spy pond partners, llc

NCHRP 08-137

Updates to the Digital Edition of the AASHTO Transportation Asset Management Guide

CONDUCT OF RESEARCH REPORT

Prepared for NCHRP

Transportation Research Board

of

The National Academies of Sciences, Engineering, and Medicine

Spy Pond Partners, LLC

With Applied Pavement Technologies, Inc. and WSP

Arlington, Massachusetts

June 2024

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DISCLAIMER

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Abstract

This report documents and presents new material added to the digital version of the *AASHTO Transportation Asset Management Guide: A Focus on Implementation,* 2nd Edition (TAM Guide). The TAM Guide provides instruction and tools to state DOTs to aid them in implementing TAM in their agencies. In response to requests made by practitioners, the digital TAM Guide has been updated to include more up-to-date information and resources. This report details new topics that are discussed in the main text of the digital guide, additional practice examples/case studies of TAM implementation, how to instructions, user checklists, revamped TAM Topic Area deep-dive pages, video interviews with experts in their fields, chapter knowledge check assessments, and additional references for further research into asset management. The full digital TAM Guide can be accessed using this link: https://www.tamguide.com/

Summary

1. Background

The U.S. transportation system lies at a critical point in its history. The current system meets the demands of hundreds of millions of Americans every day and fuels the economy. The system is made up of an extensive array of physical assets–pavement, bridges, culverts, traffic signals, signs, facilities, and other traffic and safety assets.

Figure S.1 - Critical Topics Included in the AASHTO TAM Guide Digital Edition

The current state of the transportation system, its physical assets, and the level of service these assets provide is the result of many decisions – large and small – made over time concerning how the system should be designed, constructed, maintained and operated to meet anticipated demand. Both the demands on the system and the environment it operates within are changing. And as the transportation system ages it deteriorates, requiring reinvestment to meet even existing demands. Key challenges the transportation community faces include, but are not limited to: fueling future, sustainable economic growth; improving system resilience; and reducing uncertainty in funding.

The recent passage of the Bipartisan Infrastructure Law (BIL), also known as the Infrastructure Investment and Jobs Act (IIJA) represents a milestone for the U.S. transportation system. The BIL acknowledges the many challenges to the system and sets a new path for helping meet those challenges (see sidebar on the following page). The BIL incorporates consideration of resilience in existing funding programs, creates a new bridge program to better address the aging bridge inventory and need for its functional improvement, and contains a number of other new programs and provisions to meet future travel needs in a sustainable fashion.

Transportation Asset Management (TAM) provides a framework for managing existing physical assets effectively. TAM enables agencies to make the best decisions about how to maintain and operate the current transportation system, and by increasing efficiency, helps free up additional funding for improving the system. In short, TAM provides a set of tools and approaches that are essential for meeting the challenges outlined above and implementing the new direction set by the

BIL. U.S. transportation agencies have long recognized the importance of TAM. In 1998 the American Association of State Highway and Transportation Officials (AASHTO) first adopted TAM as a priority initiative. Since that time State Departments of Transportation (DOTs), AASHTO and the Federal Highway Administration (FHWA) have worked continuously to define, improve and implement TAM systems and processes across the U.S. Internationally asset management has been a focus in transportation and other infrastructure-intensive industries in both the public and private sectors.

AASHTO's TAM Guide is an important resource for transportation agencies to use as they implement and improve their approaches to TAM. The Guide includes an overall TAM framework outlining core and supporting TAM process, built around international best practices. Each chapter of the Guide summarizes one element of the framework, providing transportation professionals with a valuable resource for understanding the state of the practice and embarking on their TAM journey.

The printed TAM Guide is accompanied by the digital TAM Guide (**tamguide.com**) which includes the same core chapters as the printed guide – along with several features designed expressly for the web. Practitioners can use the digital Guide to explore curated collections of material from the Guide, tailored to their own interests and objectives. The TAM Guide and supporting materials are structured to support ongoing efforts to implement TAM, cover topics of greatest need to the transportation community, and incorporate additional guidance as TAM practice continues to evolve. Since the current printed Guide was completed, members of the project team have actively supported its implementation through activities including facilitating a workshop on the Guide at the Transportation Research Board (TRB) Annual Meeting, organizing a "TAM Book Club" webinar series for FHWA and AASHTO, and providing ongoing updates to the digital Guide as part of the Transportation Performance Management (TPM) Pooled Fund administered by AASHTO.

NCHRP Project 08-137 was performed to continue to improve upon the materials in the Guide. It helps to ensure transportation agencies have the guidance they need to meet new challenges and foster continued implementation of the TAM concepts in the current paper-guide, strengthening U.S. TAM practice. Since the guide's publication in 2020, TAM practices have advanced, new research has been completed, and new TAM-related needs have emerged. Some of the new practices, resources and needs that are now reflected in an updated digital Guide are highlighted in the following sections, organized by the six elements of the current TAM Guide Framework that align with the Guide chapters.

2. Updates to TAM Guide by Chapter

TAM Strategy and Planning

There has been growing interest in doing more to address EDI (Equity, Diversity and Inclusion) within TAM. This imperative is being approached as part of broader efforts to more explicitly link TAM processes and decisions to agency goals, strategies and policies. For example, agencies like King County Metro are aligning equity measures in their TAMP Mobility Framework to assist in prioritizing asset investments. The Guide has been updated to reflect these new practices and reference recent related publications.

Organization and People

Transportation agencies seeking to mature their TAM capabilities face continuing challenges attracting, developing and retaining talented staff. Agencies also need guidance on putting the right organizational structures and processes in place to align decisions and effect change as they implement their TAMPs. The guide has been enhanced to provide recent guidance and insights on how to address these challenges. New practice examples have also been added.

Maximizing Asset Performance

Having met federal requirements, agencies are looking to advance their practices to support effective long-term management of assets. Agencies are applying the reliability centered maintenance (RCM) approach to establish life cycle management approaches, determine necessary data, and prioritize expansion of their asset management program to include assets other than pavements and bridges. While life cycle management approaches are well-covered in the original published version of the Guide, enhancements have been made to reflect the findings of recent studies.

Resource Allocation

Several agencies have continued to make progress in implementing multi-objective decision analysis approaches. The BIL includes a new Prioritization Process Pilot Program that funds projects undertaken by State DOTs and Metropolitan Planning Organizations (MPOs) to implement data-driven approaches for project prioritization. Additional content covering these changes have been added to Chapter 5 of the revised Guide.

Monitoring and Adjustment

Following the development of asset management plans, transportation agencies increasingly focus more attention on activities needed to monitor asset condition and performance, funding, asset work and costs, and risks. Chapter 6 of the Guide has been expanded to provide more information on this process.

Information and Systems

Information and systems for TAM continue to see significant advancements with real implications for agency practice. At the same time, DOTs are advancing their analytics capabilities to support data-informed decision making – and new organizational models for delivering analytics are emerging. The Guide has been updated to reflect this shift within the industry.

It is an exciting time for asset management in the U.S.; there are significant advancements being made through national research, additional guidance, and the experiences and accomplishments of transportation agencies that are of direct relevance to TAM practitioners. The AASHTO TAM Guide has played a central role in organizing, synthesizing, and making readily accessible the information and resources that these practitioners rely upon. The TAM community will benefit from updated materials to reflect the significant advancements in practice since the publication of the original Guide.

3. Project Objective

The objective of this project was to develop new and updated digital content for the online version of the *AASHTO Transportation Asset Management Guide: A Focus on Implementation*, 2nd Edition. These updates and enhancements will:

1. Reflect relevant, new research results
2. Include lessons learned from asset management practices used by other transportation modes
3. Describe asset management tools used by state DOTs
4. Identify gaps in practice that additional tools may address
5. Address pressing issues facing asset management practitioners and decision-makers, including but not limited to equity, climate change, risk and resiliency, making multi-objective decisions, implementation challenges, coordination with regional and local agencies, and emerging technologies
6. Add additional practice examples, how-to guides, checklists, work-flows, standard operating procedure examples, templates, and videos
7. Provide enhancements to the Transportation Asset Management Gap Analysis Tool as well as new or other enhanced asset management tools

4. Integration of the Enhanced Digital TAM Guide

A core objective of this project was updating the digital Guide while maintaining the existing structure of the first publication. This kept the core chapters of the digital version in sync with the print (PDF) version that is available through AASHTO Publications Store. New content and edits have been integrated with the original Guide architecture, supplementing and extending the main content of the Guide, providing new tools for practitioners, and creating new pathways for exploring the digital resource.

Chapter 1: Introduction

Subsection 1.1.1 What is TAM?

Video Guides to Transit Asset Management

The following videos have been produced by transportation agencies to communicate what TAM is and why it should be important to a transportation agency.

Video Resource: Why Invest in Asset Management?

- An introduction to asset management and explanation for why it is so essential.

Video Resource: Iowa Department of Transportation: TAM Defined

- Three-minute video that compares preservation and worst-first approaches to asset management.

Video Resource: An Overview of TAM from the Federal Highway Administration

- Eight-minute overview of TAM and its benefits (featuring the original TAM ETG members!)

Subsection 1.1.3 TAM Principles

Video Explanation of Asset Management Principals

Video Resource: Principles of Asset Management: Ontario

- This video from Ontario, Canada provides an overview of asset management principles.

Subsection 1.2.4 Important Tools and Resources

Introducing the TAM GAP Analysis Tool

The TAM Gap Analysis Tool serves as a powerful self-assessment resource for agencies engaged in Transportation Asset Management (TAM). Its primary purpose is to enable agencies to systematically evaluate their TAM practices, offering insights into both strengths and weaknesses. The tool is designed to facilitate this assessment process by allowing agencies to benchmark their practices against established industry standards, identify gaps between current and desired practices, prioritize improvement initiatives, and monitor the evolution of TAM maturity over time. It operates at three distinct levels: Assessment Areas (encompassing topics like Policy goals, Asset Management), Assessment Elements (subcategories within each area), and Assessment Criteria (standards for evaluating practices). The document outlines the specific number of elements and criteria within each of the eight assessment areas, providing a comprehensive framework for evaluation.

A key feature highlighted in the tool is its flexibility, allowing agencies to customize assessments based on participant relevance. The assessment itself is conducted through a user-friendly web-based interface, prompting participants to rate current practices and set desired ratings on a 5-

point scale. Results are then compiled into various visual formats such as graphs, spider diagrams, and tables. This provides flexibility for result presentation, offering options at different levels—agency, assessment area, element, or criteria—to cater to diverse reporting needs.

The tool not only assists in identifying gaps, but also provides practical guidance on using results to enhance practices. It offers a checklist of strategies tailored to each assessment area, suggesting actionable steps to address identified gaps. Strategies range from aligning agency goals with performance data and developing asset management plans to enhancing communication and outreach and addressing workforce capacity and development. In essence, the TAM Gap Analysis Tool is a versatile resource, empowering agencies to enhance their TAM practices, align with industry benchmarks, and continually improve their capabilities in transportation asset management.

Short Summary Version of this Material

The TAM Gap Analysis Tool is a versatile resource for agencies engaged in Transportation Asset Management (TAM), facilitating systematic self-assessment to identify strengths and weaknesses. Operating at multiple levels, it allows benchmarking against industry standards, pinpointing gaps, and offering flexible result presentations. The tool not only identifies areas for improvement but also provides actionable strategies, making it a valuable asset for agencies seeking to enhance their TAM practices and align with industry benchmarks.

Subsection 1.3.2 Legislation and Regulations

Video Resource: The IIJA and TPM

- AASHTO TAM Webinar #52

Infrastructure Investment and Jobs Act

The Infrastructure Investment and Jobs Act/Bipartisan Infrastructure Law (IIJA/BIL) that took effect on October 1, 2021 required State DOTs to consider extreme weather and resilience as part of the life-cycle planning and risk management analyses within a State TAMP. This means that state DOTs must take into account the potential for extreme weather events, such as hurricanes, floods, and wildfires, when making decisions about how to maintain and invest in their transportation infrastructure. This change is important because it will better inform the decision-making of State DOTs and other Federal-aid recipients who ultimately select projects in which to invest federal-aid dollars to improve the resilience of the surface transportation network. These updates were first required in 2022 as State DOT updated their TAMP development processes and TAMPs based on the 4-year cycle in Title 23, Code of Federal Regulations (CFR), Part 515.13(c).

The IIJA/BIL also provides funding for a number of new programs that are relevant to transportation asset management, such as the Bridge Investment Program and the National Electric Vehicle Infrastructure Formula Program. These programs can help state DOTs to make necessary repairs and upgrades to their transportation infrastructure, and to invest in new technologies that can make their transportation systems more sustainable and resilient.

In addition, the IIJA/BIL includes a number of provisions that are designed to improve the efficiency and effectiveness of state DOT transportation asset management programs. These provisions include requirements for state DOTs to develop and implement asset management

plans, to collect and use data to inform their asset management decisions, and to collaborate with other stakeholders on asset management issues.

Video Resource: TAMP and STIP Integration

- AASHTO TAM Webinar #44

The most recent information on federal requirements and regulations are available at the following:

FHWA Transportation Asset Management: https://www.fhwa.dot.gov/asset/

FTA Transit Asset Management: https://www.transit.dot.gov/TAM

Subsection 1.3.3 Assessment Tools and Maturity Models

TAM Gap Analysis Tool

This Excel-based gap analysis tool was developed under National Cooperative Highway Research Program (NCHRP) Project 08-90 and builds on the gap analysis tool introduced in the AASHTO Transportation Asset Management Guide – A Focus on Implementation. The tool helps agencies identify and prioritize needed enhancements to their asset management programs.

In 2023, the TAM Gap Analysis Tool was reproduced as a web-based tool, providing enhanced functionality and a streamlined user experience, resolving software compatibility issues that had developed in the 2014 excel-based version, and updating the assessment framework to better reflect current practices. More information on the TAM Gap Analysis Tool is provided in section 1.4, TAM Gap Analysis Tool Overview. The new version of the tool and the User's Guide are available on the AASHTO TAM Portal: https://www.tam-portal.com/resource-set/tam-gap-analysis-tool-nchrp-08-90/

Video Resource: TAM Tools Miniseries 04 – Techniques

- AASHTO TAM Webinar #57

TPM Assessment Tool

The self-assessment available on the Transportation Performance Management (TPM) Toolbox (https://www.tpmtools.org) is available to agencies looking to assess their level of performance management maturity. Three different assessment options are available: a quick, 2-minute assessment, a standard assessment, and an assessment by component of the TPM framework presented in the TPM Guidebook.

Video Resource: TAM Tools Miniseries 03 – Other Tools

- AASHTO TAM Webinar #56

Section 1.4 TAM Gap Analysis Tool

The TAM Gap Analysis Tool enables agencies to self-assess their TAM practices to identify areas of strength and weakness. The results from the gap analysis provide useful information for:

- Comparing agency practices against strong industry practices.
- Identifying gaps between current and desired practices.

- Recognizing areas in which the agency is not performing at its desired level.
- Prioritizing action items for improvement plans.
- Monitoring advancements in TAM maturity over time.

Note: This section was derived from the AASHTO TAM Portal. Copies of the TAM Gap Analysis Tool, User Guides, and additional information are available here: https://www.tam-portal.com/tool/tam-gap-analysis-tool-nchrp-08-90/

Subsection 1.4.1 Gap Analysis Tool Data Structure

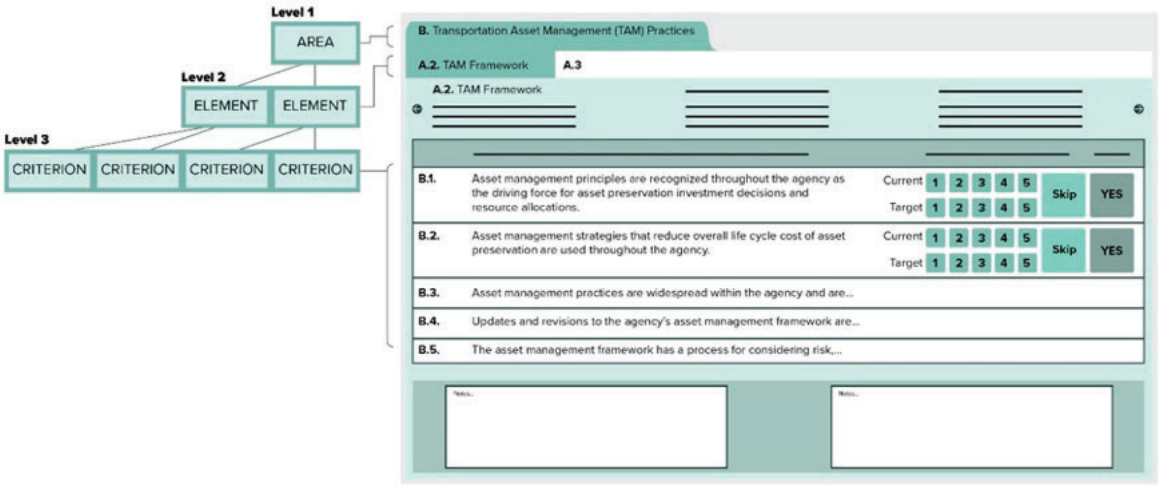
This subsection introduces the TAM Gap Analysis Tool designed for agencies to self-assess their Transportation Asset Management (TAM) practices. It outlines the tool's purpose, including comparing practices against industry standards, identifying gaps, recognizing areas for improvement, prioritizing action items, and monitoring TAM maturity over time. The tool operates at three levels—Assessment Areas, Assessment Elements, and Assessment Criteria—covering eight broad topic areas related to TAM practices, each with specific elements and criteria for evaluation during the gap analysis process.

Note: This subsection was derived from the AASHTO TAM Portal. Copies of the TAM Gap Analysis Tool, User Guides, and additional information are available here: https://www.tam-portal.com/tool/tam-gap-analysis-tool-nchrp-08-90/

Introduction

The Gap Analysis Tool supports analysis at three different levels as shown in the figure and described below:

Figure 1.6 TAM Gap Analysis Tool Demonstration



Level 1: Assessment Areas. The highest level is the Assessment Area, which includes eight topic areas:

1. Policy goals and objectives.
2. Asset management practices.
3. Planning, programming, and project delivery.

4. Data management.
5. Information systems.
6. Transparency and outreach.
7. Results.
8. Workforce capacity and development.

Level 2: Assessment Elements. Each Assessment Area has been subdivided into two or more Elements, which can be considered subsets of each of the eight broad topic areas. The tool supports each element with general recommendations for agency practice improvement, and provides the option to share custom language to support agency user benchmarking decisions.

Level 3: Assessment Criteria. Within each Element, there are two or more criteria that are used to evaluate current and desired practice. Each criterion is presented as a standard statement representing good practice. The tool allows the assessment facilitator to adjust the criterion language as needed to promote understanding by the assessment participants.

During the gap analysis, participants evaluate how closely their agency's practices match what is described in each criterion. This rating is considered representative of the agency's current practices. Agencies may also define how closely they want to reflect the practices described in each criterion. This rating represents the agency's desired practices. The difference between the current and desired practices determines whether a gap exists.

The number of Elements and Criteria within each of the eight Assessment Areas are shown in the table below.

Table 1.1 Assessment Areas of TAM Gap Analysis Tool

Assessment Areas	Proposed Elements and Number of Criteria
1: Policy Goals and Objectives	• Strategic Agency Goals and Objectives (5) • Agency Policies (4)
2: Asset Management Practices	• TAM Implementation (6) • Asset Management Plan Development (7)
3: Planning, Programming, and Project Delivery	• Planning and Programming Processes (5) • Performance-Based Management (5)
4: Data Management	• Data Availability and Access (7) • Asset Condition and Performance (6) • Data Governance (9)
5: Information Systems	• System Technology and Integration (4) • Analysis Features (6)
6: Transparency and Outreach	• Transparency and Accountability (4) • Communication and Outreach (4)
7: Results	• Compliance (4) • Data-Driven Targets (2) • Program and Plan Alignment (3)
8: Workforce Capacity and Development	• Workforce Capacity (4) • Workforce Development (3)

Subsection 1.4.2 Using the Tool

This subsection introduces the TAM Gap Analysis Tool designed for agencies to self-assess their Transportation Asset Management (TAM) practices. It outlines the tool's purpose, administration process, and the flexibility it offers in tailoring assessments to agency needs. Additionally, the document provides a checklist suggesting strategies for addressing identified gaps and advancing agency practices based on the gap analysis results across different TAM focus areas.

