

Improving the Link Between Pavement Design and Asset Management: An Asset Management Primer for Pavement Engineers



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16. Abstract <p>In 2018-2019, the Federal Highway Administration (FHWA) conducted a review of its long-standing pavement design policy (23 CFR Part 626). Part of the review involved extensive stakeholder outreach to both State Departments of Transportation (DOTs) and Industry to solicit feedback on the policy and related guidance. Participants at several outreach events commented that clarity was needed regarding how pavement design policies relate to the State's Transportation Asset Management Plan (TAMP).</p> <p>The FHWA recognized a need to further understand how project-level pavement design and network-level asset management could be better linked to help DOTs achieve long-lasting, safe, durable, cost-effective pavements. To identify potential strategies for improving the link between pavement design and asset management, FHWA conducted a case study of the New Jersey DOT and reviewed practices at several other State DOTs. Upon completion of this effort, a workshop was held to bring the participating State DOTs together to discuss the identified strategies and assess whether they could be adapted for use by other State DOTs.</p> <p>The primary output of the case study is a set of web pages that contain information on the key roles and responsibilities of pavement design, pavement management, and transportation asset management (TAM) units. The website also contains information on potential strategies for establishing links between these units including critical communications and feedback loops that may be helpful in ensuring that the agency's processes and procedures are focused toward common goals of maximizing pavement performance while minimizing long-term costs.</p> <p>The purpose of this document is to provide an overview of TAM for pavement engineers and other transportation professionals. This document provides information on TAM policies, roles, functions, processes, inputs, and outputs. More detailed information on TAM can be found from numerous other sources that are referenced in this document.</p>			
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INTRODUCTION

Purpose

This document provides a brief overview of transportation asset management (TAM), focusing on how TAM is relevant to pavement design and pavement management practices. Additional information on TAM can be found at <https://www.fhwa.dot.gov/asset/>.

Background

Transportation agencies such as State Departments of Transportation (DOTs) are responsible for operating, maintaining, improving, and expanding the approximately 8.8 million lane-miles of public roads and highways in the United States (USDOT 2020). In the past decade, growth of the physical highway infrastructure has slowed, with the total lane miles of pavement increasing by only 0.5 percent since 2010 (USDOT 2020). This slowing of system growth is occurring as the focus of improvements to public roads has changed from the creation of new routes to managing existing routes.

TAM is both an approach and a set of tools that can be applied to manage any class of asset across an entire highway network. The application of these tools is typically focused on the network level to achieve agency-wide goals. However, TAM can be applied at lower organizational levels such as districts or metropolitan planning areas to help balance resources to best achieve overall agency objectives. Thus, asset management provides a framework through which DOTs:

- Establish long-term strategies for optimizing network-wide conditions for pavements and other assets based on available funding.
- Explain funding needs.
- Identify maintenance and construction projects that will best align with the selected strategy.
- Track pavement (and other asset) performance.

Transportation Asset Management is...

- Policy-Driven
- Performance-Based
- Risk-Based
- Strategically Aligned with Agency Priorities
- Transparent
- Information-Driven / Evidence-Based
- Option Oriented

(Source: AASHTO, 2019)

TAM is “a strategic and systematic process of operating, maintaining, and improving physical assets, with a focus on both engineering and economic analysis based upon quality information, to identify a structured sequence of maintenance, preservation, repair, rehabilitation, and replacement actions that will achieve and sustain a desired state of good repair over the life cycle of the assets at minimum practicable cost” (23 CFR 515.5). TAM involves a long-term, network-level approach to analysis and strategy development. States are required to develop risk-based TAMPs for the National Highway System (NHS) ([23 U.S.C. 119\(e\)](#)).

