually and for non-NHS signals $2.1 million annually.

For ATMS assets, the TAMP included a breakdown of how much would be allocated for each component category. For example, variable message sign funding differed by year, with the largest allocation of $3.2 million planned for 2021. Allocations to transportation management system assets also varied by year, with the largest expenditure planned for 2020. In all, $17.7 million was identified by asset sub-group through 2021, when the backlog was predicted to be eliminated. The TAMP stated that the performance management plan for ATMS assets created a condition-tracking system that will provide over time a better understanding of the life cycle of each asset in the Utah environment. The TAMP stated that future funding requests will be based on the analysis of the growing body of data about ATMS components' life cycle and upon the growing number of ATMS assets.

Two investment strategies were stated for ATMS assets. One is to replace the highest value devices prior to the end of their expected life. The second was to maximize funding by replacing devices within projects developed for other assets. The Traffic Operation Center staff plan to coordinate with region staff during the project planning and scoping phases to incorporate, where feasible, ATMS device repair or replacement.

The TAMP stated that a procedure for documenting and analyzing signal system rebuilds was being established. The procedure included:

- Evaluate each signalized intersection approximately yearly to rate it from 1 to 5. Items to be inspected include steel condition, traffic signal heads, cabinets, underground components, and pavement quality. A Poor condition signalized intersection will be rated 1 and a newly rebuilt intersection will be rated as a 5.
- The target threshold will be 95 percent Fair or better.
- Intersections rated 1 or 2 will be prioritized for and rebuilt with the appropriate funding.
- Signal replacement and upgrade needs will be reported to regions to incorporate them into projects.

The TAMP included the following three investment strategies for signals:

- Conduct preventive maintenance regularly to meet the 95 percent target.
- Implement an emergency maintenance response plan for use when emergencies occur.
- Apply the established maintenance management process to minimize equipment downtime and expected failures.

California's Managing of Multiple Assets

The California Department of Transportation (Caltrans) developed its 2019 TAMP under the Federal 23 CFR Part 515 framework as well as to abide by a separate State asset management plan regulation. For the four primary assets, the California State regulation mirrors the requirements of 23 CFR Part 515 but has lesser requirements for the supplementary assets.

The Caltrans 2019 asset management plan included four primary assets and nine State-managed supplementary assets. The primary assets were pavements, bridges, drainage assets, and transportation management system (TMS) assets. The supplementary assets, addressing only the California State regulations, included drainage pump plants, highway lighting, office buildings, overhead signs, roadside rest facilities, transportation-related facilities such as garages, weigh-in-motion scales, park and ride lots, and an accessibility category that included sidewalks and Americans with Disabilities assets.

Caltrans' Management of Drainage and TMS Assets

Caltrans uses the following State performance measures for drainage assets:

- Percentage of drainage assets in Good condition, weighted by linear feet.

- Percentage of drainage assets in Fair condition, weighted by linear feet.
- Percentage of drainage assets in Poor condition, weighted by linear feet.

The TAMP stated that inventorying of drainage assets was not yet complete and that more linear feet will be added to the inventory annually. Each drainage asset was assessed based upon a visual inspection of the waterway adequacy, joint condition, the material, the drainage item's shape, and its alignment. The TAMP reported 65 percent of the assets were in Good condition, 23.5 percent Fair, and 11.5 percent were Poor. The 10-year target was to have 85 percent in Good condition, 10 percent Fair, and no more than 10 percent Poor.

The life-cycle strategy for drainage assets was based upon a 50-year cycle starting with the installation of a new culvert or the restoration of an existing one. The cycle included regular maintenance at 5-year intervals with a rehabilitation such as invert paving of the culvert bottom at year 30, with further maintenance every fifth year concluding at year 50 with a culvert restoration or a new culvert depending upon condition.

The drainage assets were valued at $21.3 billion and the TMS assets at $2.2 billion. The 10-year target for TMS assets was to have 90 percent in Good condition and no more than 10 percent in Poor.

For TMS assets, the TAMP stated that components include vehicle detection equipment, ramp meters, changeable message signs, highway advisory radio, fiber optic lines, and software that supports transportation management centers. The TAMP classified TMS assets in a binary fashion as being either Good or Poor. Good condition indicated that the asset is operational and not obsolete. Poor condition indicated that the asset is either obsolete or non-operational. Within the TMS category, ITS assets comprise most assets by value and importance. The TAMP indicated that as of 2019 there were 18,837 assets with 58.8 percent of them in Good condition and 41.2 percent in Poor condition.

The life-cycle plan for TMS assets varied by the component. The TAMP stated that Caltrans developed a model with different deterioration rates and life cycles for different assets such as closed-circuit television or ramp meters. Based upon the current assets' age, condition, and presumed life cycle, the TAMP stated that Caltrans modeled how many of which type of assets would age past their expected life each year. Based upon the modeled end of life for each component class, Caltrans could determine a needed annual investment level to sustain the network.

The Caltrans TAMP states that the TMS master plan is essential to the agency's intended life-cycle planning. When developed, the plan is intended to detail deployment needs for new TMS installations and discuss life-cycle needs for existing elements. The plan will be used to guide Caltrans on the cost of maintaining the TMS inventory, as well as to provide guidance on when to decommission existing components as new technologies come onto the market. The TAMP noted that additional maintenance and operations staff will be needed as the TMS inventory expands.

The Caltrans TAMP showed a small current gap in drainage asset conditions but a 31.2 percent gap for TMS assets. For both assets, it predicted that based upon the TAMP's investment strategies that the gaps will be eliminated within 10 years.

Although not part of the TAMP subject to the annual consistency review, the "supplementary" assets included in the TAMP, addressing the California State regulations, provided forewarning that several of the other asset classes face current and future condition gaps. For example, the TAMP noted that pump stations face a current 46.6 percent performance gap that will reduce to a 9.3 percent gap by 2028. At the end of 10 years, highway lighting faces a 39.9 percent performance gap, office buildings a 26 percent gap, overhead signs an 11.4 percent gap, roadside rest areas a 51.2 percent gap, sidewalks and ADA assets a 17.7 percent gap, facilities such as garages a 65.1 percent gap, and weigh-in-motion scales, a 31.8 percent gap.

The Caltrans financial plan reported a substantial increase in drainage and TMS asset allocations compared to baseline expenditures. The baseline included the funding before a substantial revenue increase known as "Senate Bill 1." The baseline funding for drainage assets per year was $108 million and the TAMP indicated that will rise to an average annual of $494 million. For TMS assets, the average annual investment is shown to increase from $106 million to $211 million.

Conclusion

The 2019 transportation asset management plans demonstrated an evolution in the management of assets by moving beyond only NHS pavements and bridges to a larger variety of assets. Although States may include more limited information about such additional assets (23 CFR Part 515.9(l)) in their TAMPs, the inclusion of information about the additional assets still helps legislators and the public understand the current and future condition of more of the agencies' assets. The TAMPs discussed in this case study demonstrated that agencies can develop inventories for many asset classes, assess their condition, develop life-cycle strategies for them, and predict the investment needs for those assets. The result of these efforts is a more comprehensive understanding of the States' transportation assets and what is needed to sustain them in a state of good repair.