Note: This subsection was derived from the AASHTO TAM Portal. Copies of the TAM Gap Analysis Tool, User Guides, and additional information are available here: https://www.tam-portal.com/tool/tam-gap-analysis-tool-nchrp-08-90/

Overview

A gap analysis is administered by an individual within the agency who is responsible for identifying participants, determining what part of the assessment each participant will receive, distributing links to the assessment to each participant, and compiling the results. As detailed in the User's Guide, the TAM Gap Analysis Tool provides agencies flexibility in using the survey as it's designed, or reducing the survey length by eliminating Elements or Criteria that may not be relevant. There is also flexibility in determining which parts of the assessment are appropriate for each participant. For instance, individuals associated with data collection may only be asked to evaluate the criteria related to Assessment Area 4, Data Management.

Individualized links are distributed to each participant to complete the assessment. Assessment participants are required to log into the web-based tool (using their email address). Once logged in, the participants are able to access the assessment, where they are asked to rate the agency's current practices in comparison to each Criterion using a 5-point rating scale. Optional fields are provided for notes that a participant may want to make to explain their response. In addition to rating the agency's current practices, the tool allows the agency to set a desired, or targeted, rating for each criterion using the 5-point scale.

After all assessments are completed, the results are compiled and presented as graphs, spider diagrams, and tables. Results can be compiled at the agency level or by any subset of the raters. Results can also be presented at the Assessment Area, Element, or Criteria level depending on the agency's needs. To facilitate reporting, results can also be exported in spreadsheet format for external reference and use.

Additional details on administering the assessment and interpreting the results are available in the User's Guide: https://www.tam-portal.com/document/national-cooperative-highway-research-program-nchrp-project-08-90/

Checklist

Using TAM Gap Analysis Results to Advance Practices

The results from the TAM gap analysis can help identify gaps between current and desired performance, but the greatest benefit may come from using the results to advance agency practices. Asset Management leaders can use this checklist to identify strategies for addressing any gaps that are discovered.

Did the analysis identify gaps related to:

- Policy Goals and Objectives? Consider:
  - Developing strategies to better link agency goals with performance data.
  - Using asset management data to set infrastructure performance goals.
  - Monitoring performance towards goals more regularly.
  - Establishing an asset management policy.
  - Using asset management analysis tools to convey the consequences of investment options.
- Asset Management Practices? Consider:
  - Developing strategies that ensure asset management decisions are driving investment decisions.
  - Defining roles and responsibilities for asset managers that are endorsed by leadership.
  - Creating a decision framework that considers risk, long-term investments, and trade-offs.
  - Establishing a link to upper management through an Asset Management Steering Committee.
  - Adding additional assets to your TAMP.
- Planning, Programming and Project Delivery? Consider:
  - Aligning the planned TAMP investments with long-range plans and other planning documents.
  - Relating available resources and project costs to expected levels of service or performance.
  - Reviewing existing performance measures to verify they drive desired behavior.
  - Monitoring and regular reporting of progress towards desired performance.
  - Establishing a feedback loop to ensure consistency between plans and programs.
- Data Management? Consider:
  - Aligning data capabilities with intended asset management approaches.
  - Establishing a tiering system to prioritize data investments and practices for ancillary assets.
  - Developing processes to ensure data quality.
  - Establishing a data governance plan.
  - Formalizing data stewardship roles and responsibilities.
- Information Systems? Consider:
  - Aligning information system capabilities with intended asset management approaches.
  - Reviewing the current capabilities of existing management systems and prioritizing needed enhancements.
  - Improving the reliability of performance models to predict future conditions under different scenarios.
  - Using analysis tools to support performance-based decision making.
  - Establishing processes for keeping management system data current.
  - Verifying the assumptions for treatment performance in the management systems reflects actual performance trends.
- Transparency and Outreach? Consider:
  - Establishing processes to improve accountability for performance.
  - Benchmarking agency practices with peer organizations.

- Developing a communication plan to ensure consistent messaging to internal and external stakeholders.
- Including a representative from the Public Information Office on the Asset Management Steering Committee.

· Results? Consider:
- Working with the FHWA Division office to address Federal TAMP requirements.
- Documenting progress towards national goal areas and/or agency strategic objectives more effectively.
- Evaluating the alignment between planned investments in the TAMP with programmed projects.
- Enhancing the degree of coordination with federal, regional and local agencies.

· Workforce Capacity and Development? Consider:
- Defining core competencies needed for the successful implementation of asset management.
- Developing a training plan for acquiring needed skills.
- Creating a TAM Book Club to familiarize new employees with asset management concepts. Consider using the TAM Guide as a resource and framework for these discussions.

· Participating in technology transfer events to benefit from peer experiences

Chapter 1 Knowledge Check

Q: Most transportation agencies have some elements of TAM in place.

A: True. Most agencies have elements of TAM principles in their existing practice. This TAM guide can help formalize TAM practices, identify areas for improvement, and increase understanding of how to improve.

Q: Agency priorities are determined by TAM measures.

A: False. TAM performance measures should be aligned with agency priorities to ensure that investments made to extend service life provide the maximum impact to achieve agency goals. Connecting performance measures to higher level strategic goals also supports an agency's ability to monitor progress and communicate with customers and stakeholders.

Q: TAM performance measures are meant to replace Level of Service (LoS) as a measure of performance.

A: False. In TAM, asset performance is generally defined in terms of asset condition or maintenance LoS. LoS. Provides the link between agency goals and the investments and interventions that should take priority when managing assets.

Q: The TAM guide is meant to improve the understanding of asset management practices at all levels of an organization.

A: True. The Guide is intended for readers at all levels of an agency: beginners, practitioners and executives. It is structured so that the reader can use a particular chapter, section, or topic as a source of advice; or use the whole to help drive a systematic agency-wide implementation of asset management.

Q: Implementing TAM is not required, but it is the preferred approach to managing transportation assets.

A: False. Following passage of MAP-21 and FAST the FHWA and FTA developed rules detailing the TAM requirements for highways and transit, respectively. FHWA's requirements specify that a TAMP should detail asset inventory, current conditions, and predicted future conditions over a 10-year period, using performance measures detailed in FHWA's performance management regulations. FTA's requirements detail that transit agencies must prepare TAMPs covering a four-year period and include their revenue vehicles, infrastructure, facilities, and equipment. Agencies with rail systems and/or 100 or more vehicles in peak revenue service must also include information such as a TAM/SGR policy, TAM implementation strategy, evaluation plan, and identification of resources required to implement the plan.

Chapter 2: TAM Strategy and Planning

Subsection 2.1.1 Integrating TAM Within Agency Strategic Plans and Policies

Video Resource: Integrating PM2 Targets with the TAMP

- AASHTO TAM Webinar #34

Video Resource: Integrating Effective Performance, Risk, and Asset Management

- Interview with Mara Campbell on TAM Integration

Subsection 2.1.2 Creating a TAM Policy

Video Resource: Strategic Framework for Asset Management

- Interview with Meredith Hill on Asset Management

Subsection 2.2.1 Planning and Programming

Video Resource: Using the TAMP Approach to Look at Demand Scenarios

- Interview with Jack Smith on Demand Scenarios

Video Resource: Integrating TAM Into the Planning Process

- Produced by the FHWA TAM Expert Task Group

Subsection 2.2.3

Video Resource: Improving Risk Management and Resiliency

- AASHTO TAM Guide Book Club #5

Video Resource: Risk Management

- AASHTO TAM Webinar #27

Subsection 2.2.5 Connecting Resilience with Asset Management

This subsection emphasizes the critical connection between resilience and transportation asset management (TAM) in the face of increasing threats from extreme weather events and disruptions. It outlines six major components for integrating resilience into TAM, including developing objectives and targets, identifying and assessing risks, implementing resilience strategies, incorporating resilience into planning, and monitoring and evaluating resilience efforts to ensure effective mitigation of disruption impacts.

Video Resource: TAM Resilience Building: Takeaways from the TAM Peer Exchange

- AASHTO TAM Webinar #60

As transportation systems face increasing threats from extreme weather events, climate change, and other disruptions, integrating resilience into transportation asset management plans (TAMPs) is crucial for ensuring the continued performance and reliability of these vital networks. Transportation assets are vulnerable to disruptions that have become increasingly more common or more severe, such as those caused by extreme weather events, climate change, as well as disruptions from man-made hazards such as fires, industrial accidents or security- or cyber-threats. To sustain the performance and reliability of transportation systems, it is essential to include resilience as a factor in transportation asset management practices.

In the context of transportation asset management, resilience refers to the ability of transportation assets to maintain their functionality and performance in the face of disruptions, as well as the ability of transportation systems to quickly recover from disruptions and restore service. Integrating resilience into a transportation asset management plan (TAMP) involves incorporating strategies to prepare for, withstand, and recover from disruptions caused by extreme weather events, climate change, and other hazards. This approach ensures that transportation assets remain functional and support community needs during and after disruptions.

Addressing resilience within a TAMP has the following six major components:

1. **Develop Resilience Objectives and Targets:** Transportation agencies should develop resilience goals and objectives. These objectives and targets should be aligned with the overall goals of the transportation system and should be measurable and achievable. These objectives should focus on minimizing disruptions, reducing recovery time, and enhancing the overall resilience of assets. By setting specific targets, an agency can effectively track progress and make informed decisions about resilience investments.

2. **Identify Risk:** A transportation agency needs to identify and assess the risks that its transportation assets face. This includes understanding the likelihood and severity of potential disruptions, as well as the potential consequences of those disruptions. Identifying potential hazards, such as floods, hurricanes, or earthquakes, and evaluating their likelihood, severity, and potential consequences for transportation assets are important.

3. **Assess Risk:** Calculating and assessing risk involves considering the probability of occurrence, the potential damage, and the associated costs. The formula for calculating risk can be generally described as:

   Risk = Probability of Occurrence × Damage × Cost

   - **Probability of Occurrence—**The probability of occurrence is a measure of how likely it is that a particular event will happen. It is usually expressed as a percentage or a decimal between 0 and 1. For example, if there is a 20% chance of a flood occurring in a given year, the probability of occurrence would be 0.2.

- **Damage—**The damage is the extent of the negative impact that an event would have if it were to occur. This could include physical damage to assets, financial losses, or harm to people or the environment. Damage is often expressed in monetary terms, but it can also be qualitative.

- **Cost—**The cost is the amount of money that would be required to mitigate or recover from the damage caused by an event. This could include the cost of repairs, insurance premiums, or emergency response measures.

Once you have determined the probability of occurrence, damage, and cost, you can multiply these three values together to calculate the overall risk. The resulting value represents the expected financial impact of the risk.

4. **Identify and Implement Resilience Strategies:** Transportation agencies should identify and implement a variety of resilience strategies to mitigate the impacts of disruptions. These strategies may include hardening assets, improving redundancy, and developing emergency response plans. Understanding the specific risks faced by your transportation network will guide the development of tailored resilience strategies.

5. **Incorporate Resilience into a TAMP:** The resilience strategies and considerations should be incorporated into all aspects of transportation asset management planning, including asset inventory, condition assessment, and prioritization of investments.

6. **Monitor and Evaluate Resilience:** Transportation agencies should monitor and evaluate their resilience efforts to ensure that they are effective in reducing the impacts of disruptions. This includes collecting data on asset performance, disruptions, and recovery efforts.

Resilience considerations should be integrated into all aspects of your TAMP, including asset inventory, condition assessment, and prioritization of investments. Consider the resilience implications of each decision and how it affects the overall resilience of your transportation system. For example, when prioritizing maintenance or replacement projects, consider the vulnerability of assets to disruptions and prioritize those that are critical for maintaining network connectivity or supporting emergency response efforts.

Video Resource: Resiliency and the IIJA

- AASHTO TPM Webinar #27

Subsection 2.3.2 Defining and Prioritizing Improvement in TAM Approaches

Video Resource: TAM Innovations

- AASHTO TAM Webinar #31

Subsection 2.3.3 Developing a TAM Implementation Plan

Video Resource: TAMP Implementation

- AASHTO TAM Webinar #39

Subsection 2.4.1 The Basic TAMP

Video Resource: The 2022 TAMPs and BIL Requirements

- AASHTO TAM Webinar #58

Video Resource: Developing a Complete TAMP

- AASHTO TAM Webinar #35

Video Resource: Improving Your Next TAMP Miniseries - Overview

- AASHTO TAM Webinar #46

Video Resource: 2022 TAMPs – Lessons from Practitioners

- AASHTO TAM Webinar #53

Video Resource: Preparing for Your 2022 TAMP with the TAM Guide

- AASHTO TAM Guide Book Club #1

Subsection 2.4.2 Beyond the Basic TAMP

Video Resource: TAM Tools Miniseries 02 – Management Systems

- AASHTO TAM Webinar #55

Video Resource: TAMP Implementation and Integration

- AASHTO TAM Guide Book Club #2

Section 2.5 Moving Beyond Pavement and Bridges to Other Assets

Most of the available funding, and management effort, allocated by transportation agencies for preserving infrastructure is spent on highways and bridges. While these assets constitute the predominant contribution to the overall value of their infrastructure portfolio, other assets in the road corridor can be significant as well (with consequential investment and liabilities). Agency personnel are responsible for maintaining various ancillary assets, such as signs and signals, guardrails, culverts, lighting, pavement markings, sidewalks, and retaining walls. As agencies increasingly adopt TAM principles, they find more effective ways to manage all their assets through data-driven decisions. However, with often limited information about these ancillary assets, transitioning to data-driven management has been challenging. Nonetheless, some agencies have made progress in using data to manage certain ancillary assets. Including ancillary assets in a TAMP helps highlight maintenance funding needs and provides a more comprehensive view of the total cost of delivering mobility at the service standards set by the agency.

There is growing interest in developing comprehensive inventories for ancillary assets and establishing procedures for regular performance evaluation. Due to limited resources, it is often

impractical to collect inventory and condition data for all assets simultaneously. Therefore, a systematic method is needed to identify the appropriate management approach and complementary data collection processes to support decision-making for these asset classes.

Subsection 2.5.1 Drivers for Including Ancillary Assets

This subsection highlights various drivers prompting agencies to collect additional ancillary asset data, such as performance-based investment decisions, technological advancements, and the integration of information across business units. It emphasizes that these drivers necessitate a strategic assessment considering risks, organizational changes, and existing practices when expanding data collection efforts for ancillary assets.

Video Resource: Geotechnical Assets and TAM

- AASHTO TAM Webinar #43

A number of factors might prompt an agency to modify its requirements, priorities, or procedures, which necessitate the collection of additional ancillary asset data. For instance, an agency might choose to:

- Make performance-based investment decisions for assets beyond pavements and bridges.
- Invest in new data collection technology enabling a more cost-effective alternative to past methods.
- Integrate and share information across business units, leading to a review of future data needs across multiple asset classes.
- Better understand the full cost of mobility including construction, maintenance, preservation, rehabilitation, and replacement of ancillary assets.
- Adopt risk-based management strategies to improve resiliency and avoid damage due to recurring events such as flooding, slope failures, safety incidents, and liability risk.
- Implement a more efficient process to address funding requests for expanded data collection efforts from various business units within the agency.

These, or other types of changes within an agency, typically prompt an evaluation of data needs to support decision-making for ancillary assets. Most agencies acknowledge the benefits of having comprehensive and accurate inventory and condition data for their assets. However, maintaining this information requires available resources, along with existing business processes and software tools to support analysis and reporting.

As shown in Figure 2.10, this strategic assessment of ancillary asset data needs is typically influenced by the risks the agency aims to manage, organizational or technical changes enabling new processes, or discrepancies between current and desired management practices. In its strategic review and decisions on expanding data collection efforts, the agency should consider its policies, budgets, resources, performance, legislated mandates, and available technology.

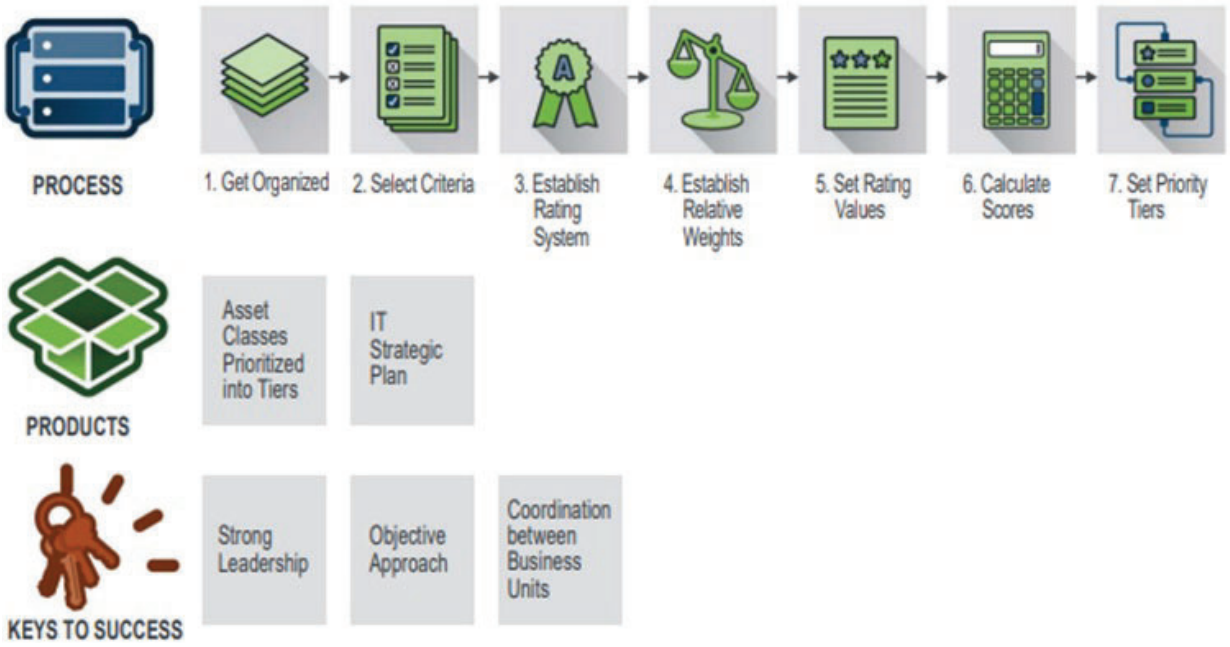
Figure 2.10 Strategic Review of Risks, Changes, and Gaps

Subsection 2.5.2 Selecting Assets for Inclusion in Asset Management Programs

This subsection discusses the challenges agencies face in expanding asset management programs due to limited resources and budget constraints. It introduces a handbook that outlines a seven-step process for prioritizing asset classes, providing examples of typical highway ancillary asset classes and illustrating how agencies like Nevada and Ohio establish priority tiers for efficient data collection and management aligned with their management priorities.

Organizations face constraints on resources and budgets. Therefore, those seeking to broaden their asset management programs by incorporating additional information require a method for assessing the benefits and costs of system development, data collection, and data management. The Handbook for Integrating Ancillary Assets into TAM Programs (FHWA 2019) presents structured approaches, outputs, and essential guidelines concerning the steps needed to formulate a prioritized strategy for integrating asset classes. Prioritization is crucial to ensure the effective and efficient use of limited resources. The Handbook outlines a seven-step procedural framework fostering collaboration among business units with asset data requirements or responsibilities in data collection and management. Determining which asset classes to include in an organization's asset management program hinges on a thorough grasp of the organization's IT policies, architecture, and strategies.

Figure 2.11 Prioritization Overview



Typical asset classes considered though this process can be extensive. The assets listed in Table 2 are an illustration of potential classes that may be considered by agencies and was compiled in the Handbook (FHWA 2019), adapted from NHI 2017.

Table 2.2 Typical Highway Ancillary Asset Classes

FUNCTIONAL AREA	ASSET CLASS
Structures (not Bridges or otherwise in the National Bridge Inventory)	• Drainage Structures • Overhead Sign and Signal Supports • Retaining Walls (Earth Retaining Structures) • Noise Barriers • Sight Barrier • High-Mast Light Poles
Traffic Control and Management—Active Devices	• Signals • ITS Equipment • Network Backbone
Traffic Control and Management—Passive Control Devices	• Signs • Guardrail • Guardrail End Treatments • Impact Attenuator • Other Barrier Systems
Drainage Systems and Environmental Mitigation Features	• Drain Inlets and Outlets • Culverts (<20 ft. total span)/Pipes • Ditches • Stormwater Retention Systems • Curb and Gutter • Erosion Control • Other Drains (e.g. Underdrain and Edge Drain)
Other Safety Features	• Lighting • Pavement Markings • Rockfall
Roadside Features	• Geotechnical assets such as retaining walls and cut/fill slopes* • Sidewalks • Curbs • Fence • Turf • Bush Control • Roadside Hazard • Landscaping • Access Ramps • Bike Paths • Roadside Graffiti • Roadside Litter
Other Facilities and Other Items	• Rest Areas • Weigh Stations • Parking Lots • Buildings • Fleet • Gravel/Unpaved Roads • Vehicle Charging Stations

*- See *NCHRP Research Report 903: Geotechnical Asset Management for Transportation Agencies (FHWA 2019) for more details on best practice for managing geotechnical assets.*

Many agencies institute priority tiers to group asset classes, enabling the development of distinct plans for gathering, storing, and managing necessary data in accordance with management objectives. Determining which assets to include in a specific implementation project depends on a wide range of interconnected factors, rendering the development of a precise ranked order for all assets challenging. Streamlining this process can be achieved through the adoption of a tiered system which groups assets of comparable priority together. As exemplified in Table 2.3, both Nevada and Ohio compiled ranked lists that can be translated into prioritized tiers. Each agency

possesses distinct priorities and can utilize a similar methodical approach to assess their portfolio within the framework of their operational and strategic planning capabilities, as well as their management objectives.