The transportation asset management plan (TAMP) describes how a State DOT will carry out transportation asset management ([23 CFR 515.9\(a\)](#)), as required under [23 USC 119\(e\)](#). The TAMP must cover at least a 10-year period ([23 CFR 515.9\(e\)](#)), and include, at a minimum, the pavement and bridge assets on the NHS ([23 CFR 515.9\(b\)](#)), but States may also include other assets and highway networks in their TAMPs ([23 CFR 515.9\(c\)](#)). In contrast, pavement design is a project-specific process that seeks to establish the best engineering solution within project scope, budget, and other constraints. As a result, many State DOTs and local agencies are applying the same principles to their non-NHS assets.

TAM also helps support national goals and performance management measures “to provide a means for the most efficient investment of Federal transportation funds” ([23 U.S.C. 150\(a\)](#)). State DOTs are required to set performance targets for NHS pavements and bridges ([23 USC 150\(d\)\(1\)](#)) and submit a report to the Secretary of Transportation every 4 years describing State DOTs progress in achieving the performance targets. TAM investment strategies are developed to support the achievement of asset condition and system performance targets at the minimum practicable cost ([23 CFR 515.5](#)).

TAM involves the establishment of objectives for operating, maintaining, and improving physical assets throughout their life-cycle at minimum practicable cost. Policies and procedures help to guide an agency’s activities toward achieving these objectives. Agencies rely on technology and data to carry out these procedures and to inform decision-making. This document focuses on the TAM policies, functions, processes, and data that apply to managing pavements. This information is presented to provide a better understanding of how pavement design and pavement management practices can be better linked to TAM.

ASSET MANAGEMENT POLICIES

Executive-level policies within the State DOTs typically set the broad direction for agency objectives and actions, including the implementation and administration of TAM and pavement program development. Some agencies have chosen to develop policies to specifically support TAM implementation. TAM policies typically establish direction for:

- Funding priorities among different asset classes (pavement, bridge, operations, etc.).
- Establishing a formal desired state of good repair (SOGR) and condition targets.
- Establishing program priorities such as minimizing congestion or stewardship of the network.
- Balancing stakeholder requests with goals and risk-based decision making.

Some DOTs have established their own policies specific to asset management. These policies may:

A TAMP is...

“a document that describes how a State DOT will carry out asset management as defined in this section. This includes how the State DOT will make risk-based decisions from a long-term assessment of the NHS, and other public roads included in the plan at the option of the State DOT, as it relates to managing its physical assets and laying out a set of investment strategies to address the condition and system performance gaps. This document describes how the highway network system will be managed to achieve State DOT targets for asset condition and system performance effectiveness while managing the risks, in a financially responsible manner, at a minimum practicable cost over the life cycle of its assets” ([23 CFR 515.5](#)).

- Describe the scope of the asset management program.
- Describe how asset management data and analysis will be used to support agency decisions.
- Establish an expectation of how these TAM-related processes or business units should coordinate.
- Define expectations.
- Describe desired courses of action.
- Establish goals in terms of desired future outcomes.
- Determine criteria or procedures that will be followed when managing assets, e.g., pavements.
- Identify guiding principles to be used in TAM-related processes such as pavement management or pavement design.
- Reinforce the importance of specific procedures or requirements.

TAM policies are typically high level and tied to agency-wide objectives. The following bullets highlight key aspects of typical TAM policies related to:

- *Financial and Programming Policies.* DOTs develop and implement a wide range of financial policies and procedures to support delivery of their pavement programs. Policies related to how revenue sources are allocated to programs can form a strong link between pavement management and the TAMP. These include:
 - Revenue or fund source policy typically set by entities that oversee or provide the funding to the DOT, such as State or Federal governments.
 - Funding allocation policies that may be established by the DOT or imposed on the DOT from another authority. These policies guide how funding is dedicated to address specific needs, programs, or geographic areas and are closely related to an agency’s organizational structure and control format, e.g. centralized, decentralized, or hybrid.
- *Performance Management Policies.*
 - [23 CFR part 490](#) contains the Federal requirements for the performance management of pavement conditions to help guide State DOT policies.
 - State DOTs often have separate performance management policies that establish goals, objectives, measures, and targets, or a desired SOGR for pavement conditions.
- State DOTs may establish policies for performance areas that can be impacted by pavement conditions such as safety and mobility.