Table 2.3 - Examples of prioritized tiers developed by Nevada and Ohio DOTs

TIER LEVEL	NEVADA DOT	OHIO DOT
I	• Pavements • Bridges • ITS assets • Rest areas, buildings and storage facilities	• Pavements • Bridges • Culverts • Barriers/guardrail • Overhead sign structures
II	• Slopes • Hydraulic infrastructure • Signs • Sign structures	• Lighting • Retaining walls • Curb ramps • Geotechnical assets
III	• Traffic Signals • Noise barrier walls • Lighting structures • Bike paths and sidewalks • Pavement marking • Weigh stations and pump houses • Retaining walls • Curb and gutter • Embankments • ADA Features • Cattle guards and fences	• Signals • Noise walls • Ground mounted signs • Sidewalks

Subsection 2.5.3 Data Collection

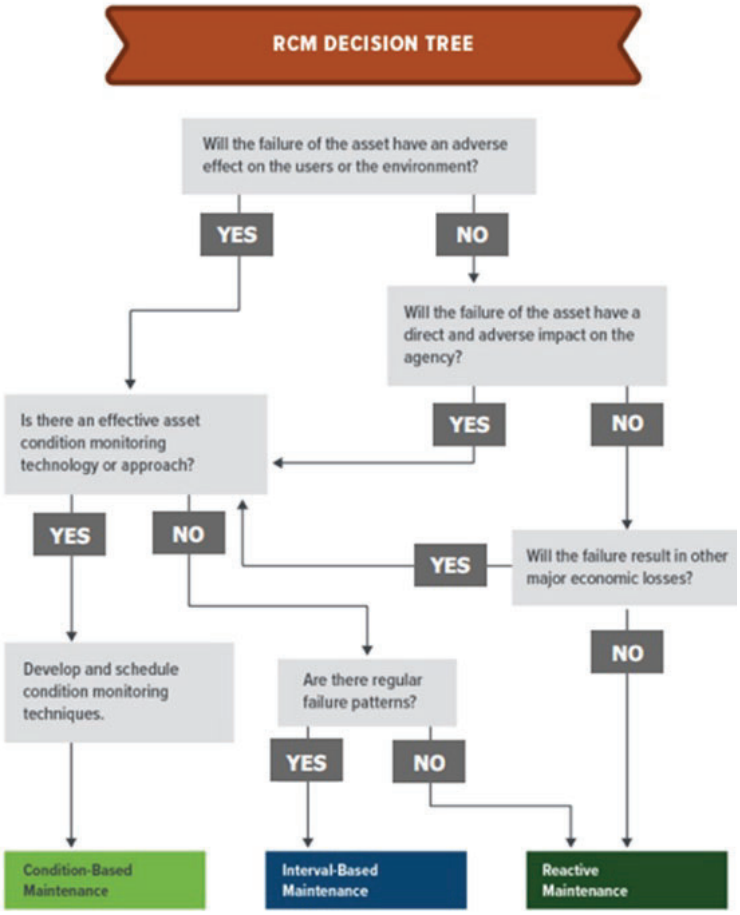
This subsection discusses the importance of data collection in asset management programs, emphasizing the need for coordination between different agency groups. It introduces a performance-based management strategy using the RCM approach, detailing condition-based, interval-based, and reactive maintenance components relevant to life cycle planning of ancillary highway assets. The document also provides a table summarizing maintenance approaches for various asset classes, supporting agencies in efficiently collecting high-quality data for informed decision-making.

After evaluating the priority of asset classes, asset stewards need to understand the intended functions, potential failure possibilities, available maintenance options, and the consequences of failure for each asset class. This information is typically dispersed across various areas or business units within an agency. Gathering this information necessitates coordination among different groups within the agency. The ideal approach involves following a framework to establish a performance-based management strategy for ancillary assets, identifying the optimal data elements for collection, and selecting the most suitable data collection techniques for each asset class.

Figure 2.12 Reliability Centered Maintenance

The Handbook (FHWA-HIF-19-006) offers a potential framework of interconnected processes that can be tailored to an agency's specific requirements. The process for developing a performance-based management strategy employs the Reliability-Centered Maintenance (RCM) approach, which is elaborated upon in Chapter 4. RCM utilizes a series of risk-based questions to assist agencies in identifying the most effective and efficient management strategies. The three primary components of an RCM program pertinent to the life-cycle planning of ancillary highway assets are condition-based maintenance, interval-based maintenance, and reactive maintenance. This is illustrated in Figure 2.12, as adapted in the Handbook from NASA (2008. Reliability-Centered Maintenance Guide for Facilities and Collateral Equipment. National Aeronautics and Space Administration, Washington, DC). A decision tree can be used to establish an appropriate management and maintenance approach for each ancillary asset class to inform data requirements. This is also illustrated in Figure 4.5 of Chapter 4.

Figure 2.13 RCM Decision Tree



- Condition-based maintenance includes predictive maintenance and real-time monitoring. Inspections note current capital and maintenance interventions as well as current state to be considered by maintenance teams and inputted into predictive models.
- Interval-based maintenance is conducted independently of the asset's condition and involves performing inspections or replacements at predetermined intervals.
- Reactive maintenance assumes that failure is low risk to operations and where there are no practical monitoring approaches and/or regular deterioration or failure patterns. Repairs are made after the failure. Table 2.4 presents a summary of the applicability of condition, interval, or reactive maintenance for each of the asset classes.

Table 2.4 Typical Maintenance Approaches by Asset Class

Asset Class Elements	Condition Based	Interval Based	Reactive Based
All Structures (excluding bridges)	Preferred	Not Recommended	Feasible
Traffic Control and Management - Active Devices	Feasible	Preferred	Feasible
Traffic Control and Management - Passive Devices	Feasible	Feasible	Preferred
Drainage systems and environmental mitigation features	Feasible (except preferred for small culverts)	Preferred (except feasible for small culverts)	Feasible
Other Safety Features	Feasible	Feasible	Preferred
Roadside features	Feasible	Feasible* (not recommended for roadside hazards)	Preferred**
Other facilities items			
Rest areas, weigh stations and buildings	Preferred	Feasible	Feasible
Parking Lots, Roadside litter and fleet	Feasible	Preferred	Feasible
Graffiti	Feasible	Feasible	Preferred

* - Preferred for landscaping, access ramps, and bike paths
** - Feasible for landscaping, access ramps, and bike paths

Subsection 2.5.4 Data Required for Decision-Making

This subsection emphasizes the significance of data collection for effective decision-making in asset management programs, particularly using a Reliability Centered Maintenance (RCM) approach. It outlines essential data requirements for different maintenance types, such as condition-based, interval-based, and reactive-based maintenance, and highlights the importance of complete and reliable data. Additionally, the document discusses desirable data that can enhance decision-making by providing clarity, supporting different agency departments, generating accurate work orders, managing asset risks, and tracking the asset's full life cycle.

Data-driven decisions depend on asset data to guide effective investment choices. Effective data collection practices allow an agency to execute strategic RCM maintenance and streamline work order distribution. With accurate data, metrics can be derived, and performance measures compared to assess the effectiveness of a maintenance strategy and identify areas for improvement. Ancillary asset data can be categorized as either essential or desirable, depending on the management approach. Regardless of the data type, it is crucial that the data be complete and reliable. Generally, the RCM process required the following essential data for effective management.

Table 2.5 Essential Data by Maintenance Approaches for Ancillary Assets

Maintenance Type	Asset Type	Asset Location	Asset Unique ID	Condition Data
Interval-based maintenance	X	X	X	-
Condition-based maintenance	X	X	X	X
Reactive-based maintenance	X	X	X	-

There are various strategies and technologies that support data acquisition that can be found in Chapter 7 and in the Handbook for Ancillary assets (FHWA-HIF-19-006). Other desirable data can augment decision-making by:

- Providing additional clarity and accuracy to the essential data collected.
- Supporting different departments within an agency.
- Assisting in generating accurate work orders.
- Helping manage asset risks.
- Tracking the asset's full life cycle to make informed decisions.

The above list is not all-inclusive but provides clear examples of reasons why additional data collected in the field could be beneficial to an agency. Each of these items is described in more detail in the handbook. Other desirable data attributes have been referenced elsewhere (HMEP 2013), and may also be considered, including:

- Maintenance intervals.
- Frequency of failure.
- Allocated risk factors.
- Maintenance requirements.
- Engineering specific data

Subsection 2.5.5 Managing Ancillary Asset Data

This subsection underscores the importance of integrating ancillary asset data into an agency's overall data management system for informed decision-making on management, maintenance, and capital investment. It outlines guiding principles for effective data management practices, including interdepartmental coordination, an authoritative hub with integrated databases and web services, a common data dictionary, and business improvements in querying, analyzing, displaying, and reporting data.

Integrating ancillary asset data into an agency's overall data management system ensures that decision-making associated with management, maintenance and capital investment is based on the best available information across the organization. An agency will, at the same time, improve transparency and public trust. The following guiding principles distinguish good data management practices from less comprehensive approaches to data management:

- Strategic Plan—Interdepartmental coordination.
- Authoritative Hub—Integrated database and web services.

- Common Data Dictionary—Agency agreement on assets and attributes.
- Business Improvements—Query, analyze, display, and report data.

Data management concepts are discussed in more detail in Chapter 7.

Practice Example: Yukon Department of Transportation and Public Works Vegetation Control

The Yukon Department of Transportation and Public Works (TPW) is committed to taking a consistent, strategic approach to asset planning and management to deliver services matching their customers' expectations, while maximizing value for money. Vegetation management is a key part of TPW's roadside safety program. It improves highway safety and helps preserve their infrastructure by:

- Improving visibility and vehicle sight lines.
- Reducing wildlife collisions.
- Establishing a clear zone.
- Facilitating roadside drainage.
- Preserving roadside surfaces.
- Controlling invasive weeds.
- Enhancing the overall driving experience.

The TPW roadside vegetation management program was established in the early 2000's to address the challenges of maintaining right-of-way growth throughout Yukon. Over the past few years, the program was reassessed, leading to several improvements in the inspections and decision-making processes. This included establishing a life cycle model in the agency's dTIMS management system, to project the future condition of roadside vegetation, generate possible treatment strategies (e.g., mowing, brushing) for each section of road, and identify an optimal solution by assessing the life cycle costs and benefits from each treatment strategy for each road section. This included steps to define and compile the model inputs, including roadway inventory, vegetation condition ratings, deterioration curves, treatment options, treatment decision logic and financial parameters. The dTIMS roadside vegetation life cycle model was used to develop an optimized long-term investment plan that assessed the impacts of alternative budget scenarios and/or constraints. It also provided an example of how the software could be used by TPW staff to later model decision making for other asset types.

Section 2.6 Incorporating Equity into TAM

In recent years, transportation agencies have turned their attention to integrating equity considerations into their policies and practices, including within their asset management programs. This process entails incorporating notions of fairness, inclusivity, and accessibility across various aspects, ranging from asset management strategy and prioritization criteria to investment strategies. The aim is to achieve equitable asset management that provides equal access and benefits for all.

This ensures that all communities, including historically marginalized ones, have equal access to safe, reliable, and efficient transportation services. By addressing disparities and providing

equitable opportunities for all, transportation asset management becomes a tool for enhancing social, economic, and environmental well-being. This integration requires data-driven analysis, community engagement, and a commitment to rectifying historical imbalances in resource allocation and infrastructure development.

Subsection 2.6.1 Understanding Equity

This subsection explores the concept of equity in transportation, emphasizing its diverse applications, particularly in relation to environmental justice for low-income and minority populations. It clarifies distinctions between equality, equity, and justice, highlighting their interrelated yet distinct roles in fostering fairness and social balance within transportation systems.

In transportation, the notion of equity in the broad sense has been applied to encompass a diverse range of populations. In certain instances, it signifies environmental justice, often relating to low-income and minority populations. It is crucial to discern the distinctions between equality, equity, and justice. These concepts are interrelated terms that pertain to distinct notions within the realm of fairness and social equilibrium.

- **Equality:** centers around the idea of treating everyone the same, regardless of their circumstances or needs.
- **Equity:** recognizes that different individuals or groups have different needs, and it involves distributing resources and opportunities to ensure fairness.
- **Justice**: encompasses a broader notion of fairness and addresses deeper structural issues. It involves rectifying historical injustices and ensuring that systems, laws, and policies are designed to treat all individuals and groups fairly and equitably.

Subsection 2.6.2 Integration Equity in TAM Practices

This subsection emphasizes the need to integrate equity frameworks into Transportation Asset Management (TAM) practices, addressing various types of transportation inequities. It outlines steps, including defining equity, embedding it in policies, setting clear objectives, identifying measurable criteria, engaging communities, and continuously assessing initiatives to reduce disparities and enhance access for marginalized groups.

Video Resource: TPM and Equity

- AASHTO TPM Webinar #11

Integrating equity frameworks in transportation requires a systematic approach that addresses disparities and promotes fairness, inclusivity and community engagement. Transportation inequity can be broadly categorized into three interrelated types:

- **Spatial or Geographic Inequities:** often related to historical discrimination or rural underinvestment.
- **Modal Inequity:** revolves around disparities in the availability, accessibility, and quality of different transportation modes.

- **Social and Economic User Inequities:** closely tied to socioeconomic factors. Marginalized and vulnerable groups might experience discrimination or safety concerns on top of reduced mobility and accessibility opportunities.

These steps are recommended to consider these inequalities in TAM planning processes:

1. Define Equity: Define the meaning and intent behind the words we use to describe transportation equity in the context of your organization.
2. Integrate Equity in Policies and Planning Processes: Embed equity considerations into transportation policies, plans, and guidelines to ensure all decisions consider fairness and inclusivity.
3. Establish clear equity objectives: Set objectives that address disparities and align with the needs of underserved communities, as well as with the strategic goals of the agency.
4. Identify Measurable Criteria: Define performance measures or indicator that are both measurable and conducive to achieving equity goals.
5. Identify performance gaps (inequities): Collect data to identify existing disparities in transportation access, services, and outcomes among different communities. Conduct equity analyses to evaluate how transportation policies, plans, and projects impact various groups, considering factors such as income, race, gender, age, and ability. Furthermore, ensure that evaluation is integrated into planning processes, prioritization schemes, and other related procedures.
6. Engage community: Solicit feedback from underserved communities and respond to their interests by crafting investment strategies with equity goals at the forefront. Employ diverse engagement tactics, including public meetings, surveys, focus groups, and online platforms, to ensure that all voices are heard.
7. Implement Equity Considerations: Continuously assess the impact of implemented initiatives on reducing disparities and enhancing access for marginalized communities and identify areas for improvement in the process.

Practice Example: Integrating Equity in Transportation Decision-Making

Minnesota Department of Transportation (MnDOT) has integrated equity into transportation decision-making through its Advancing Transportation Equity Initiative, which seeks to enhance access and opportunities for underserved communities in the state. This initiative is based on community input and feedback received during the development of the 2017 Statewide Multimodal Transportation Plan. The plan identified the reduction of transportation disparities and the incorporation of equity into decision-making processes as high-priority objectives. The 2022 Statewide Multimodal Transportation Plan, along with its internal Strategic Plan, includes additional goals, strategies, and actions to further advance transportation equity. MnDOT is committed to creating an equitable transportation system.

Table 2.A MnDOT Integration of Equity in Decision-Making

Acknowledge Inequalities	Defining Transportation Equity:	Proposed Journey
MnDOT acknowledges historical injustices in transportation, where some communities were underserved and harmed by agency decisions. They recognize that past choices denied Black, Indigenous, and disabled communities full transportation benefits.	Transportation equity, as defined by MnDOT, seeks fairness and justice in the distribution of benefits and burdens within transportation systems, with a focus on empowering underserved communities, particularly Black, Indigenous, and People of Color, in decision-making processes.	MnDOT acknowledges that their journey toward transforming transportation systems and achieving equity requires ongoing listening, learning, adaptation, and implementation.

MnDOT has facilitated a series of conversations between MnDOT staff and individuals and organizations that work with and represent underserved communities in Minnesota through the Community Conversation Project. The objective of these conversations is to directly learn from underserved communities about their unique experiences and challenges with transportation. Main findings include:

- Inadequate transportation options create barriers to the community.
- Private vehicles are common.
- Capacity of public transit does not meet demand.
- Land use and natural barriers also affect access.
- Relationships are key to engagement.
- People have many ideas to solve challenges with transportation equity.
- Organizations provided varied definitions and examples of equity.

These conversations have culminated in the creation of a report for each of the eight operational districts, which summarizes findings and provides recommendations for the future direction of transportation decisions. Additionally, MnDOT has initiated "The Equitable Contracting and Engagement" project to explore methods of enhancing the accessibility and inclusivity of MnDOT's contracting and engagement processes. MnDOT aims to collaborate with more community-based organizations and nonprofits and advance their engagement efforts. Furthermore, MnDOT has prioritized and sponsored research projects with an equity focus to enhance understanding and promote initiatives that embrace equity principles.

Note: This practice example was derived from the Minnesota Department of Transportation's website. Further details on the "Advancing Transportation Equity Initiative" can be found here: https://dot.state.mn.us/planning/program/advancing-transportation-equity/

Checklist:

Identifying and Assessing Risks

1. Identify and assess risks: Begin by identifying the potential hazards that could impact transportation assets, such as floods, hurricanes, earthquakes, or cyberattacks. Assess the likelihood and severity of these hazards, considering factors like historical data, climate projections, and regional vulnerabilities.
2. Evaluate asset vulnerability: Analyze the vulnerability of transportation assets to identified hazards. Consider factors such as asset location, design, materials, age, and condition.

Identify critical assets that are essential for maintaining network connectivity and supporting emergency response.

3. Develop resilience goals and objectives: Establish clear goals and objectives for enhancing resilience, such as minimizing asset damage, reducing recovery time, and maintaining critical services during disruptions. These goals should align with the overall objectives of the TAMP and the broader transportation system.
4. Incorporate resilience strategies: Integrate resilience strategies into the TAMP's asset management framework. This may include:
    a. Preventive measures: Implement measures to reduce the likelihood of asset damage, such as elevating structures, strengthening foundations, or installing protective barriers.
    b. Mitigation measures: Plan for quick and effective response to disruptions, such as pre-positioning emergency supplies, establishing communication protocols, and training personnel for disaster response.
    c. Adaptive measures: Consider long-term adjustments to asset design and management practices to accommodate changing climate conditions and hazard risks.
5. Monitor and evaluate resilience performance: Establish metrics to track the effectiveness of resilience strategies and assess progress towards resilience goals. Regularly monitor and evaluate the performance of these strategies and make adjustments as needed.
6. Continuous improvement: Incorporate lessons learned from past events and ongoing monitoring into the TAMP, continuously improving resilience planning and implementation.

Chapter 2 Knowledge Check

Q: There is a strict process for developing a TAM strategy that every agency needs to follow.

A: False. Practices in TAM strategy development can and do vary across agencies. Whatever approach is used, however, a strategy will generally establish agency specific TAM principles, connect to agency strategic goals, and provide a framework for how TAM will be carried out.

Q: TAM is a stand-alone practice that is only applicable to select areas of a DOT.

A: False. Ideally, TAM principles and practices should be integrated within an agency's vision, mission and strategy documents, and awareness of the TAM approach should exist throughout the agency.

Q: Aligning TAM with the agency's strategic documents helps ensure an agency's vision is all encompassing and cohesive.

A: True. The TAMP and the agency's other strategic documents should be aligned. These documents include agency-wide strategic plan and/or business plan (including long-range plans), agency-wide financial plan, state long-range plan, and other performance plans (safety, mobility, freight, etc.).