ASSET MANAGEMENT ROLES AND FUNCTIONS

Asset management is a category of activities that describe the processes and actions performed to manage a wide variety of assets. While these practices can vary considerably in their specifics, there are common roles and functions within an organization that are common to the various asset classes. The AASHTO Transportation Asset Management Guide (AASHTO 2019) describes several asset management functions. Use of the functions within this Guide is not a Federal requirement.

- Collecting network-level data to monitor the inventory and condition of assets.
- Developing desired and expected levels of service (LOS) or SOGR.

- Performing gap analysis to compare actual performance with desired performance.
- Managing risk, i.e., threats and opportunities related to the achievement of agency objectives.
- Understanding the potential for asset failure and developing intervention strategies.
- Developing strategies to manage assets throughout all life cycle stages.
- Quantifying available resources (e.g., financial), resource needs, and gaps.
- Optimizing the use of available revenues to achieve agency objectives.
- Identifying and prioritizing appropriate investments in each work type: new construction, maintenance, preservation, rehabilitation, and reconstruction.
- Allocating resources and prioritizing work based on both short- and long-term performance.
- Providing internal and external stakeholders with timely, accurate, and relevant information.
- Developing and documenting asset management practices through the TAMP with continuous improvements based on feedback.

Each DOT has its own way of organizing around these functions. DOTs should also coordinate with other public and private organizations, e.g., metropolitan planning organizations (MPOs) or toll authorities, to manage the overall highway network. Similarly, each of those agencies should have its own organizational approach and practices for delivering these functions. Understanding how these functions are delivered in each agency can help DOTs align their diverse set of internal business units with each other and external stakeholders. Strategic coordination and communication guide these groups to work together to achieve the network-level asset management goals and to support agency policies and priorities.

ASSET MANAGEMENT PROCESSES

A DOT carries out the strategic processes of asset management as established in an agency's TAMP. These processes, described below, are used for planning, programming, and project development efforts.

Inventory and Condition Assessment. TAM is data intensive, involving the regular collection of asset inventory and condition data to establish objectives and monitor asset conditions. The complexity, precision, and frequency of data collection can vary widely between asset classes, highway networks, and agencies. Historical condition data are used to establish long-term predictive models that allow conditions to be forecast under different potential scenarios. Scenarios may vary in terms of funding, strategies for determining needed work, and network priorities. In some cases, inventory and condition data may be estimated based on the evaluation of a statistically valid sample of the full inventory.

Performance Measures, Targets, and Objectives. Asset performance is assessed in terms such as physical conditions as well as the relationship between physical conditions and the overall performance of the highway system. Performance assessments are made in terms of specific measures, such as those established in [23 CFR part 490](#). Agencies establish performance targets for each measure to quantify the level of performance to be reached within a specific time frame. In addition to time-bound targets, State DOTs can also establish other objectives such as a desired SOGR for each asset class. A desired SOGR is typically established as an average condition state for the entire highway network or a significant subnetwork (e.g., interstate highways). The desired SOGR for each asset is established by the agency; it is not a Federal requirement.

Performance Gap Analysis. A performance gap is the difference between the current asset condition and the desired, or target, condition. The gaps in system performance effectiveness are best addressed by improving the physical assets ([23 CFR 515.5](#)). The process of performance gap analysis involves comparing current and predicted levels of performance to the desired levels.

Life-Cycle Planning (LCP) is “a process to estimate the cost of managing an asset class, or asset sub-group, over its whole life with consideration for minimizing cost while preserving or improving the condition” ([23 CFR 515.5](#)). For pavements, LCP is performed using a pavement management system that meets the requirements of [23 CFR 515.17](#). The steps of an LCP analysis are shown in figure 1. This involves an assessment of current conditions and a means of forecasting future conditions. Agencies can assess the likelihood of attaining the asset management objectives in the short- and long-term through scenario analysis. LCP analysis considers different potential constraints (e.g., funding levels or treatment options) that the agency may face in trying to attain asset management objectives. Specialized software tools designed for asset management analysis are typically used for complex assets with multiple performance measures and treatment options (e.g., pavements). For pavements and bridges included in their TAMPs, State DOTs must use management systems meeting the requirements of [23 CFR 515.17](#).