Q: Development of a TAM policy relies solely on the input of leadership and asset experts.

A: False. As an agency develops its TAM policy, it is important to consult internal and external stakeholders on its general contents. Once a draft of the policy is available, it is important to circulate it to stakeholders to ensure the policy appropriately reflects all previous discussions and decisions. This helps educate stakeholders on the importance of TAM and also helps the agency communicate meaningful progress to the public.

Q: Asset management plans document the process and investment strategies developed by an agency to manage its infrastructure assets.

A: True. Asset management plans support an agency's performance-based planning and programming processes for making long-term investment decisions and feed shorter-term project and treatment selection activities. Together, these activities ensure the investment decisions of an agency are aligned with performance objectives and goals.

Q: Transportation agencies do not need to include risk considerations as part of their asset management process, since this is something they do every day.

A: False. Although agencies typically manage risk every day, are well-equipped to handle risks at the project and activity levels, and regularly consider risks on a larger scale, formally considering and documenting potential risks at all levels can help bring greater attention to them and improve risk management. Risk management strengthens asset management by explicitly recognizing that any objective faces uncertainty, and by identifying strategies to reduce uncertainty and its effects. Being proactive, rather than reactive, in managing risk and avoiding "management by crisis," helps agencies best use available resources to minimize and respond to risk as well as further build public trust.

Q: Agencies face challenges in integrating asset information across the life cycle of assets, because there is often a disconnect between maintenance activities, and planning and programming improvements.

A: True. Improving the linkage between future work an agency is planning, the work it is currently undertaking, and the general condition of its assets is important to cultivate and strengthen an agency's asset management efforts.

Q: Depending on the nature of the asset and the level of risk involved, different asset management approaches can be selected by an agency.

A: True. TAM processes can vary in their level of detail and complexity. It is common for an agency to begin at a simple level and mature over time towards more complex asset management that integrates processes and decision-making. The asset management processes an agency adopts should depend on the readiness of the agency and the problem being addressed. Consideration should be given to the data, processes, and tools available to support the asset management approach, as well as resource availability and capability.

Q: A TAM Implementation Plan is roughly the same as a Transportation Asset Management Plan.

A: False. An implementation plan focuses on business process improvement, while a TAMP focuses on an organization's assets and how it is investing in and managing them. However, the implementation plan may be included as a section of the TAMP. The implementation plan

recognizes potential barriers to implementation and should consider foreseeable obstacles, such as the need for leadership support, improved staff skills, or better data integration and analysis.

Q: The TAMP is only required to focus on NHS pavements and bridges.

A: True. But while these assets make up the greatest portion of a typical state highway agency's assets, an agency may wish to include additional assets in its TAMP. The agency may also wish to extend the network scope of the TAMP. In updating a TAMP with NHS pavement and bridges, an agency may include other assets, such as drainage assets, traffic and safety features, or the agency may wish to include all of the assets it owns. For transit TAMPs, the initial focus is on revenue vehicles, facilities, and infrastructure, as these require the greatest investment, but an agency may wish to expand its TAMP to include additional assets that are important to the systems, albeit less costly, such as bus shelters and signage.

Chapter 2 References

Guide to Asset Management Overview Part 2: Managing Asset Management
Austroads | July 10, 2018 | https://austroads.com.au/publications/asset-management/agam02
Part 2 of the Guide to Asset Management covers the 'management of asset management', a crucial subject for senior managers, leaders, and those who influence organizational culture. The governance of asset management is a shared responsibility between senior management and the corporate governance tiers of the road agency.

Asset Management Strategy for Road-Related Assets (Safety Infrastructure)
Austroads | May 9, 2018 | https://austroads.com.au/publications/road-safety/ap-t309-18
This report offers guidance on managing safety infrastructure assets to maximize service levels at minimal life-cycle costs, reduce risks to road users, and aid in the continuous improvement of planning, maintenance, and operations.

Asset Management Guide for Local Agencies
Minnesota Local Road Research Board | November 1, 2019 |
https://mdl.mndot.gov/items/2019RIC06
This document aims to guide the development of an asset inventory and condition assessment, the establishment of performance measures and goals, the identification and rating of risks, the determination of lifecycle planning and funding strategies, and the creation of asset management plans as well as programs using both existing and new resources.

Integrating Effective Transportation Performance, Risk, and Asset Management Practices
Transportation Research Board | January 20, 2022 |
https://www.trb.org/Publications/Blurbs/182511.aspx
Research and practice in transportation performance, risk, and asset management have enhanced the tools, methods, and strategies available to state departments of transportation and other agencies. Transforming the culture of a transportation agency and integrating these changes into traditionally siloed management practices demand the dedicated effort of the entire organization, involving nearly every individual.

Implementation of the AASHTO Guide for Enterprise Risk Management

Transportation Research Board | January 1, 2022 | https://nap.nationalacademies.org/catalog/26516/implementation-of-the-aashto-guide-for-enterprise-risk-management
The TRB National Cooperative Highway Research Program's NCHRP Research Report 986: Implementation of the AASHTO Guide for Enterprise Risk Management details how several state departments of transportation are incorporating risk management principles and practices.

Right-Sizing Transportation Investments: A Guidebook for Planning and Programming
Transportation Research Board | January 1, 2019 | https://nap.nationalacademies.org/catalog/25680/right-sizing-transportation-investments-a-guidebook-for-planning-and-programming
The TRB National Cooperative Highway Research Program's NCHRP Research Report 917: Right-Sizing Transportation Investments: A Guidebook for Planning and Programming offers guidance on identifying right-sizing opportunities. This approach aims to enhance social and economic value by repurposing, reusing, or fundamentally resizing existing transportation system assets.

The Relationship Between Transit Asset Condition and Service Quality
Transportation Research Board | January 1, 2018 | https://nap.nationalacademies.org/catalog/25085/the-relationship-between-transit-asset-condition-and-service-quality
TRB's Transit Cooperative Research Program (TCRP) Research Report 198: The Relationship Between Transit Asset Condition and Service Quality outlines the creation of a quantitative method for assessing service quality and illustrates how this measure fluctuates with changes in asset condition. It offers guidance on the relationship between asset condition and transit service quality concerning investment prioritization.

Identification of Effective Next Generation Pavement Performance Measures and Asset Management Methodologies to Support MAP-21 Performance Management Requirements
FHWA | January 17, 2017 | http://www.pdth.com/images/NextGenTAMphase1.pdf
This study aims to identify or conceptually create methodologies for fully implementing a comprehensive asset management plan. It includes trade-off analysis from a unified perspective among various assets, typically assessed and managed separately. The proposed framework begins with the fundamental objectives and management considerations shared by most highway agencies. These form the basis for a unified set of methodologies across assets to aid decision-making in all the essential business processes required for implementing TAM Plans.

Case Study 2 - Linking Asset Management to Planning and Programming
FHWA | May 1, 2020 | https://rosap.ntl.bts.gov/view/dot/54455
This case study showcases how asset management is connected to long-term plans, the statewide transportation improvement program (STIP), and state planning and programming practices. It includes examples drawn from the TAMPs in Missouri, Maine, Utah, Ohio, Wyoming, and Montana.

Linking Performance and Asset Management
FHWA | July 1, 2019 | https://rosap.ntl.bts.gov/view/dot/67127
This paper explores the correlation between transportation asset management processes outlined in 23 CFR 515, transportation performance management processes detailed in 23 CFR 490, and

planning requirements specified in 23 CFR 450. It aims to expand upon previous research and investigate how the regulations in 23 CFR 450, 490, and 515 endorse a nationally implemented performance-based asset management approach.

Case Study 6 - Communicating Asset Management Strategies
FHWA | May 1, 2020 | https://austroads.com.au/publications/road-safety/ap-t309-18
This case study showcases the communication methods utilized by State departments of transportation (DOTs) to involve and interact with internal and external stakeholders. These communication strategies enhanced collaboration within the DOTs and with crucial external partners, including National Highway System (NHS) asset owners and metropolitan planning organizations (MPOs).

Case Study 1 - Asset Management Practices and Benefits
FHWA | May 1, 2020 | https://rosap.ntl.bts.gov/view/dot/54454
This case study showcases methods employed by State departments of transportation (DOTs) to communicate and involve both internal and external stakeholders. These communication approaches fostered greater coordination within the DOTs and with significant external collaborators, including National Highway System (NHS) asset owners and metropolitan planning organizations (MPOs).

Integrating Effective Transportation Performance, Risk, and Asset Management Practices
Transportation Research Board | January 1, 2022 |
https://nap.nationalacademies.org/catalog/26326/integrating-effective-transportation-performance-risk-and-asset-management-practices
Integrating Effective Transportation Performance, Risk, and Asset Management Practices is structured as a process framework. The source is designed to be resilient to the expected evolution of an agency as it matures throughout its management integration.

How to Develop an Asset Management Policy, Strategy and Governance Framework
Federation of Canadian Municipalities | January 1, 2018 |
https://fcm.ca/en/resources/mamp/guidebook-how-develop-asset-management-policy-and-strategy
This guide demonstrates the steps to create an asset management policy, strategy, and governance framework tailored for a Canadian municipality. It advocates for a unified approach to planning and decision-making to effectively oversee municipal infrastructure assets.

Georgia DOT Asset Management Policy
Georgia Department of Transportation | February 19, 2021 |
http://mydocs.dot.ga.gov/info/gdotpubs/Publications/4B-1.pdf
The objective of this policy is to officially embrace Transportation Asset Management as the institutional approach for overseeing and preserving infrastructure assets and determining capital investment choices at the Georgia Department of Transportation (GDOT).

Building a Better Tomorrow: An Infrastructure Planning, Financing and Procurement Framework
Ontario Ministry of Public Infrastructure Renewal | January 1, 2004 |
https://books.google.com/books/about/Building_a_Better_Tomorrow_an_Infrastruc.html?id=u9KenQAACAAJ

This document establishes a framework for planning, financing, & procuring public infrastructure in Ontario. The framework encompasses: an outline of the government's infrastructure planning procedure; essential aspects to be tackled in the planning, design, funding, and administration of public infrastructure projects; the duties and obligations of government ministries and agencies, municipalities, broader public sector collaborators, and the private sector in the planning, funding, and procurement of public infrastructure assets; an introduction to optimal practices in infrastructure procurement; and a summary of the provincial government's asset management guidelines.

Integrated Planning and Reporting Manual
Government of Western Australia: Department of Local Government, Sport, and Cultural Industries| September 1, 2021 | https://www.dlgsc.wa.gov.au/local-government/strengthening-local-government/integrated-planning-and-reporting
The council, community, and administration each possess distinct roles and responsibilities in formulating efficient and enduring integrated plans for the local area, as well as reporting on the advancement of those plans.

City of Townsville Strategic Asset Management Plan
Townsville City Council | January 1, 2023 |
https://www.townsville.qld.gov.au/__data/assets/pdf_file/0034/193885/SAMP_23-24.pdf
This Strategic Asset Management Plan (SAMP) delineates the Asset Management System Model, Asset Management Framework, and Asset Management Capability Delivery Model for the Townsville City Council. The Asset Management System Model illustrates the key components of the Council's asset management system and how they relate.

Chapter 3: Organization and People

Subsection 3.1.3 Competencies

Video Resource: More Than Just Asphalt, Concrete, and Steel: Innovations from Our People that are Moving Our Transportation System Forward

- AASHTO TPM Webinar #14

Subsection 3.2.3 Communication

Video Resource: Communicating the TAMP and Stakeholder Engagement

- AASHTO TAM Webinar #37

Video Resource: Transportation Asset Management Communications

- Interview with Trisha Stefanski

Video Resource: TAM Communication

- AASHTO TAM Webinar #25

Section 3.4 Managing the TAM Workforce

The compounding effects of COVID-19 and the Baby Boomer generation leaving the workforce have contributed to the civilian labor force participation rate dropping to below 62.5% (January 2023) — the lowest rate in 45 years — and presenting challenges for DOTs to find workers. Those who remain active in the labor force have higher expectations of their employers in terms of salaries and working conditions, especially flexibility and the ability to work remotely. At the same time, demands on DOTs for personnel trained in asset management have increased, most recently due to the Infrastructure Investment and Jobs Act (IIJA), 2021, also known as the Bipartisan Infrastructure Law (BIL).

In the past 20 years, DOTs have moved from predominantly performing work themselves to contracting more work to be performed by consultants, with management systems and indicators to guide the work. This shift requires new skill sets, but also presents new opportunities for innovation.

The effective management of a Transportation Asset Management (TAM) workforce is crucial for realizing the benefits of TAM application. This section outlines best practices, strategies, and considerations for developing and sustaining a skilled and efficient TAM workforce.

TIP:

An important resource for workforce management is the AASHTO Agency Capability Building Guidance and Portal that was developed through the NCHRP 20-24(95) Ensuring Essential Capability for the Future Transportation Agency project. It provides a library of resources related to transportation agency workforce needs (https://www.agencycapability.com/).

Subsection 3.4.1 TAM Workforce Development

This page emphasizes the importance of workforce planning and development in Transportation Asset Management (TAM). It suggests conducting skill assessments and gap analyses to address evolving needs, implementing effective recruitment and retention strategies, and leveraging technology through digital competency and data-driven decision-making. Additionally, it recommends resources such as the AASHTO TAM Portal and NCHRP reports for further guidance on skill development, recruitment, and technology adoption in the TAM field.

Recruitment and Retention Strategies

Attracting good talent involves developing competitive recruitment strategies that emphasize the importance and impact of TAM roles. This should involve highlighting career progression opportunities and the benefits of contributing to public service and infrastructure development and management.

Effective retention practices involve fostering a positive work environment that values employee contributions. Although options may be limited, it is important to implement recognition programs, competitive compensation packages, and develop or showcase opportunities for career advancement to reduce turnover rates.

The NCHRP Research Report 1008: Attracting, Retaining, and Developing the 2030 Transportation Workforce: Design, Construction, and Maintenance that was published in 2023 is a good resource for recruitment and retention strategies (https://nap.nationalacademies.org/catalog/26768/attracting-retaining-and-developing-the-2030-transportation-workforce-design-construction-and-maintenance).

Video Resource: Increasing Your Workforce Capacity

- AASHTO TAM Guide Book Club #6

Video Resource: New Employee Training

- Interview with Chris Whipple on Onboarding staff

Leveraging Technology and Tools

Digital competency is a critical skill in the current TAM organization. Ensuring the workforce is proficient in using TAM-related software and tools enables greater effectiveness and efficiency. Regular training on digital tools and data management systems is essential.

A key element of TAM programs is data-driven decision-making. It is important to train staff in data analytics and the use of data-driven approaches for asset management decision-making, enhancing efficiency and effectiveness.

NCHRP Report 1075 Becoming a Tech-Savvy DOT of Tomorrow – A Playbook for State DOTs, published in 2023 could be a good resource: https://nap.nationalacademies.org/catalog/27293/becoming-a-tech-savvy-dot-of-tomorrow

Subsection 3.4.2 TAM Workforce Management

This subsection underscores the significance of collaboration, communication, and performance management in Transportation Asset Management (TAM) workforce success. It advocates for fostering a collaborative culture, establishing effective internal communication channels, and

implementing performance management practices aligned with TAM goals to ensure a competent and motivated workforce for the sustainable implementation of TAM programs.

Collaboration and Communication

Interdepartmental collaboration is a key ingredient of TAM success. A good approach to TAM workforce management is to promote a collaborative culture by facilitating interaction and knowledge-sharing between different departments and teams involved in TAM. Section 3.2.1 Internal Coordination of this guide is a good resource for increasing collaboration.

Developing strong internal communication channels to ensure that all team members are informed and engaged with the organization's goals and strategies builds a stronger workforce. TAM Guide Section 3.2.3 Communications is a good resource for TAM communication.

Performance Management and Evaluation

A key element of TAM is performance management. Applying this to workforce management is important to having happy human resources. Setting clear, measurable objectives for workforce performance aligned with your agency's TAM goals will yield better results.

It is important to have regular evaluations of your staff's performance to provide feedback, identify areas for improvement, and recognize achievements.

Conclusion

Managing the TAM workforce effectively is vital for the successful implementation and sustainability of transportation asset management programs. By focusing on skills development, recruitment, retention, and leveraging technology, TAM organizations can ensure they have a competent and motivated workforce capable of meeting current and future challenges.

Section 3.5 Knowledge Management for TAM

Knowledge management involves the systematic handling of information and resources to effectively support decision-making. This section explores strategies and practices for efficient and effective knowledge management in TAM.

There has been a lot of research related to knowledge management for state departments of transportation. The AASHTO Committee on Knowledge Management website has a wealth of resources for applying knowledge management at transportation agencies.

https://transportation.org/km/

Subsection 3.5.1 Accumulating Knowledge

This page emphasizes the importance of establishing a Knowledge Management Framework for Transportation Asset Management (TAM) programs. It outlines key steps, including developing a knowledge management strategy, creating a centralized digital repository, implementing standardized procedures for data collection, promoting information sharing, leveraging technology systems, and providing regular training programs for staff to maximize the value of knowledge management in TAM.

Establishing a Knowledge Management Framework

A good first step is to develop a knowledge management strategy for your TAM program. It involves defining clear objectives and goals for knowledge management aligned with the broader TAM objectives. It also involves identifying key knowledge areas essential for decision-making in asset management.

After a knowledge strategy has been developed, next create a knowledge repository. Doing so establishes a centralized digital repository to store and organize all TAM-related data, documents, best practices, and historical information.

Data Collection and Information Sharing

A key element of successfully gaining value from knowledge management is data collection and information sharing. Implementing standardized procedures for collecting, updating, and validating data related to transportation assets helps ensure the use and quality of data agency-wide.

An agency can enhance information-sharing by promoting a culture of open communication across departments, using intranet platforms, newsletters, and regular meetings to disseminate knowledge.

Integrating Technology in Knowledge Management

Utilizing IT systems effectively will yield greater value for the agency and the public. IT systems like Enterprise Resource Planning (ERP) and Asset Management Systems can streamline data storage and retrieval for both internal and external use. Encouraging the use of advanced analytics and business intelligence tools for data interpretation can help inform decision-making to maximize benefits and performance.

Training and Development for Knowledge Utilization

Regular training programs can help ensure staff are competent in using knowledge management systems and understanding the data analytics. Staff need regular guidance on how best to use knowledge management tools and apply them for greater results. Workshops and seminars that focus on sharing experiences, insights, and best practices in TAM can further improve staff understanding of the importance of knowledge management in TAM.

Subsection 3.5.2 Building on Knowledge

This subsection underscores the importance of capturing tacit knowledge in Transportation Asset Management (TAM) by regularly documenting insights and experiences of seasoned professionals. It advocates for mentorship programs to transfer critical tacit knowledge to new staff, emphasizes periodic knowledge reviews, addresses challenges in knowledge management, and concludes by highlighting the pivotal role of effective knowledge management in enhancing decision-making and optimizing transportation assets within TAM organizations.

Capturing Tacit Knowledge

There are a few ways that agencies can ensure the capture of tacit knowledge. For example, an agency can find ways to regularly document insights and experiences of seasoned professionals and experts in the field of TAM, including through expert interviews and more structured documentation. Mentorship programs are another way to transfer knowledge from those with

expertise to new staff who are learning, by encouraging experienced staff to share critical tacit knowledge to newer employees.

Knowledge Review and Update

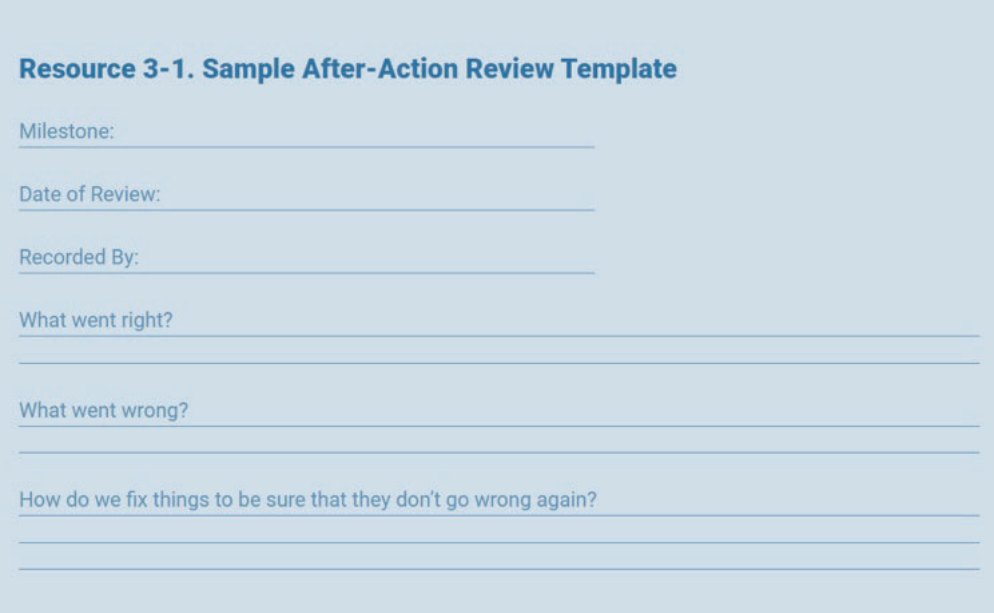
Agencies can conduct periodic audits of their knowledge repository to ensure accuracy, relevance, and completeness of information. It is important to update information to stay relevant and add tools as they become available and establish mechanisms for continuous feedback and improvement of the knowledge management processes.

Capturing Lessons Learned

Building an effective TAM program is a process of continuous improvement. The practices will improve as your TAM program matures. It will also improve as new methods and tools become available. It's important to capture what has been learned as you conduct a TAM function (i.e., building a TAMP, developing a resilience improvement plan, target setting, investment planning, etc.). Taking the step of looking back at what you have learned and documenting what worked and what did not work will help you the next time you do the activity. Consider as a part of this step what you would change the next time you do the activity to do it better.

After Action Reviews (AAR) are a formal mechanism for capturing lessons learned. They are designed to identify and document what went well, what could have been improved, and how to fix things to be sure that they don't go wrong again. You can use Before- and During-Action Reviews to document lessons learned as they go and make corrective actions as needed. The following is a sample AAR template from NCHRP Report 813 A Guide to Agency-Wide Knowledge Management for State Departments of Transportation.

Figure 3.A Sample After-Action Review Template



Resource 3-1. Sample After-Action Review Template

Milestone:

Date of Review:

Recorded By:

What went right?

What went wrong?

How do we fix things to be sure that they don't go wrong again?

Another resource that provides guidance on AARs is from the USAID: USAID After-Action Review Guide (Introduction/Technical Guide) https://pdf.usaid.gov/pdf_docs/pnadf360.pdf

Challenges and Solutions in Knowledge Management

There are challenges to successful knowledge management. They include addressing knowledge silos and managing knowledge overload. Agencies that identify and address barriers to information sharing within the organization can promote a more integrated approach to knowledge management. Mechanisms to filter and prioritize relevant and high-quality information for decision-makers are also needed to ensure the efficient use of data in the decision-making process.

Conclusion

Effective knowledge management is a cornerstone of successful Transportation Asset Management. By systematically collecting, storing, sharing, and utilizing knowledge, TAM organizations can significantly enhance their decision-making processes, ensuring the efficient management and optimization of transportation assets.

Chapter 3 Knowledge Check

Q: A TAM unit needs to be established as an agency begins to undertake an asset management approach to planning and programming.

A: False. There are many choices to consider when identifying a 'home' for asset management. Some agencies do choose to establish a TAM unit, some appoint a TAM lead to coordinate activities and resources, and others focus TAM activities in a single business unit and use committees for coordination. Regardless of where the TAM home is located, asset management committees can help coordination and enhance the asset management culture across the organization.

Q: If a TAM unit is established, the best place for it is in engineering.

A: False. Placement of a TAM unit or lead within the organization should support agency priorities. Agencies that have priorities focused on activities based in planning, such as economic development or sustainability, may choose to house TAM in planning. A greater focus on safety and rebuilding infrastructure may lead to locating TAM in engineering. Agencies that prioritize preservation and operations may choose maintenance for the TAM location. Across the country, agencies have located TAM units or leads in engineering, planning, maintenance, or executive areas of the department.

Q: A TAM organizational model can be centralized or decentralized.

A: True. The TAM organizational model can be strongly centralized, or it can be decentralized to a greater or lesser degree, which encourages decision-making closer to the customer, but requires clear guidance and standards to avoid inconsistencies. The advantage of the more decentralized model is the stronger link between TAM policies, goals, and objectives and work that is implemented. The disadvantage is the lack of consistent application of TAM across the agency.

Q: Three key roles provide the foundation for implementing TAM in an agency: a Champion, a Lead, and Asset Stewards.

A: True. The TAM champion, typically a senior manager or executive, communicates the importance of TAM throughout the agency. The TAM lead coordinates various TAM program activities and makes sure staff and external partners are working together to advance TAM. Asset stewards – sometimes called "Asset Owners," "Asset Managers" or simply "Asset Leads" – manage a particular

class of asset, understand the asset well, and can communicate the asset's needs and the consequences of underinvestment in that asset.

Q: Implementation of TAM relies on a variety of key staff competencies, from data collection to management and communications.

A: True. Successful TAM practices rely on competencies across the agency, including leadership, management, engineering, planning, and environmental and financial expertise, as well as problem-solving, relationship building, strategic planning, analysis, computer and data knowledge, and communications.

Q: Internal and external TAM communities can help strengthen coordination and communications.

A: True. State DOTS rely on a variety of both internal and external committees to coordinate and communicate TAM activities. The approach that works best for each DOT depends on a combination of strategic priorities and asset ownership. Many TAM activities depend on internal, and even external, agency coordination, including development of the TAMP. Users don't distinguish who owns the various parts of the transportation network, so it is up to the various agencies to work together and seamlessly deliver the best results.

Q: Agencies should use a variety of tactics to communicate effectively regarding TAM implementation and progress.

A: True. State DOTs generally use a combination of formal and informal mechanisms to communicate progress related to TAM activities and investment. The variety of audiences that benefit from better information dictates the need to use different tactics with different groups.

Q: Every organization has employees that embrace change, employees that resist it, and many others in between. Early adopters of the changes that TAM will bring are all that are needed for successful implementation.

A: False. For TAM implementation to be truly successful, all employees need to embrace or at least accept the changes that will be needed. Using a combination of various types of internal communication, training, and celebrations of success can help convince skeptical or resistant employees of the benefits of a TAM approach to investment.

Chapter 3 References

Attracting, Retaining, and Developing the 2030 Transportation Workforce: Design, Construction, and Maintenance
Transportation Research Board | January 1, 2022 |
https://nap.nationalacademies.org/catalog/26768/attracting-retaining-and-developing-the-2030-transportation-workforce-design-construction-and-maintenance
The TRB National Cooperative Highway Research Program's NCHRP Research Report 1008, titled "Attracting, Retaining, and Developing the 2030 Transportation Workforce: Design, Construction, and Maintenance," offers a comprehensive guide with detailed strategies and action plans. These resources are designed to assist agencies in identifying and addressing their workforce needs up to and beyond 2030.

Transportation Workforce Planning and Development Strategies
Transportation Research Board | March 12, 2021 |
http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4657

The TRB National Cooperative Highway Research Program's NCHRP Synthesis 543, "Transportation Workforce Planning and Development Strategies," summarizes the current practices used by state departments of transportation (DOTs) as well as local and tribal technical assistance programs (LTAPs/TTAPs) in implementing workforce planning and development strategies.

Attracting, Retaining, and Developing the Transportation Workforce: Transportation Planners
Transportation Research Board | December 6, 2021 |
https://austroads.com.au/publications/asset-management/agam02
This report assesses the current and emerging factors influencing transportation planning practices and the planning workforce. The research aims to identify talent profiles for state, regional, and local transportation planners that align with current and future agency needs, and offers guidance on how agencies can attract, develop, manage, and retain planning talent.

Defining the TSMO Workforce Pipeline
FHWA | November 14, 2021 | https://transportationops.org/tools/defining-tsmo-workforce-pipeline
This report emphasizes the importance of diversifying the workforce pipeline sources for the TSMO industry. Best practices for developing the TSMO workforce pipeline involve forming innovative partnerships, broadening the scope of current development activities, and targeting a range of diverse communities.

Attracting, Retaining, and Developing the Transportation Workforce: Design, Construction, and Maintenance
Transportation Research Board | April 4, 2022 |
https://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_1008Summary.pdf
NCHRP Research Report 1008 serves as a comprehensive guide to help agencies develop and maintain a high-quality workforce in transportation design, construction, and maintenance. It includes a roadmap and decision tree to assist agencies in assessing their specific workforce needs and implementing the practical strategies outlined in the guide.

Assessing and Measuring the Business Value of Knowledge Management
Transportation Research Board | June 13, 2023 |
https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=5002
With 40% of the workforce in many DOTs nearing retirement eligibility within a few years, this report emphasizes the importance of knowledge management (KM) techniques and practices. These methods can assist transportation agencies in identifying, capturing, and transferring institutional knowledge, thereby fostering continuous learning and development.

Lessons Learned from State DOTs on Innovation and Knowledge Management Programs
U.S. DOT Volpe Center | March 1, 2021 | https://connect.ncdot.gov/projects/Value-Management/CLEARProgram/Documents/Lessons%20Learned%20from%20State%20DOTs%20on%20Innovation%20and%20Knowledge%20Management%20Programs.pdf
This report presents a summary of interviews conducted with state DOTs, offering a comprehensive overview of their approaches to managing innovation. It details the methods used for collecting and disseminating knowledge and identifies common themes and challenges faced by various DOTs.

Asset Management Manual: Organization
PIARC | October 16, 2023 | https://road-asset.piarc.org/en/management/organization

This chapter covers various topics on modifying a road organization's structure to maximize asset management potential and support its goals. These include leadership and culture, evaluating current asset management practices, the importance of asset management champions in driving necessary changes, and an organizational structure conducive to implementing asset management.

Developing a School to Workforce Pipeline in North Carolina
U.S. DOT Volpe Center | July 15, 2022 |
https://connect.ncdot.gov/projects/research/RNAProjDocs/School%20to%20Work%20Pipeline%20Recommendations_FINAL.pdf
This report provides several actions for North Carolina Department of Transportation to consider pursuing while developing a school-to-career pipeline that focuses on minority students.

Workforce Management in Transportation
Transportation Research Board | October 5, 2021 |
https://onlinepubs.trb.org/onlinepubs/webinars/211005.pdf
This presentation gives a strategic overview on how to develop or refine an agency workforce plan.

Strategic Workforce Development Toolkit
FHWA | October 16, 2022 |
https://www.fhwa.dot.gov/innovativeprograms/centers/workforce_dev/hcwp/toolkit/
The Strategic Workforce Development (SWD) Toolkit offers a range of resources and inventive approaches aimed at involving organizations seeking to recruit, train, and employ individuals in construction roles vital for the advancement of the nation's highway system.

ADKAR: A Model for Change in Business, Government and our Community
Prosci Learning Center Publications | July 10, 2018 | https://austroads.com.au/publications/asset-management/agam02
This resource explores the ADKAR Model, a framework facilitating change management planning. Describes the objectives and achievements associated with implementing successful, extensive change initiatives.

The Balanced Scorecard: Step-by-Step for Government and Nonprofit Agencies
John Wiley & Sons, Inc.; 2nd Edition | June 1, 2003 | https://www.wiley.com/en-us/Balanced+Scorecard+Step+by+Step+for+Government+and+Nonprofit+Agencies-p-9780471475446
The Balanced Scorecard serves as a methodology for instituting performance management systems and enhancing operational effectiveness. Tailored specifically for the public and not-for-profit sectors, this book offers guidance to these organizations in surmounting the distinct hurdles encountered during the implementation of a Balanced Scorecard.

The Balanced Scorecard: Translating Strategy into Action
Harvard Business Review Press | August 2, 1996 | https://hbr.org/product/the-balanced-scorecard-translating-strategy-into-action/6513-HBK-ENG
The Balanced Scorecard converts the vision and strategy of an organization into a unified collection of performance metrics. Its four perspectives—financial measures, customer knowledge, internal business processes, and learning and growth—provide equilibrium between short-term and long-term goals, between desired outcomes and the factors influencing them, and between quantifiable metrics and qualitative assessments.

Building a Winning Culture in Government: A Blueprint for Delivering Success in the Public Sector
Mango Publishing | April 15, 2018 | https://mango.bz/books/building-a-winning-culture-in-government-by-patrick-r-leddin-and-shawn-d-moon-376-b
The book offers a systematic guide for reshaping governmental entities, delivering invaluable perspectives on change management, strategic blueprinting, and fostering vibrant workplace environments.

Project Route Map Organizational Design and Development Module – Improving Infrastructure Delivery
Infrastructure and Projects Authority | June 1, 2014 | https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/529336/ODD_Module.pdf
Authored by the UK government, this handbook delineates the Organization Design and Development module. The model aims to facilitate strategic decision-making, particularly concerning coordination between sponsors and clients, as well as project initiation and execution.

HBR's 10 Must Reads on Change Management
Harvard Business Review Press | March 7, 2011 | https://hbr.org/product/hbr-s-10-must-reads-on-change-management-with-featured-article-leading-change-by-john-p-kotter/12599E-KND-ENG
This source contains a compilation of articles that delve into optimal strategies for change management. They reframe change as a progressive process marked by distinct phases, rather than a singular occurrence.

Advancing Workforce Development: Leading a Performance-Based Culture
FHWA | July 1, 2020 | https://highways.dot.gov/public-roads/summer-2020/advancing-workforce-development-leading-performance-based-culture
Introduces the National Highway Institute's Maintenance Leadership Academy (MLA), a workforce development program that combines technical and leadership training to prepare new managers and supervisors in transportation maintenance. The MLA emphasizes a performance-based maintenance culture, covering topics such as leadership skills, pavement and bridge preservation, environmental protection, and more. The flexible course structure includes self-paced online study and instructor-led classroom training to efficiently equip participants with the necessary skills for effective maintenance practices.

Fact Sheet: Technical Assistance and Workforce Development
FHWA | December 6, 2021 | https://www.transit.dot.gov/funding/grants/fact-sheet-technical-assistance-and-workforce-development
This resource provides a fact sheet on the funding allocation for Technical Assistance and Workforce Development under the Bipartisan Infrastructure Law (IIJA) for fiscal years 2022 to 2026. The program aims to support effective transportation service delivery, compliance with federal laws, and workforce development through various activities, including technical assistance, standards development, and human resource programs. Eligible recipients include government entities and organizations with demonstrated capacity in public transportation.

Primary/Secondary/Post Secondary and Professional Development
FHWA | January 1, 2018 | https://www.fhwa.dot.gov/innovativeprograms/centers/workforce_dev/education_professional_development.aspx

The Center for Transportation Workforce Development (CTWD) actively promotes initiatives aimed at cultivating curiosity and enthusiasm for prospective careers in transportation among K-12 students. Its array of programs and resources equips individuals with the essential skills required to excel in the transportation workforce of the future. Furthermore, the CTWD oversees endeavors that embed transportation themes into college and university curricula, fostering a greater interest among post-secondary students in pursuing careers in transportation-related fields. By offering management, leadership, and coordination, the Center spearheads student transportation education programs, contributing to the cultivation of a highly skilled workforce in the transportation sector.

A Guide to Agency-Wide Knowledge Management for State Departments of Transportation
Transportation Research Board | January 1, 2015 |
https://nap.nationalacademies.org/catalog/22098/a-guide-to-agency-wide-knowledge-management-for-state-departments-of-transportation
Providing comprehensive advice tailored to state transportation agencies, "A Guide to Agency-Wide Knowledge Management for State Departments of Transportation" offers insights into establishing a deliberate knowledge management (KM) strategy and showcases various approaches adopted by organizations. KM encompasses diverse methods aimed at safeguarding and enriching the collective knowledge of an organization's workforce, thereby harnessing it as a valuable asset for productivity.

Lessons Learned from State DOTs on Innovation and Knowledge Management Programs
U.S. DOT Volpe Center | March 1, 2021 | https://connect.ncdot.gov/projects/Value-Management/CLEARProgram/Documents/Lessons%20Learned%20from%20State%20DOTs%20on%20Innovation%20and%20Knowledge%20Management%20Programs.pdf
The document provides insights into innovation and knowledge management initiatives in state Departments of Transportation (DOTs). It outlines program structures, challenges, successes, and future plans, emphasizing the importance of communication, empathy, and staff recognition for program success, and highlights strategies such as establishing innovation centers, updating submission structures, and enhancing organizational involvement for future development. The document features lessons learned from various state DOTs, including California, Idaho, Illinois, Iowa, Michigan, Utah, and Wisconsin.

Michigan Boosts Local Construction Workforce Through Innovative Training Strategy
FHWA | January 1, 2022 |
https://www.fhwa.dot.gov/programadmin/contracts/sep14mi202201_casestudy.pdf
The following case study offers a comprehensive examination of the implementation, advantages, challenges, and tactics employed in the Michigan Department of Transportation's On-the-Job Training Voluntary Incentive Program.

Chapter 4: Maximizing the Performance of Transportation Assets

Subsection 4.1.3 Developing Life Cycle Strategies

Video Resource: Life Cycle Planning and Management

- AASHTO TAM Book Club #3

Video Resource: Whole-Life Approach to Asset Management

- Interview with Andrew Williams

Video Resource: Improving Life Cycle Planning and Management

- AASHTO TAM Webinar #49 – Improving Your Next TAMP Miniseries

Subsection 4.2.1 Life Cycle Management Approaches

Video Resource: Life Cycle Planning and Management

- AASHTO TAM Webinar #32

Subsection 4.3.1 Managing Assets Using Condition Based Management

Video Resource: Asset Inventory Condition, Target Setting, and Ten-Year Projections

- AASHTO TAM Webinar #26

Subsection 4.3.2 Applying Other Life Cycle Management Approaches

Video Resource: Advanced Technologies and TAM

- AASHTO TAM Webinar #38

Chapter 4 Knowledge Check

Q: Life cycle management is only necessary at the project level.

A: False. Life cycle management can be used at both network level and at project level. At a project level, life cycle management is commonly used to develop asset-specific strategies, but project level life cycle plans can also provide input into network level life cycle plans. At network-level, life cycle management considers the needs of an entire asset class, as well as the available funding, to determine the most appropriate life cycle strategies. Network-level analysis can establish the optimal proportions of overall investment that should be allocated to different types of interventions over the network, to minimize investment to achieve performance targets.

Q: Once a performance target is set, it should not change.

A: False. The performance target represents a desired level of performance and may be adjusted over time to reflect changes in agency performance, changes in asset condition, capacity, safety, resiliency, and other factors.

Q: System performance relies on strategic, tactical, and operational performance targets.

A: True. For example, a strategic target such as improved freight movement can be supported by a performance target of no load-posted or restricted bridges on interstate highways. This can be accomplished with the tactical delivery of work to address the physical condition of bridges and operational improvements such as more responsive snow clearance.

Q: It is more important to focus on a few Key Performance Indicators (KPIs) that are directly related to stakeholder perception of performance than try to manage using a list of more technical measures.

A: True. The more directly KPIs relate to the agency's business decision and stakeholders' understanding of performance, the better. For these reasons KPIs based on user experience such as congestion, safety, or freight movement can be helpful, although they may not relate directly to asset management metrics which focus on condition. There is also a need to choose KPIs which can be measured accurately and at the lowest expense. Agencies should revisit their list of KPIs on a regular basis to make sure they are still the right measures, and there isn't a more cost-effective means of collecting the needed information.

Q: Strategies with a short-term outlook provide better short-term performance and are more cost effective.

A: False. While strategies with a short-term outlook may provide better short-term performance, they can greatly increase the risk of higher future costs. By establishing sound long-term strategies, agencies can minimize the life cycle costs of preserving assets, while also managing asset performance to a defined target, to the extent possible with available resources.

Q: FHWA's Adaptation Decision-Making Assessment Process (ADAP) is a tool for planners and designers to address resilience in the design of infrastructure projects.

A: True. But it can also be applied to the development of a life cycle strategy. The key difference is understanding the context. When applied to a project, ADAP context focuses on a specific physical location. When developing a life cycle strategy, context will be broader - area that is expected to be subject to a given environmental change such as sea level rise, for example. Once the proper context is established, the ADAP process steps can be followed to evaluate potential strategic adjustments that will allow life cycle management practices to account for the anticipated effects of environmental change.

Q: Risk is a factor that helps determine the type of life cycle management approach an agency will take for a particular asset type.

A: True. Life cycle management must include long-term predictions that come with inherent uncertainty. Further complicating matters, the condition or performance of some assets may be difficult, expensive, or impossible to discern. Addressing this uncertainty requires integration with the agency's risk management practices, and consultation with technical experts. Depending on the

cost and availability of data and analysis, agencies may choose one of three approaches: condition-based, interval-based, or reactive.

Q: Reliability Centered Maintenance (RCM) is a technique that is sometimes used by an agency to identify the most appropriate management method.