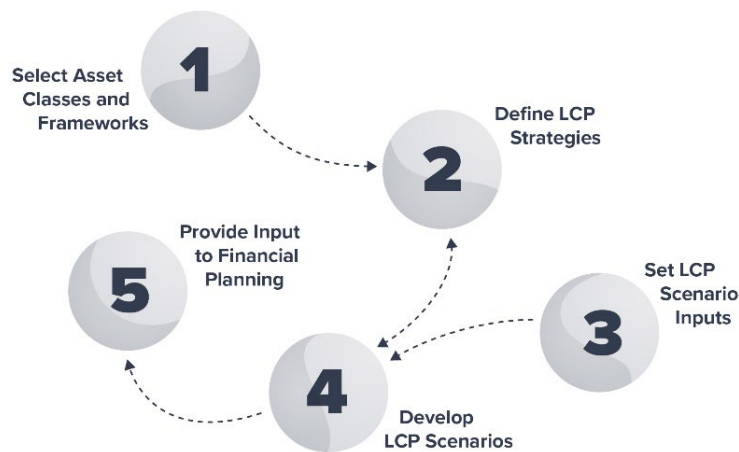


Figure 1. Life-cycle planning process.

Risk Management. Risk-based asset management considers the impact of uncertainty in investment decisions. A risk-based TAMP is one that identifies, assesses, and prioritizes the uncertainties, variability, and threats that could impede or enhance achievement of its objectives. A risk-based plan may also make trade-offs based on risk assessment. Limited resources may be prioritized to high-risk assets or to make the transportation network more resilient to threats. A risk-based TAMP may also include risk appetite statements, or the level of risk that an agency is willing to accept. For example, an agency may experiment with new but promising treatments knowing they are not risk free but could provide higher performance for lower costs. Or an agency could allow a low-risk asset to deteriorate below its desired target to address a higher-risk structure or traffic-control device. A typical risk management process is shown in figure 2.

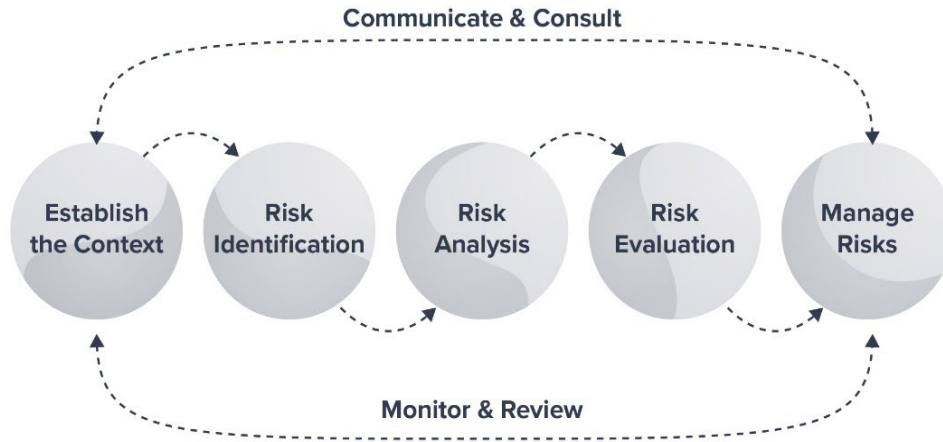


Figure 2. The risk management process.

TAM Financial Planning. Financial planning starts with identifying the funds available to the agency for investing toward achieving the asset management objectives. Not all of the funding received by a DOT can be used to preserve or improve infrastructure conditions. Some funding is dedicated to other purposes such as system operations or transportation alternatives. Asset managers work with transportation planners and financial officers to estimate the amount of funding that can be used to maintain or improve the condition of assets included in the TAM. This estimate is made for each year of the TAM. The estimated future funding is then compared to the level of the funding needed to achieve the agency's asset management objectives, e.g. condition targets and desired SOGR. If there is an imbalance between the available funding and the need, the DOT can determine if funding can be increased, decreased, or transferred to close the gap. Agencies can also choose to raise or lower objectives.