A: True. Looking at an asset or asset class from an RCM perspective helps to select a management approach based on safety, operational and economic criteria. RCM is commonly applied to complicated assets that may require a range of management approaches for different components of the asset.

Q: Condition-based assessment is appropriate for all transportation assets.

A: False. Not all assets fit with a condition-based approach to life cycle management. The most common reasons assets are not subject to a condition-based approach are because 1) they do not have a typical life cycle or predictable deterioration patterns, 2) assessing their condition may not be practical or feasible, 3) their life cycle is driven by factors other than condition, 4) they have long service lives and their failure poses limited risk to safety or performance, or 5) performance expectations require the asset to remain in near-new condition.

Q: Although TAM agencies identify projects and types of work based on life cycle management, these decisions are subject to changes in the field, which will not impact the overall TAM strategy.

A: False. Life cycle management approaches and corresponding life cycle strategies are how agencies identify the work necessary to meet their asset management goals within funding constraints, and for those goals to be met, the identified work must actually be delivered. Any changes made in the field, however necessary based on context, need to be communicated and subsequent work incorporated into future life cycle analyses.

Chapter 4 References

Case Study 3 - Life Cycle Planning Practices
FHWA | May 1, 2020 | https://rosap.ntl.bts.gov/view/dot/50768
Several TAMPs were commendable for detailing how they manage assets using life cycle plans. This case study includes examples from the DOTs in Minnesota, Ohio, Tennessee, and New Jersey. The asset management plans highlighted an increasing focus on the whole life of assets and utilizing life-cycle strategies to maintain a state of good repair (SOGR). Additionally, the plans underscored the importance of pavement and bridge management systems in supporting life-cycle strategies.

Case Study 7 - Managing Assets Beyond Pavements and Bridges
FHWA | May 1, 2020 | https://rosap.ntl.bts.gov/view/dot/54335
This case study summarizes 2019 asset management plans, highlighting how U.S. transportation departments are extending their efforts beyond pavements and bridges. These efforts have spurred innovations in developing inventories, identifying life cycles, and adopting investment strategies.

Using an LCP (Life Cycle Planning) Process to Support Transportation Asset Management: A Handbook on Putting the Federal Guidance into Practice
FHWA | January 3, 2019 | https://rosap.ntl.bts.gov/view/dot/43564

Since LCP is a relatively new process for State DOTs, the Federal Highway Administration (FHWA) launched a project to develop guidance documents on LCP, risk management, and financial planning to help State DOTs implement these activities. This particular initiative expands on the LCP guidance by offering more detailed information on implementing an LCP process for both pavements and bridges.

Addressing Resilience to Climate Change & Extreme Weather in Transportation Asset Management
FHWA | April 1, 2023 | https://www.fhwa.dot.gov/asset/pubs/hif23010.pdf
This handbook aims to assist transportation practitioners in integrating natural hazard resilience into asset management. It outlines who should be involved in the planning process and how various groups can collaborate.

Geotechnical Asset Management for Transportation Agencies, Volume 2: Implementation Manual
Transportation Research Board | September 26, 2019 |
https://www.trb.org/Publications/Blurbs/178602.aspx
This document critiques the traditional understanding of geotechnical assets as unpredictable hazard sites with significant potential liability. Rather, the report characterizes geotechnical assets as vital to the successful operation of transportation systems and claims they present an opportunity for system owners and operators to realize new economic benefits through risk-based asset management.

Lessons Learned and Impacts to Date of State DOT Implementation of New Federal Transit Asset Management and Public Transportation Agency Safety Requirements
Transportation Research Board | December 31, 2019 |
https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4332
This resource details how recent FTA rulings on asset management have influenced state DOTs internally and impacted asset condition. It provides states with information to assess the effectiveness of their efforts and refine their implementation strategies.

Return on Investment in Transportation Asset Management Systems and Practices
Transportation Research Board | January 30, 2018 |
https://www.trb.org/NCHRP/Blurbs/177179.aspx#:~:text=TRB's%20National%20Cooperative%20Highway%20Research,investment%20for%20adopting%20or%20expanding
This report examines how transportation agencies manage their assets and offers guidance on evaluating the return on investment for adopting or expanding transportation asset management systems within an agency.

Bridge Element Data Collection and Use
Transportation Research Board | January 1, 2022 |
https://nap.nationalacademies.org/catalog/26724/bridge-element-data-collection-and-use
The TRB National Cooperative Highway Research Program's NCHRP Synthesis 585: Bridge Element Data Collection and Use documents the practices and experiences of state DOTs in collecting element-level data and ensuring its accuracy. The synthesis also explores how state DOTs utilize data from inspection reports.

Highway Infrastructure Inspection Practices for the Digital Age

Transportation Research Board | January 1, 2022 | https://nap.nationalacademies.org/catalog/26592/highway-infrastructure-inspection-practices-for-the-digital-age
The TRB National Cooperative Highway Research Program's NCHRP Synthesis 582: Highway Infrastructure Inspection Practices for the Digital Age details the technologies employed by DOTs for inspecting highway infrastructure during construction and maintenance. These technologies include unmanned aircraft systems (UASs), embedded and remote sensors, intelligent machines, mobile devices, and new software applications.

Transportation System Resilience: Research Roadmap and White Papers
Transportation Research Board | January 1, 2021 | https://nap.nationalacademies.org/catalog/26160/transportation-system-resilience-research-roadmap-and-white-papers
Transportation System Resilience: Research Roadmap and White Papers identifies key knowledge gaps within AASHTO and state departments of transportation, proposes a 5-year research plan to bridge these gaps, and explores critical resilience-related challenges facing senior transportation leaders today.

Resilience Primer for Transportation Executives
Transportation Research Board | January 1, 2021 | https://nap.nationalacademies.org/catalog/26195/resilience-primer-for-transportation-executives
Resilience Primer for Transportation Executives offers a concise overview of resilience benefits, the CEO's role in enhancing resilience, and the strategies adopted by various states to strengthen their transportation systems. It also provides concepts and tools to guide agencies toward greater resilience.

Mainstreaming System Resilience Concepts into Transportation Agencies: A Guide
Transportation Research Board | January 1, 2021 | https://nap.nationalacademies.org/catalog/26125/mainstreaming-system-resilience-concepts-into-transportation-agencies-a-guide
Mainstreaming System Resilience Concepts into Transportation Agencies: A Guide equips transportation officials with a self-assessment tool to evaluate the current status of their agency's efforts to enhance transportation system resilience by integrating resilience concepts into decision-making and procedures. This tool can be used to address a wide range of natural and human-caused threats to transportation systems and services.

Disparate Approaches to Maintaining Roads and Sidewalks: An Interview Study of 16 U.S. Cities
Transportation Research Board | May 3, 2022 | https://trid.trb.org/view/1945979
While America's "crumbling roads" dominate the infrastructure narrative, deteriorating sidewalks are also in urgent need of attention. This research aims to explore the similarities and differences in how American cities manage their road versus sidewalk networks by examining whether these two essential urban public assets are repaired, maintained, and funded differently.

Technical Asset Management for Railway Transport: Using the URRAN Approach
Springer Cham | January 4, 2022 | https://link.springer.com/book/10.1007/978-3-030-90029-8
This book familiarizes readers with the fundamental elements of the URRAN-based technical asset management system, a methodology devised for managing resources and risks by assessing and ensuring the necessary levels of reliability and safety within Russia's railway transport infrastructure. It outlines the structure of the URRAN information system's unified corporate

platform (UCP URRAN) and its subsystems dedicated to infrastructure facilities and rolling stock complexes.

Best Practices in Bridge Management Decision-Making
Transportation Research Board | November 1, 2009 |
http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-68A_07-05.pdf
This resource is a domestic review centered on practices adopted by state DOTs for identifying, prioritizing, and implementing programs aimed at managing highway bridges. The review encompasses evaluations of DOT manuals, guidelines, and policy statements, along with compiling responses to detailed inquiries from DOTs and conducting visits to seven sites for discussions with DOT staff.

Incorporating Maintenance Costs into a Transportation Asset Management Plan
FHWA | October 1, 2022 | https://nap.nationalacademies.org/catalog/27290/incorporating-maintenance-costs-into-a-transportation-asset-management-plan
"Incorporating Maintenance Costs into a Transportation Asset Management Plan," part of TRB's National Cooperative Highway Research Program, presents research aimed at constructing a framework for state DOTs and other transportation agencies to integrate maintenance costs into their TAMPs.

Handbook for Including Ancillary Asses in Transportation Asset Management Programs
FHWA | September 1, 2019 |
https://www.fhwa.dot.gov/publications/research/infrastructure/19068/index.cfm
This handbook introduces a methodology designed to assist highway asset owners and maintenance personnel in identifying the assets crucial for supporting their agencies' missions and objectives, extending beyond pavements and bridges. The methodology prioritizes asset classes and identifies relevant data that best support a performance-based approach to managing the condition and utilization of these assets.

A Guide to the Reliability-Centered Maintenance (RCM) Standard
SAE International | August 1, 2011 |
https://www.sae.org/standards/content/ja1012_201108/?utm_source=google&utm_medium=ppc&utm_campaign=iso_campaign&utm_content=pd_pmax_iso_refresh032023&utm_term=b2c&gclid=CjwKCAjwp8OpBhAFEiwAG7NaEhmWwRJVHSLpTJbYILosMFpm-tfah9hgD7sCmFWyJUZ7rpjHbxD4TxoCIjAQAvD_BwE
The Guide to Reliability-Centered Maintenance (RCM) elaborates on and provides clearer explanations for each of the key criteria outlined in SAE JA1011 "Evaluation Criteria for RCM Processes." Additionally, it summarizes other essential considerations necessary for the successful application of RCM.

Evaluation Criteria for Reliability-Centered Maintenance (RCM) Processes
SAE International | August 1, 2009 | https://studylib.net/doc/25686202/23.-sae-ja1011---2009---evaluation-criteria-for-reliabili...
This document outlines the essential criteria that any process must meet to be considered compliant with RCM standards. Its purpose is to offer a framework for assessing whether a particular process adheres faithfully to the foundational principles of RCM as initially conceived.

Vulnerability Assessment and Adaptation Framework
FHWA | December 1, 2017 |
https://www.fhwa.dot.gov/environment/sustainability/resilience/adaptation_framework/

The Vulnerability Assessment and Adaptation Framework by the Federal Highway Administration is a guidebook designed to assist transportation agencies and their collaborators in evaluating the susceptibility of transportation infrastructure and systems to the impacts of extreme weather and climate conditions. It also aids agencies in incorporating climate adaptation considerations into their transportation decision-making processes.

Climate Change Adaptation Case Studies
FHWA | December 6, 2022 |
https://www.fhwa.dot.gov/environment/sustainability/resilience/case_studies/
This tool provides a series of climate change adaptation case studies. Use this search tool to narrow down the list of studies, or select "All Records" to see all of the case studies on file.

Chapter 5: Resource Allocation

Subsection 5.1.1 What is Resource Allocation: New Summary

In the context of TAM, resource allocation is the process of assigning scarce resources to investments in transportation assets. *The assigned resources can be money, staff time, contractor capacity, equipment, or anything else that an organization requires for its assets. The investments can be capital projects, maintenance efforts, or other projects and activities that require the use of an organization's resources through various delivery methods.*

Subsection 5.1.2 Transportation Agency Context: New Paragraph

Beginning in 2018, again as a result of MAP-21, state DOTs are required to prepare TAMPs addressing pavements and bridges on the NHS at a minimum, while potentially including other asset classes and road systems. An agency's TAMP describes the asset inventory and its conditions, how assets are managed over their life cycles, and a 10-year financial plan for how to best maintain assets in a "desired state of good repair."

Subsection 5.2.3 Use of Multi-Objective Decision Analysis for Resource Allocation

Video Resource: Investing Strategies and Multi-Objective Decision Making

- AASHTO TAM Guide Book Club #7

Subsection 5.3.1 TAM Financial Plan

Video Resource: Improving TAM Financial Planning

- AASHTO TAM Guide Book Club #4

Video Resource: Financial Plans and Investment Strategies

- AASHTO TAM Webinar #28

Video Resource: Improving Your Next TAMP Miniseries – Improving Your Financial Plan

- AASHTO TAM Webinar #48

Section 5.5 Asset Valuation

Asset value is an important piece of financial reporting and TAM. It can be used in financial statement balance sheets, it communicates what an agency owns and maintains, and it supports investment decisions. Financial reporting standards and requirements dictate how to perform the calculations; however, in practice, there is no single correct way to measure an asset's value.

Note: This section was derived from the web version of NCHRP Web-Only Document 335: A Guide to Computation and Use of System Level Valuation of Transportation Assets. More detailed information is available in this NCHRP Report. A summary is provided below to provide an overview and context.

Subsection 5.5.1 Asset Valuation Framework

This subsection discusses the significance of asset valuation in transportation asset management (TAM) and its applications, emphasizing its role in communication, fiscal responsibility, testing investment strategies, and prioritizing investments. It explores three perspectives of asset value: cost, market, and economic perspectives, highlighting their differences and applications in assessing the worth of transportation assets.

Note: This subsection was derived from the web version of A Guide to Computation and Use of System Level Valuation of Transportation Assets. More detailed information is available in this NCHRP Report. A summary is provided below to provide an overview and context.

Asset Valuation and Asset Management

Knowing what a physical asset is worth – its value – can be very useful both for financial reporting and for supporting asset management. Even if the notion of asset value is somewhat abstract, an asset owner generally prefers that the value of their assets increases or at least remains constant over time. Fundamentally, tracking and reporting asset value helps a transportation agency monitor the state of its assets and provides a sense of whether the inventory is improving or in a state of decline. Transportation agencies use data on asset value in a variety of ways to support asset management. There are four major applications of asset value aiding an overall asset management program as described below.

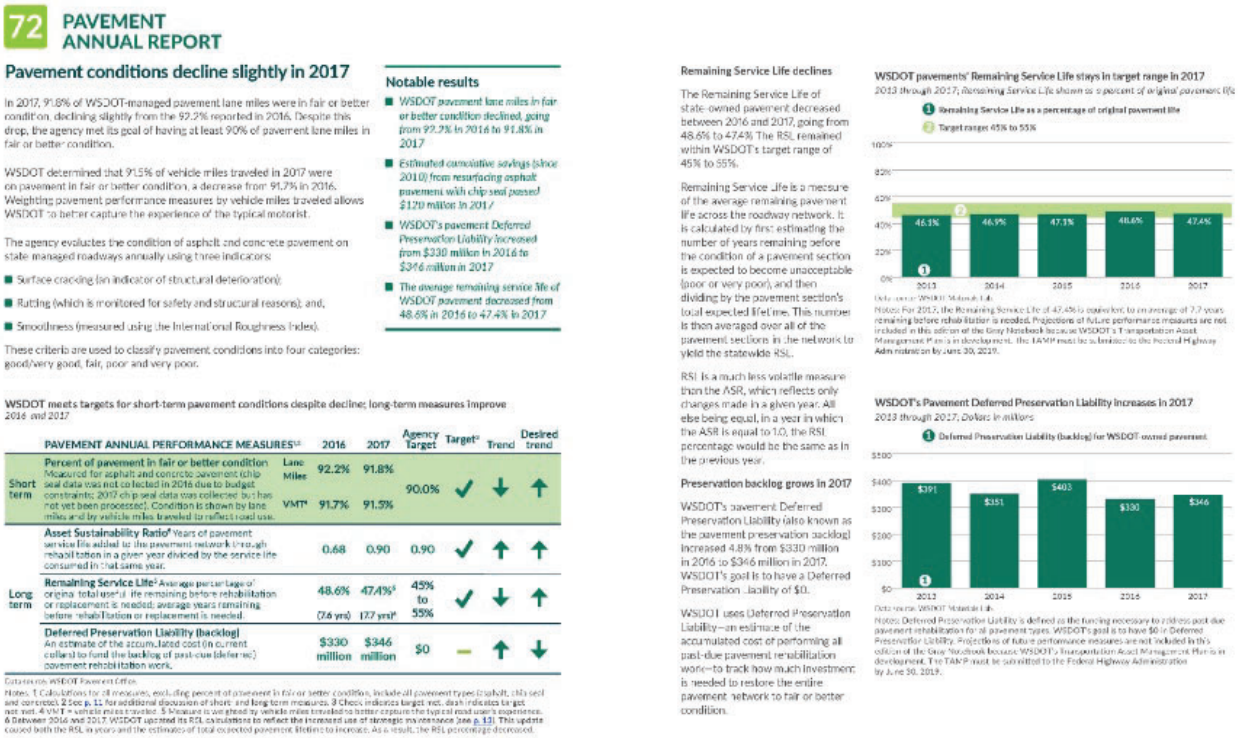
- **Communicating the Asset Inventory**–Asset value is used to communicate what assets an agency owns, their extent, and the agency's responsibility for maintaining the asset inventory. Each asset has its own unit of measure: pavements may be summarized in terms of lane miles, bridges in terms of deck area, and other assets in terms of a count. However, it can be hard to relate these different units and to summarize the asset portfolio as a whole.
- **Demonstrating Fiscal Responsibility**–Various measures have been formulated that use asset value and changes in value to demonstrate that an agency is managing its assets responsibly. The basic premise is that as assets deteriorate or depreciate, an agency should invest to maintain their value. Public agencies in Australia and New Zealand have used asset value in this manner for over a decade. In the U.S., several agencies have calculated similar measures such as the Washington State Department of Transportation (WSDOT) Gray Book, which includes several long-term measures for pavement assets related to asset value.
- **Testing Investment Strategies**–Asset value can be used to help illustrate the difference between alternative investment strategies, such as when comparing a strategy of performing recommended preservation treatments on an asset over its life to an alternative strategy in which preservation treatments are deferred, resulting in worse relative condition and potentially a shorter asset life.

Prioritizing Investments–Another potential application of asset value for supporting TAM is helping compare and understand asset investment options. While asset value alone is insufficient for prioritizing investments, when used in conjunction with life cycle cost analyses it can provide a complete view of the asset's worth. In particular, asset value can help prioritize decisions such as: Resilience investments; Reconstruction; or Decommissioning. Asset value provides insights for assets identified for decommission or reconstruction by pitting their intrinsic value (including the replacement cost and socio-economic importance) against the costs necessary to maintain or replace the asset.

Practice Example: Gray Notebook: Quarterly Performance Report – Washington State DOT

Washington State DOT (WSDOT) uses asset value-related performance measures for pavement assets to support responsible management of those assets as they deteriorate or depreciate. The WSDOT Gray Notebook, a quarterly performance report of the agency's assets, includes several long-term measures for pavement assets, including Asset Sustainability Ratio (ASR), Remaining Service Life (RSL), and Deferred Preservation Liability (backlog).

Figure 5.A Pavement Annual Quarterly Performance Report



72 PAVEMENT ANNUAL REPORT

Pavement conditions decline slightly in 2017

In 2017, 91.8% of WSDOT-managed pavement lane miles were in fair or better condition, declining slightly from the 92.2% reported in 2016. Despite this drop, the agency met its goal of having at least 90% of pavement lane miles in fair or better condition.

WSDOT determined that 91.5% of vehicle miles traveled in 2017 were on pavement in fair or better condition, a decrease from 91.7% in 2016. Weighting pavement performance measures by vehicle miles traveled allows WSDOT to better capture the experience of the typical motorist.

The agency evaluates the condition of asphalt and concrete pavement on state-managed roadways annually using three indicators:

- Surface cracking (an indicator of structural deterioration);
- Rutting (which is monitored for safety and structural reasons); and,
- Smoothness (measured using the International Roughness Index).

These criteria are used to classify pavement conditions into four categories: good/very good, fair, poor and very poor.

Notable results

- WSDOT pavement lane miles in fair or better condition declined, going from 92.2% in 2016 to 91.8% in 2017
- Estimated cumulative savings (since 2010) from resurfacing asphalt pavement with chip seal passed $120 million in 2017
- WSDOT's pavement Deferred Preservation Liability increased from $330 million in 2016 to $346 million in 2017
- The average remaining service life of WSDOT pavement decreased from 48.6% in 2016 to 47.4% in 2017

WSDOT meets targets for short-term pavement conditions despite decline; long-term measures improve 2016 and 2017

	PAVEMENT ANNUAL PERFORMANCE MEASURES[1,2]		2016	2017	Agency Target	Target[3]	Trend	Desired trend
Short term	Percent of pavement in fair or better condition. Measured for asphalt and concrete pavement (chip seal data was not collected in 2016 due to budget constraints; 2017 chip seal data was collected but has not yet been processed). Condition is shown by lane miles and by vehicle miles traveled to reflect road use.	Lane Miles	92.2%	91.8%	90.0%	✓	↓	↑
		VMT[4]	91.7%	91.5%				
	Asset Sustainability Ratio[5] Years of pavement service life added to the pavement network through rehabilitation in a given year divided by the service life consumed in that same year.		0.68	0.90	0.90	✓	↑	↑
Long term	Remaining Service Life[5] Average percentage of original total useful life remaining before rehabilitation or replacement is needed; average years remaining before rehabilitation or replacement is needed.		48.6% (7.6 yrs)	47.4%[6] (7.7 yrs)[6]	45% to 55%	✓	↓	↑
	Deferred Preservation Liability (backlog) An estimate of the accumulated cost (in current dollars) to fund the backlog of past-due (deferred) pavement rehabilitation work.		$330 million	$346 million	$0	–	↑	↓

Data source: WSDOT Pavement Office.

Notes: 1 Calculations for all measures, excluding percent of pavement in fair or better condition, include all pavement types (asphalt, chip seal and concrete). 2 See p. 11 for additional discussion of short- and long-term measures. 3 Check indicates target met, dash indicates target not met. 4 VMT = vehicle miles traveled. 5 Measure is unweighted by vehicle miles traveled to better capture the typical road user's experience. 6 Between 2016 and 2017 WSDOT updated its RSL calculations to reflect the increased use of strategic investment (see p. 13). This update caused both the RSL in years and the estimates of total expected pavement lifetimes to increase. As a result, the RSL percentage decreased.

Remaining Service Life declines

The Remaining Service Life of state-owned pavement decreased between 2016 and 2017, going from 48.6% to 47.4%. The RSL remained within WSDOT's target range of 45% to 55%.

Remaining Service Life is a measure of the average remaining pavement life across the roadway network. It is calculated by first estimating the number of years remaining before the condition of a pavement section is expected to become unacceptable (poor or very poor), and then dividing by the pavement section's total expected lifetime. This number is then averaged over all of the pavement sections in the network to yield the statewide RSL.

RSL is a much less volatile measure than the ASR, which reflects only changes made in a given year. All else being equal, in a year in which the ASR is equal to 1.0, the RSL percentage would be the same as in the previous year.

Preservation backlog grows in 2017

WSDOT's pavement Deferred Preservation Liability (also known as the pavement preservation backlog) increased 4.8% from $330 million in 2016 to $346 million in 2017. WSDOT's goal is to have a Deferred Preservation Liability of $0.

WSDOT uses Deferred Preservation Liability—an estimate of the accumulated cost of performing all past-due pavement rehabilitation work—to track how much investment is needed to restore the entire pavement network to fair or better condition.

WSDOT pavements' Remaining Service Life stays in target range in 2017

2013 through 2017; Remaining Service Life shown as a percent of original pavement life

Data source: WSDOT Materials Lab.

Notes: For 2017, the Remaining Service Life of 47.4% is equivalent, on average, to 7.7 years remaining before rehabilitation is needed. Projections of future performance measures are not included in this edition of the Gray Notebook because WSDOT's Transportation Asset Management Plan is in development. The TAMP must be submitted to the Federal Highway Administration by June 30, 2019.

WSDOT's Pavement Deferred Preservation Liability increases in 2017

2013 through 2017; Dollars in millions

Data source: WSDOT Materials Lab.

Notes: Deferred Preservation Liability is defined as the funding necessary to address past-due pavement rehabilitation for all pavement types. WSDOT's goal is to have $0 in Deferred Preservation Liability. Projections of future performance measures are not included in this edition of the Gray Notebook because WSDOT's Transportation Asset Management Plan is in development. The TAMP must be submitted to the Federal Highway Administration by June 30, 2019.

ASR measures the agency's investments in pavement against the lost value due to depreciation. RSL is a measure of remaining useful life before rehabilitation or replacement is needed due to deterioration. Backlog is the cost incurred due to delayed rehabilitation work. The agency sets targets and monitors trends for these measures, using them to communicate fiscal responsibility and allowing for improved asset management decision-making. In the 2021 Gray Notebook, for example, the RSL target is met, but the ASR fell short of the target, indicating that pavement investment was outpaced by deterioration in that year.

Source: WSDOT, *Gray Notebook: Pavement Conditions & Performance*. Washington State DOT. 2021. https://wsdot.wa.gov/about/data/gray-notebook/gnbhome/preservation/pavement/conditionperformance.htm

Defining Asset Value

The Organization for Economic Co-Operation and Development (OECD), states that a physical asset has no intrinsic value. Instead, its value results from the benefits it yields, be they to the asset owner, a set of transportation system users, society as a whole, or some combination thereof. As an asset ages, it depreciates, or loses value as its benefits are consumed. The OECD defines three different perspectives to consider asset value: Cost Perspective, Market Perspective, and Economic Perspective. The following provides a brief synopsis of these three perspectives.

- **Cost Perspective**–The cost perspective focuses on capital costs incurred by the asset owner. When establishing value from this perspective the question is "How much does it cost us to acquire this asset and operate it over time?" The basic issue with the cost perspective is that it leaves no daylight between cost and value; these are one and the same. If one asks what value will be derived from spending $1 million to reconstruct a road, from the cost perspective the answer is "$1 million, of course." Consequently, the cost perspective can help answer questions about how best to manage assets, but it is ill-suited for addressing questions concerning the underlying value of transportation assets to society. To answer that question requires an economic perspective.
- **Market Perspective**–The market perspective focuses on the price of an asset on the open market. When establishing value from this perspective the question becomes "How much would this asset sell for on the open market?" For example, the value of an automobile might be the resale value should the car be sold through an auction or to a reseller. The virtue of this perspective is that it leverages the behavior of free markets to determine how much value an asset is expected to yield in the future. If the market for an asset is competitive, then the asset's market value should theoretically account for the future benefits provided to the buyer. The competitive nature of the market should ensure that no asset is sold at less than this value. This perspective is extremely valuable where a well-defined market exists for an asset. The market value of an asset is viewed as the best representation of asset value based on international accounting guidance.
- **Economic Perspective**–The economic perspective focuses on the benefits generated by an asset. When establishing value from this perspective the question is "What are the benefits of the asset to travelers and society?" In general guidance for asset value, this perspective is also called the "income perspective," as it involves calculating the income generated by not just by the asset, but by its existence. An economic measure of asset value stems from a more comprehensive value, based on the use of a facility. Economic asset valuation is an analytical exercise that establishes a rationale on whether and when a facility ought to be constructed or improved.

The cost, market, and economic perspectives on asset value differ in subtle and important ways. For example, a cost perspective generally starts from an implicit assumption that a facility is worth maintaining at the level of service for which it was originally planned and constructed. The actual use of the facility does not factor into the assessment except when it is used to indirectly estimate the rate of deterioration and maintenance schedule. In comparison, the market approach directly

considers the value of the facility to users in addition to the cost to maintain it. The market approach can be considered from the perspective of a concessionaire who could evaluate the facility based on the opportunity to recover the costs to date and earn a profit, perhaps through revenue collection or the value of the land.

Each asset value perspective emphasizes a specific aspect of how transportation assets are constructed and utilized. All three perspectives are valid and can provide insights that help communicate information about assets and support decision-making. While each of the perspectives supports some of the applications described in Section 5.5.1, many public agencies rely on the cost perspective for their calculation of asset value. The cost perspective helps an agency directly relate its expenditures on assets to changes in their value, and it supports a large number of TAM-related applications. Also, where a market exists, the cost of replacing the asset, depreciated based on its age or use, tends to correlate closely to its price. Where no market exists, the depreciated replacement cost serves as a proxy for its market price.

Subsection 5.5.2 Using Asset Value to Support TAM Decisions

Once calculated, asset value and related measures can support a range of applications in transportation asset management. These applications are summarized through a set of six key questions which asset value and related measures may help answer.

Note: This subsection was derived from the web version of A Guide to Computation and Use of System Level Valuation of Transportation Assets. More detailed information is available in this NCHRP Report. A summary is provided below to provide an overview and context.

6 Key Summarizing Questions

1. **What is the overall value of the asset inventory?** This is the most fundamental question about asset value. What exactly is the value of a given inventory of assets?
2. **What is the cost to maintain current asset value?** Establishing overall asset value for each asset classification is a prelude to this follow up question. An agency would need to determine how much value is lost each year as assets age, and what investments are needed to offset depreciation and optimize the assets' lifespans.
3. **How much should an agency invest in existing assets?** This question is closely related to the second question, but the two questions may have different answers. If the measure of value is meaningful, then an agency should ideally spend enough money to maintain or increase asset value over time. However, it is inevitable that the value of a given asset will decline following construction or renewal of the asset: it is simply not realistic to expect assets to remain in a "like new" condition indefinitely. On the other hand, if the value of the asset inventory has declined to the point that is demonstrably suboptimal (e.g., a case in which assets are in such poor condition that users experience increased costs from delay and the agency incurs increased costs from emergency maintenance) then merely maintaining existing condition is undesirable. Answering this question requires additional analysis to determine the asset value associated with achieving an agency's "desired state of good repair," and the cost to achieve this value. Once obtained, the answer supports decisions about how much to invest in the asset inventory.
4. **How should funds be allocated between different assets or networks?** To the extent that funds are insufficient for addressing all of an agency's investment needs, it may be

necessary to prioritize between different asset classes or networks (e.g., the Interstate System, Non-Interstate NHS, and Non-NHS). Information on asset value helps communicate the size of the inventory expressed in a single unit of measure – dollars.

5. **What's the best life cycle strategy for our assets?** Information on asset value, together with supporting management systems, can be used to test different asset life cycle strategies and illustrate the effectiveness of different strategies for maximizing value. Doing this requires predicting asset value assuming different strategies and comparing their results.
6. **What is the value generated by the asset?** Much of the discussion thus far has revolved around the value of the asset, as it relates to construction and maintenance costs. However, two assets of the same type, length, and roadway characteristics may generate strikingly different value for the communities that use them. Variations in the volume of traffic, the availability of alternative routes, and the accessibility offered by these roads are only some of the factors affecting how road users perceive their value. When considering investment decisions, it is important to account for the road user's perspective.

Practice Example: Melbourne Asset Management Plan – Department of Transport and Planning

The City of Melbourne, the capital of the Australian state of Victoria, uses asset value to drive asset management in two ways:

First, the city communicates the asset inventory in part through asset value. The City Asset Plan includes both the fair, written-down value (current depreciated value) and a replacement value for each of the assets owned by the agency, including numerous infrastructure assets such as roads, bridges, footpaths, drainage, and other assets. The city uses these two numbers to communicate the extent and condition of their assets to the public and other stakeholders.

Second, the city uses two performance measures related to asset value to demonstrate fiscal responsibility: the ratio of renewal and upgrade expenditures to depreciation, and the ratio of total capital replacement expenditures to depreciation. These measures are variations of an asset sustainability ratio, which summarizes whether an agency is investing sufficiently to maintain asset value and conditions. The city of Melbourne set performance targets of 0.5 for the renewal and upgrade ratio and 1.0 for the capital replacement ratio. Meeting those targets means that the city is investing at a level sufficient to maintain or improve asset value. The table below demonstrates these measures. It shows the actual values from 2016 through 2019, and forecasts values for 2020-2021.

Table 5.A Excerpt 2 from City of Melbourne Asset Management Plan

CAPITAL WORKS PERCENTAGE OF DEPRECIATION	2016-17 ACTUAL ($'000)	2017-18 ACTUAL ($'000)	2018-19 ACTUAL ($'000)	2019-20 ACTUAL ($'000)	2020-21 Forecast ($'000)
Renewal & Upgrade Works	53,190	58,698	55,722	71,836	108,668
Depreciation	57,717	58,507	57,889	61,048	64,658
Renewal & Upgrade / Depreciation Totals	79%	86%	82%	85%	168%
Five-Year Average					116%
All Capital Works / Depreciation Totals	136%	180%	211%	202%	288%
Five-Year Average:					205%

In addition to calculating asset sustainability ratios based on actual historical data, the city estimates the performance measures for 10 years into the future, predicting depreciation and capital expenditures. This allows the city to better align planned expenditures and needs.

Source: **City of Melbourne**. *City of Melbourne Asset Plan 2021-31*. City of Melbourne, 2021. Web access: http://www.melbourne.vic.gov.au/about-council/governance-transparency/policies-protocols/Pages/asset-plan-2021-31.aspx

Practice Example: Carver County Public Works – Minnesota DOT

Carver County, located in the Minneapolis-St. Paul metropolitan area, is responsible for managing a variety of transportation assets, including rural and urban roads, intersections, lighting, railroad crossings, and pedestrian crossings. Carver County Public Works captured these assets in a 2021 Transportation Asset Management Plan which uses asset value to communicate the scope and condition of the system.

Figure 5.B Overview of Carver County Transportation Assets & Condition

Asset	Inventory (unit)	Replacement Value ($M)	Current Value($M)	Condition
Pavement	573.7 lane miles	$573.7	$395.8	
Bridges	63 bridges	$95.0	$80.7	
Culverts	844 culverts	$26.9	$13.7	
Signalized Intersections	52 intersections	$20.8	$10.0	
Medians	843,591 (sf) median 120,432 (ft) curb	$6.0	$6.0	
Guardrail	31,633 (linear ft)	$3.0	$1.7	
Pedestrian Ramps	924 ramps	$2.7	$1.1	
Signal/Sign Supports	4,970 sign supports 120 signal supports	$2.1	$1.1	
Pavement Markings	4,335,242 (linear ft of markings 39,963 (sq ft) of transverse markings	$1.8	$0.9	
Signs	7,811 signs	$0.5	$0.3	
Stormwater	5,593 assets	-	-	
Lighting	115 assets	-	-	
Railroad Crossings	55 crossings	-	-	

For each asset, Carver County calculates a replacement value (unit costs * units) and a current value (replacement value – depreciation) using the cost perspective. Due to varying levels of resources and data available for each asset, there are multiple ways that depreciation is calculated, including age-based and condition-based approaches. Some assets use compliance with standards and guidelines (e.g. ADA) as a proxy for condition, which in turn is used to calculate depreciation.

The asset replacement and current values help communicate the state of the county's asset inventory to the public and provide a financial account of the publicly owned assets.

Source: Carver County Public Works Division. *Transportation Asset Management Plan: Carver County*. Carver County Public Works Division, 2021.

Checklist:

Asset Value Checklist:

Note: This checklist was derived from the web version of A Guide to Computation and Use of System Level Valuation of Transportation Assets. More detailed information is available in this NCHRP Report. A summary is provided below to provide an overview and context.

1) Define the Analysis Scope–Determine which assets to incorporate and the level of detail of the calculation. Assets may be incorporated based on their asset type, class or system, they can be analyzed in their entirety or in component parts, and they may have different treatments applied over their lifetimes.

2) Establish Initial Value–In many TAM applications the preferred approach for initial value uses the cost perspective and the current replacement cost. However, in some applications other methods are valuable, including the economic perspective, market perspective and historic cost.

3) Determine Treatment Effects–The inclusion or exclusion of treatment effects depends on the factors which influence the asset's expected useful life. Often, treatments may be excluded from analysis, but it is worth documenting the anticipated maintenance plan and understanding which treatments impact the expected useful life.

4) Calculate Depreciation–The best method for depreciating an asset varies based on the intended application of the calculation, the asset type, the value perspective, and the resources and data available. The three proposed methods for calculating depreciation are straight-line depreciation, condition-based depreciation, and non-linear benefit consumption.

5) Calculate Value and Supporting Measures–To support the final asset value and its application in the agency, several additional measures may be necessary. These measures include: cost to maintain value, asset sustainability ratio (ASR), asset consumption ratio (ACR), asset funding ratio (AFR), the net present value (NPV), and others.

6) Communicate and Apply the Results–Lastly, the asset value should be interpreted, communicated and applied to appropriate TAM decision-making. The agency may want to conduct sensitivity analyses to describe the accuracy of the calculated value and identify any assumptions or variables which significantly impact the final asset value.

Chapter 5 Knowledge Check

Q: All organizations practice resource allocation in some manner.

A: True. All organizations have a process to allocate resources, whether formally or informally. But by using a structured and repeatable approach for resource allocation, an organization improves its own resilience and ensures that it will continue to succeed even as new challenges arise and personnel changes over time.

Q: The resource allocation process outlined in this guide is appropriate for long-term resource allocation, but not for short-term resource allocation decisions.

A: False. The steps of the resource allocation process are appropriate for both short- and long-term resource allocation decisions, but different steps may receive different emphasis, depending on the context and what resources are being allocated.

Q: Risk factor that impacts resource allocation decisions.

A: False. While the scope of risk management may be broad, an organization's approach to risk management and the outcomes resulting from a risk assessment may have important implications for TAM resource allocation. Some specific implications of addressing risk as part of resource

allocation may include the need for better data, additional staff or staff skills, or the need to make allocation decisions based on different scenarios.

Q: Organizations typically rely on a combination of strategic, tactical and operational targets, either formally or informally.

A: True. A strategic target is one which an organization expects to meet at some future time and reflects the agency's overall goals and objectives, such as a target for pavement condition. A tactical target is a value that needs to be met to support a strategic target, such as a specific number of miles of repaving annually. An operational target is one that helps track day-to-day performance, such as the average time to respond to an incident.

Q: Factors not considered in management systems don't really impact performance.

A: False. Management systems can help determine realistic targets, but there are simplifying assumptions inherent in these systems that may impact performance. For instance, a management system might assume treatment on an asset is performed in a single year, with an immediate impact on performance, but in reality, projects can take several years, with a significant lag between when funds are committed and results achieved. Factors outside the scope of management systems, such as diversions for emergency events, may also impact performance.

Q: A multi-Objective Decision Analysis (MODA) tool can be useful in prioritizing investments outside the scope of a specific management system.

A: True. Using MODA can help prioritize investments across asset classes and investment categories, such as corridor projects combining pavement, bridge, and safety improvements. It also provides a means to compare asset management investments with other investments to improve mobility and achieve objectives outside the scope of a typical asset management system.

Q: A State DOT or MPO must use the same financial plan for all federally-required planning documents.

A: False. Different requirements mean different financial plans are compiled for different applications, but for practical purposes an organization should use consistent assumptions in developing all its financial and strategic plans.

Q: Asset valuation has many uses, including helping to communicate the agency's asset inventory, testing investment scenarios, and demonstrating fiscal responsibility.

A: True. Asset valuation can be used in many ways. Asset value is used to communicate what assets an agency owns, their extent, and the agency's responsibility for maintaining the asset inventory. It can also be used to help illustrate the difference between alternative investment strategies, such as when comparing a strategy of performing recommended preservation treatments on an asset over its life to an alternative strategy in which preservation treatments are deferred, resulting in worse relative condition and potentially a shorter asset life.

Q: Asset value is used to determine the cost to maintain the asset but not used to determine how much to invest in the asset.

A: False. Asset value combined with state of good repair can be used to determine how much to invest in the asset. An agency can determine how much value is lost each year as assets age, and what maintenance and investments are needed to offset the decline in asset value.

Chapter 5 References

A Guide to Computation and Use of System-Level Valuation of Transportation Assets
Transportation Research Board | July 27, 2022 |
https://nap.nationalacademies.org/catalog/26667/a-guide-to-computation-and-use-of-system-level-valuation-of-transportation-assets
Establishing the worth of a transportation organization's physical assets holds significance for both financial reporting and transportation asset management (TAM). The Guide to Computing and Utilizing System-Level Valuation of Transportation Assets provides instructions on computing asset value and leveraging it to enhance its application in TAM.

Prioritization of Public Transportation Investments: A Guide for Decision-Makers
Transportation Research Board | January 1, 2021 |
https://nap.nationalacademies.org/catalog/26224/prioritization-of-public-transportation-investments-a-guide-for-decision-makers
"Prioritizing Public Transportation Investments: A Guide for Decision-Makers" offers practical guidance to transportation agencies seeking to enhance their prioritization processes for public transportation projects.

Measuring the Effectiveness of Public Involvement in Transportation Planning and Project Development
Transportation Research Board | January 1, 2019 |
https://nap.nationalacademies.org/catalog/25447/measuring-the-effectiveness-of-public-involvement-in-transportation-planning-and-project-development
“Measuring the Effectiveness of Public Involvement in Transportation Planning and Project Development” offers a field-validated and practitioner-ready toolkit to measure the impact of a transportation agency’s public involvement activities. The toolkit is designed to collect feedback from the public on several indicators of effectiveness and to compare that feedback with the agency’s internal perspective.