A TAM financial plan provides a basis for the allocation of resources and prioritization of work to achieve asset management objectives. [23 CFR 515.7\(d\)](#) describes the processes for developing a TAM financial plan. State DOTs typically do not own or manage the full extent of the NHS. Because of these types of shared responsibility, the financial planning process often includes coordination with other agencies and stakeholders to obtain data, verify assumptions, and coordinate investment strategy development.

Investment Strategy Development. Through the financial planning process, a DOT develops investment strategies that optimize the use of available revenue sources to meet a wide range of agency objectives. The balancing of different needs is supported by a multi-objective decision analysis that may be formalized and performed either using software tools or based on deliberations by agency staff and stakeholders. [23 CFR 515.7\(e\)](#) describes the process for developing a TAM investment strategy.

ASSET MANAGEMENT INPUTS

TAM data supports analysis and reporting to inform the planning, programming, and delivery of work to achieve the agency's TAM objectives. To determine what data are needed, an agency should first understand the decisions that will be made. Before collecting data on a class of assets, the agency should formalize its approach to managing those assets and identify the key decisions that will be made throughout the life of a typical asset in that class (FHWA 2019). In general, asset management analysis and reporting relies on the following types of data:

- Inventory data that describes the physical assets. Inventory attributes can describe:
 - Asset type, class, or subgroup.
 - Location (geospatial, or in relation to a linear referencing system).
 - Specific attribute data that can describe features or sub-components of an asset. It can also include information about highway features located near the asset that may impact management or investment decisions, e.g. the presence of curb ramps or closed drainage systems that may limit choices for pavement preservation treatments because of the need to maintain the same elevation.
- Condition data, which are important to establishing performance targets and performance models.
- Treatments describe the types of work that can be performed to maintain, preserve, rehabilitate, or reconstruct an asset. To facilitate analysis, treatment costs are also needed.
- Performance models provide a means of estimating future conditions based on potential or actual investment actions. This includes modeling both performance and condition improvement immediately following treatment application, as well as deterioration that may occur when no treatment is applied.
- Constraints is a broad category input that describes limitations or assumptions that influence analysis methods, results, and reporting. This includes budget data or other policies that may affect the potential application of treatments. It can also include assumptions such as discount rates used in life-cycle cost analysis (LCCA).

ASSET MANAGEMENT OUTPUTS

TAM processes generate different types of reports and plans that support decision making at all levels of the agency, as well as for stakeholder agencies (e.g., metropolitan planning organizations, local public agencies, or advocacy groups). In general, asset management outputs fall into the categories below.

- **The TAMP.** State DOTs are required to develop a TAMP covering at least a 10-year period (23 CFR 515.9(e)). The content and processes used to develop the TAMP must be updated at least every 4 years ([23 CFR part 515.13\(c\)](#)). Other agencies that are not subject to this requirement may also choose to develop TAMPs.
- **Performance Forecasts.** Asset management systems are used to predict asset conditions using performance models and assumptions such as future funding. These predictions are used for many different purposes, including:
 - Establishing performance objectives.
 - Supporting long-term planning.
 - Developing life-cycle strategies for managing assets.
 - Developing TAMP investment strategies.
 - Assessing risks.
 - Communicating with external stakeholders.
- **Treatment Strategies.** In addition to the long-term analyses described above, asset management analysis may also be used to develop treatment strategies for each asset class within a pavement network. Each strategy has four primary components.

- The asset (individual, class, or subgroup) to be treated.
- The type of treatment to be delivered.
- The time frame for delivery.
- The cost estimate of the treatment.

This results in a set of actions, or treatments, to be performed on specific assets within a specific period of time. These strategies are used to inform planning and programming processes that allocate funding to programs of work including capital projects and maintenance efforts. Asset management system outputs rarely lead directly to defining project scopes and do not provide the level of detail necessary for project-level pavement design. Instead, this information is used in conjunction with other project-specific data to develop project scopes and to balance overall agency needs and objectives with available funding to develop capital and maintenance programs.

THE LINK BETWEEN ASSET MANAGEMENT AND PAVEMENT DESIGN

TAM is a strategic and systematic process that supports management of asset conditions throughout the entire asset life cycle – new construction, maintenance, preservation, rehabilitation, and reconstruction ([23 CFR 515.5](#)). In contrast to TAM, pavement design is a project-specific process that seeks to establish the best engineering solution within project scope, budget, and other constraints.

Despite the differences between the two processes, both TAM and pavement design influence each other. TAM investment strategies influence project prioritization and selection. Pavement design ensures pavement construction, preservation, rehabilitation, and reconstruction projects that provide the expected long-term performance as cost effectively as possible. Linking these two processes supports achievement of an agency's pavement objectives by making sure project-level decision makers are aware of the strategic implications of their decisions and by making sure that strategies are developed with an understanding to how pavements are designed and likely to perform.

REFERENCES

American Association of State Highway and Transportation Officials (AASHTO). 2019. *Transportation Asset Management Guide: A Focus on Implementation*. American Association of State Highway and Transportation Officials, Washington, DC. <https://www.tamguide.com/>

Federal Highway Administration (FHWA). 2019. *Handbook for Including Ancillary Assets in Transportation Asset Management Programs*. Federal Highway Administration, Washington, DC. <https://www.fhwa.dot.gov/publications/research/infrastructure/19068/index.cfm>

National Highway Institute (NHI). 2020. *NHI Course 136106A, An Introduction to Asset Management—Instructor Guide*. National Highway Institute, Federal Highway Administration, Washington, DC. https://www.nhi.fhwa.dot.gov/training/course_search.aspx?tab=0&key=introduction+to+asset+management&cat=22&sf=0&course_no=136106A

U.S. Department of Transportation (USDOT). 2020. *Transportation Statistics Annual Report 2020*. U.S. Department of Transportation, Washington, DC. <https://rosap.ntl.bts.gov/view/dot/53936>

ADDITIONAL RESOURCES

The following resources provide additional information on TAM that may be of interest to the reader.

Documents

American Association of State Highway and Transportation Officials (AASHTO). 2016. *Guide for Enterprise Risk Management*. AASHTO, Washington, DC.

Federal Highway Administration (FHWA). 2017. *Incorporating Risk Management into Transportation Asset Management Plans*. Federal Highway Administration, Washington, DC.

https://www.fhwa.dot.gov/asset/pubs/incorporating_rm.pdf

Federal Highway Administration (FHWA). 2017. *Using a Life Cycle Planning Process to Support Asset Management*. Federal Highway Administration, Washington, DC.

https://www.fhwa.dot.gov/asset/pubs/life_cycle_planning.pdf

Federal Highway Administration (FHWA). 2019. *Using a Life Cycle Planning Process to Support Transportation Asset Management: A Handbook on Putting the Federal Guidance into Practice*. Federal Highway Administration, Washington, DC. <https://www.fhwa.dot.gov/asset/guidance/hif19006.pdf>

National Goals and Performance Measures. 23 USC Part 150.

<https://uscode.house.gov/view.xhtml?hl=false&edition=prelim&req=granuleid%3AUSC-prelim-title23-section150&num=0&saved=%7CZ3JhbnVsZWlkOIVTQy1wcmVsaW0tdGI0bGUyMy1zZWNoaW9uMTE5%7C%7C%7C0%7Cfalse%7Cprelim>

Websites

American Association of State Highway and Transportation Officials (AASHTO). Transportation Asset Management Portal. www.TAM-portal.com.

Federal Highway Administration (FHWA). Asset Management. <https://www.fhwa.dot.gov/asset/>.