A Multi-asset Transportation Infrastructure Asset Management Framework and Modeling for Local Governments
CTEDD | June 7, 2019 | https://rosap.ntl.bts.gov/view/dot/65589
This resource suggests that to uphold aging infrastructure in a state of good repair amid shrinking budgets, local governments should embrace a systematic approach to carry out cost-effective maintenance, rehabilitation, and reconstruction (MR&R), rather than depending solely on subjective individual knowledge and experience.

Case Study 5 – Financial Planning and Investment Strategies
FHWA | May 1, 2020 | https://rosap.ntl.bts.gov/view/dot/54333
This case study examines the financial planning and investment strategies observed in state DOTs in 2019. These strategies demonstrate how DOTs formulated long-term funding allocations for pavements and bridges, relying on projected revenue forecasts and estimates of funding requirements for each asset category, using the LCP processes to enhance, maintain, and preserve their transportation assets in a state of good repair.

Investment Prioritization Methods for Low-Volume Roads
Transportation Research Board | January 1, 2018 |
https://nap.nationalacademies.org/catalog/25142/investment-prioritization-methods-for-low-volume-roads

“Investment Prioritization Methods for Low-Volume Roads” outlines current practices and strategies used by transportation agencies to make investment decisions about low-volume roads.

Fix It, Sign It, or Close It: State of Good Repair in an Era of Budget Constraints
Transportation Research Board | July 1, 2021 |
https://nap.nationalacademies.org/catalog/26266/fix-it-sign-it-or-close-it-state-of-good-repair-in-an-era-of-budget-constraints
“Fix It, Sign It or Close It: State of Good Repair in an Era of Budget Constraints” examines the legal implications for transportation agencies facing decisions on whether to repair, enhance, or reconstruct assets in deteriorating condition.

Geotechnical Asset Management for Transportation Agencies, Volume 2: Implementation Manual
Transportation Research Board | January 1, 2019 |
https://nap.nationalacademies.org/catalog/25364/geotechnical-asset-management-for-transportation-agencies-volume-2-implementation-manual
"Geotechnical Asset Management for Transportation Agencies, Volume 2: Implementation Manual" offers a guidebook designed for implementing Geotechnical Asset Management (GAM) planning.

Guide to Asset Management – Processes Part 8: Financial Management
Transportation Research Board | July 26, 2018 | https://trid.trb.org/view/1527948
Chapter 8 of the GAM is designed to aid professionals in financial management, particularly in asset valuation and auditing. It emphasizes regular reporting and accounting for assets, alongside guidance on ensuring financial sustainability. This includes compiling a financial strategy, developing a long-term financial plan, and utilizing financial sustainability indicators to ensure the affordability and longevity of the asset management plan.

Asset Management Manual: Organization
PIARC | October 16, 2023 | https://road-asset.piarc.org/en/management/organization
This chapter delves into various aspects of restructuring a road organization to unlock the benefits of asset management and assist the organization in meeting its goals. These include leadership and cultural considerations, self-assessment of current asset management practices, the pivotal role of asset management champions in driving necessary changes, and establishing an organizational structure conducive to implementing asset management strategies.

Asset Valuation Practices and Functionality
FHWA | January 1, 2020 | https://rosap.ntl.bts.gov/view/dot/57420
This report improves asset management planning endeavors to align more effectively with Federal requirements by offering diverse approaches to valuing transportation assets. The project encompassed a review of current practices, an assessment of relevant literature, and an overview of workshops and training sessions demonstrating the application of various approaches.

A Guide to Incorporating Maintenance Costs into a Transportation Asset Management Plan
Transportation Research Board | January 1, 2023 |
https://nap.nationalacademies.org/catalog/27291/a-guide-to-incorporating-maintenance-costs-into-a-transportation-asset-management-plan
“A Guide to Incorporating Maintenance Costs into a Transportation Asset Management Plan,” part of TRB's National Cooperative Highway Research Program, guides practitioners through a six-part

framework intended to address the major hurdles agencies encounter when projecting future maintenance costs in TAMP activities.

The Balanced Scorecard – Measures that Drive Performance
Harvard Business Review | February 1, 1992 | https://hbr.org/1992/01/the-balanced-scorecard-measures-that-drive-performance-2
This resource provides a framework for performance management, challenging conventional strategies developed for assessing performance measurements. The "Balance Scorecard" method includes both financial and operational measures, creating a more accurate and holistic evaluation of efficiency.

A Guide to Developing Financial Plans and Performance Measures for Transportation Asset Management
Transportation Research Board | January 1, 2019 | https://nap.nationalacademies.org/catalog/25285/a-guide-to-developing-financial-plans-and-performance-measures-for-transportation-asset-management
“A Guide to Developing Financial Plans and Performance Measures for Transportation Asset Management” offers advice for state departments of transportation (DOTs) and other agencies conducting financial analyses and crafting financial plans to bolster the efficient and effective management of the agency’s transportation assets.

Chapter 6: Monitoring and Adjustment

Subsection 6.1.1 Future Directions in Performance Measures: New Content

Video Resource: Caltran's Performance Management Framework

- AASHTO TPM Webinar #16

Video Resource: Ancillary Asset Management

- Interview with Trisha Stefanski

Future Directions in Performance Measures

As agencies advance the maturity of their practices and move towards investment decisions across assets and modes (as discussed in Chapter 5), there is increasing interest in the use of leading measures and asset performance measures that can be used in concert with asset condition measures.

Asset management plans document the processes and investment strategies developed by an agency to manage its infrastructure assets. These asset management plans support an agency's performance-based planning and programming processes for making long-term investment decisions and feed shorter-term project and treatment selection activities. Together, these activities ensure the investment decisions of an agency are aligned with performance objectives and goals.

Examples of innovative new performance measures include:

- **Financial Measures –** Internationally, financial performance measures have been used successfully to express whether the level of investment has been adequate to offset the rate of asset deterioration or depreciation. For example, the Queensland Department of Infrastructure and Planning uses an Asset Sustainability Ratio defined as the capital expenditure being made on asset renewals (e.g., improvements) divided by the depreciation expense (discussed further in Chapter 4). If the ratio is less than 100 percent, the level of investment is not adequately replacing the depreciation occurring each year. Queensland also uses an Asset Consumption Ratio comparing the current value of the depreciable assets to their replacement value in order to show the aged condition of the assets.
- In the United States, some agencies are evaluating the use of an Asset Sustainability Index (ASI), which is the ratio of the budget allocated to address needed improvements identified by a pavement or bridge management system (FHWA. 2012. *Asset Sustainability Index: A Proposed Measure for Long-Term Performance*, Federal Highway Administration, Washington, D.C.). The ASI is a unitless measure that allows comparisons across asset classes and provides an overall assessment of the adequacy of an agency's investment in

its assets. Since it is unitless, an agency could individually calculate a Maintenance Sustainability Ratio, a Pavement Sustainability Ratio, and a Bridge Sustainability Ratio that are all combined into an overall ASI. One of the difficulties in calculating the ASI is defining the needed level of investment since needs are significantly impacted by targeted condition levels. Slight changes in targeted conditions can have a significant impact on the resulting ASI calculation.

- **Life Cycle Measures –** A life cycle performance measure is a relatively new leading measure, promoting the selection of sound, long-term strategies best able to maximize performance at the lowest possible cost. There are several life cycle performance measures under consideration, including the Remaining Service Interval (RSI validated under an FHWA-sponsored research project. The RSI is based on identifying a structured sequence of the type and timing of various repair and replacement actions needed to achieve a desired LOS over a long timeframe at the minimum practicable cost. The results of the RSI evaluation may be used to generate a Life Cycle Impact Factor, summarizing the difference in life cycle costs associated with the various strategies being considered. Documentation from a pilot implementation of the RSI approach is available through the FHWA. (https://www.fhwa.dot.gov/publications/research/infrastructure/pavements/21006/21006.pdf).
- **Sustainability Measures –** With an increased focus on identifying long-term sustainable solutions to transportation system needs, agencies may seek to develop new sustainability performance measures in order to properly indicate the impact a proposed solution may have on environmental conditions. The use of a recycling measure for gauging the amount of recycled material used in road construction is an example of this type of measure, as are measures for monitoring carbon dioxide emissions.
- **Equity Measures –** The increased emphasis on equity, inclusion, and diversity is impacting planning and investment decisions at several transportation agencies. As equity considerations are added, there has been some discussion related to the types of measurable performance measures that can be used without bias toward certain users or modes of transportation. In a case study prepared by the FHWA's Transportation Asset Management Expert Task Group, a suggestion was made to further explore both quantitative and qualitative performance measures in this area.

Subsection 6.1.2 Evaluating the Effectiveness of Performance Measures

Video Resource: Agency Innovations and Improvements Blitz

- AASHTO TPM Webinar #17

Subsection 6.1.3 Target Setting Methods

This subsection outlines methods for setting transportation performance targets, focusing on safety, infrastructure condition, reliability, and traffic congestion. It introduces quantitative target-setting approaches, such as policy-based methods, historical trends, probabilistic approaches, statistical models, and summarizes their ease of application, technical robustness, ease of

communication, and support for agency policies. The guide also offers suggestions for selecting an appropriate target-setting approach.

Introduction

NCHRP Research Project 23-07, *Guide to Effective Methods for Setting Transportation Performance Targets*, presents several approaches for setting performance targets to support a TPM framework. It focuses on target setting for the national measures that are required under federal TPM requirements, including:

- Safety measures: Number of fatalities, rate of fatalities, number of serious injuries, rate of serious injuries, number of nonmotorized fatalities and nonmotorized serious injuries.
- Infrastructure condition measures: Percentage of the Interstate system pavements in good and poor condition, percentage of the non-Interstate NHS pavements in good and poor condition, and percentage of the NHS bridges in good and poor condition.
- Reliability (travel time and freight) measures: Percentage of person miles traveled on the Interstate and Non-Interstate NHS that is reliable and truck travel time reliability index.
- Congestion measures: Annual hours of peak hour excessive delay per capita and percentage of non-single-occupancy vehicle travel.
- Target setting for nonrequired measures, such as accessibility, greenhouse gas emissions, active transportation, transit ridership, and customer satisfaction are included in the final section of the guide.

Video Resource: Target Setting

- AASHTO TPM Webinar #12

Target Setting Approaches

The guide recognizes that transportation agencies take different approaches to target setting. Some may prioritize setting realistic targets based on fiscal constraints. Other agencies may set aspirational (or fiscally unconstrained) or conservative targets.

Regardless of the approach to target setting, the guide recognizes that both quantitative and qualitative approaches may be considered. In some instances, qualitative approaches that are heavily influenced by politics or agency leadership may be appropriate. An annual target to reduce fatalities to address a long-term Vision Zero goal is an example of a qualitative target. Other approaches may use statistics or probabilities to define a quantitative target. The use of travel demand forecasts to set a mobility target illustrates the use of a quantitative approach to target setting. A combination of qualitative and quantitative approaches may also be used to set effective targets.

The following five quantitative methods for setting targets are presented in detail within the guide (Grant, M., et.al. 2023A):

1. Policy-based approaches, such as establishing a maximum rate of change (e.g., annual increase of at least 2 percent).
2. Historical trends (e.g., set a value based on a 5-year trend).

3. Probabilistic and risk-based approaches that consider performance variability (e.g., performance based on the likelihood of increased storm frequency and intensity).
4. Statistical models (e.g., rates of deterioration based on regression models).
5. Other tools and models (e.g., output from a bridge or pavement management system).

When selecting the appropriate method for target setting, the guide offers the following tips (Grant, M., et.al. 2023A):

- Understand the complexity of the methods – some methods require sophisticated data that may not be readily available and may result in marginal improvements in the target's effectiveness.
- Consider combining methods – by using several approaches, an agency has the benefit of considering the results from multiple methods in setting the final target.

The Guide (NCHRP Report 1035) presents several target-setting methods for each of the Federal performance measure categories along with a summary of their ease of use, robustness, ease of communication, and support for agency policies. A high-level synopsis of the information presented in the Guide is presented in the following table.

Table 6.2 Features Associated with Different Target-Setting Approaches

Federal Performance Measure Category	Target Setting Approach	Description	Ease of Application	Technical Robustness	Ease of Communication	Allows for Policy Preference
Safety	Targeted Reduction	Defined decrease from baseline regardless of past trends	H	L	H	H
Safety	Time-Series Trend	Based solely on historical performance data	H	M	H	L
Safety	Trend Plus Other Factors	Adjustments made to results from other approaches	H	L	M	H
Safety	Multivariable Statistical Model	Statistical analysis considering multiple variables	L	H	M	L
Infrastructure Condition	Target Based on Change in Condition	Consensus decision	H	None	L	H
Infrastructure Condition	Time-Series Trend	Based solely on historical performance data	H	L	M	M
Infrastructure Condition	Time-Series Trend Plus Future Funding	Historical trends extrapolated into the future	H	L	M	M
Infrastructure Condition	Asset Management System	Condition forecasts based on expected funds	L	H	M	M
Infrastructure Condition	Scenario Analysis	Management system analysis of multiple scenarios	L	H	M	M
Reliability	Building off the Baseline with Assumptions	Qualitative approach to adjusting baseline values	H	L	H	M
Reliability	Time-Series Trend Analysis	Based solely on historical performance data	H	M	M	M
Reliability	Trend Plus Other Factors	Adjustments made to results from other approaches	H	M	M	M
Reliability	Performance Risk Analysis	Statistical analysis of variations due to risks	M	H	M	M
Reliability	Segment Risk Analysis	Analysis of individual segments to determine those that shift between reliable and unreliable	L	H	M	M
Reliability	Multivariable Statistical Model	Statistical analysis considering multiple variables	L	H	L	L
Traffic Congestion	Building off the Baseline with Assumptions	Qualitative approach to adjusting baseline values	H	L	H	H
Traffic Congestion	Time-Series Trend Analysis	Based solely on historical performance data	M	M	M	M
Traffic Congestion	Trend Plus Other Factors	Adjustments made to results from other approaches	M	M	H	H
Traffic Congestion	Travel Forecasting Model	Model used to estimate excessive delay for the base year and forecasted year	H	M	M	L
Traffic Congestion	Policy Based	Model based on regional policy goals	H	L	H	H

Practice Example: Correlation Between NJDOT CS and Federally-Mandated Condition Ratings

NCHRP Web-Only Document 358, which is a supplemental report to the *Guide to Effective Methods for Setting Transportation Performance Targets*, provides examples documenting how target-setting methods are being used by various transportation agencies. One of the examples illustrates how the New Jersey DOT piloted the use of a scenario analysis approach for setting its pavement infrastructure condition targets. An important consideration in the use of this approach was the availability of a pavement management system (PMS) capable of forecasting future pavement conditions. However, the New Jersey DOT had not established prediction models for the Federal cracking metric, so methods were developed to correlate forecasted conditions from existing models to the Federally-required cracking metric. Correlations were developed using three years of condition data collected in accordance with both the agency's legacy Condition Status rating and the Federal measures in 0.1-mi segment lengths. Using both sets of data, correlations were developed based on the likelihood that a pavement section rated "Good" using the agency's CS rating would also be classified as a "Good" pavement using the Federal definitions. The correlations found that 88.43 percent of the segments were rated "Good" based on both approaches (Grant, M., et.al. 2023B). A similar approach was used to correlate "Poor" conditions, but the analysis showed more variability in correlating segments at this condition level. To address the variability, New Jersey DOT decided to use 3-year averages to establish the final correlations, which are presented below (Grant, M., et.al. 2023B).

Table 6.A Correlation Between NJDOT CS and Federally-Mandated Condition Ratings

	Federal Good	Federal Fair	Federal Poor
NJDOT Good	87.5%	13.78%	0.00%
NJDOT	23.74%	76.25%	0.01%
NJDOT	6.36%	86.02%	7.62%

The correlations were applied to the predicted conditions generated by the PMS to determine the expected conditions using the Federally-mandated performance measures. Several scenarios were generated, allowing the NJDOT to use the results to set realistic Federal targets.

Addressing Disruptions to Performance in Target Setting

It is inevitable that agencies will face events that disrupt what might be expected to be typical performance. Sometimes these events alter performance for a short period of time before performance returns to typical patterns. In other situations, the event may alter performance for a long period of time, as the changes associated with working from home following the COVID-19 pandemic have had on traffic patterns, congestion, and safety. The guide provides examples illustrating times when an agency might choose to include or exclude the disruption or use the disruption to alter previous performance patterns.

Subsection 6.3.2 Using Trend Data to Make Program Adjustments

Video Resource: Strengthening How Data Supports Your TAM Program

- AASHTO TAM Guide Book Club #8

Subsection 6.5.1 Lessons Learned from Implementing Risk Management: New Content

Video Resource: Improving Your Next TAMP Miniseries – Improving Risk Management and Resiliency

- AASHTO TAM Webinar #50

Lessons Learned from Implementing Risk Management

Following the 2016 publication of the AASHTO Guide for Enterprise Risk Management, TRB initiated an NCHRP project to pilot the framework introduced in the Guide. Pilot case studies were conducted by the Tennessee, Utah, and Washington State DOTs; a peer exchange was conducted; and a national community of practice (COP) was formed to provide support for the implementation of risk management and to advocate for further research in this area. Several risk management tools were developed through the research that are documented in the NCRHP report.

A variety of different types of risks were considered during the pilot studies. The Tennessee DOT focused primarily on three types of risks:

- Those associated with inconsistencies in quick-clearance processes associated with crashes and other highway incidents.
- Those associated with roadway plans that could affect the quality, cost, and schedule for delivering projects.
- Those caused when incomplete project plans are submitted for bids.

Several tools were developed to better manage these risks, including checklists, plan submittal delay forms, and a Memorandum of Understanding with the Tennessee Department of Safety to clarify roles and responsibilities for quick clearances.

The Utah DOT pilot addressed four initiatives:

- Reduce risks to Utah DOT objectives by improving hiring practices and retention.
- Reduce risks of poor performance by enhancing the employee evaluating process and strengthening leadership skills.
- Reduce risks of poor performance through a knowledge management process.
- Develop a repeatable and scalable process to assess corridor risks caused by natural disasters.

The study improved leadership access to information for hiring and leading employees, provided a training toolkit for supervisors, and resulted in a process to integrate and incorporate risk and resilience assessments into existing decision-making processes.

Washington State DOT used the pilot to support the full integration of its enterprise risk management practices. The agency also elected to address cultural sensitivity and inclusion in workforce development activities. These efforts resulted in new workforce development and outreach materials.

The pilot studies helped expose the participating agencies to strategies for managing risk. They demonstrated the importance of promoting enterprise risk management concepts among agency leaders to mainstream the concepts into common agency practices. This increases the likelihood that enterprise risk management practices endure beyond changes in agency leadership.

The participants also recognized important links between risk management and both performance and asset management programs. Several agencies recognized the importance of risk management to improving the resilience of a highway network to unexpected events such as flooding or erosion. The pilot studies demonstrated that the ability to use risks to inform planning and investment decisions can be beneficial.

Subsection 6.5.2 Monitoring TAM Processes and Improvements

Video Resource: Process Improvements

- AASHTO TAM Webinar #29

Video Resource: Consistency Reporting

- AASHTO TAM Webinar #63

Section 6.6 Incorporating Maintenance Costs into a TAMP

As discussed in section 6.4 monitoring asset work and costs is essential to assessing progress toward TAM objectives and continually improving TAM analyses and forecasts. This section describes specific challenges and approaches to capturing costs related to the maintenance of highway infrastructure assets.

Subsection 6.6.1 Categorizing and Tracking Maintenance Activities and Costs

Maintenance can be performed at any stage of the asset life cycle. *Some maintenance work may or may not change the measured asset condition, extend the expected asset life cycle, or reduce risk. NCHRP Report 1076: Guide for Incorporating Maintenance Costs into a TAMP establishes five categories of maintenance work to be considered in the incorporation of maintenance costs into TAM Analyses.*

Video Resource: Incorporating Maintenance Costs Into a TAMP

- AASHTO TAM Webinar #59

Operations and Routine Maintenance

Operational and routine maintenance activities may restore or sustain the functionality of an asset, but they do not change measured asset conditions (e.g., road patrol, mowing, and snow and ice control). These activities do not typically have a direct impact on an asset's service life. Therefore, these are activities that are not generally considered in lifecycle planning (LCP) analysis. An absence of routine maintenance may increase the likelihood of some risks, as the performance of these tasks is typically assumed as part of the highway design process (Allen, et. Al. 2023).

Preventative Maintenance

As the name indicates, preventative maintenance prevents or addresses deterioration to delay a decline in measured conditions but does not significantly improve conditions. Common Examples include crack seal, chip seal, sweeping, drain cleaning, bridge washing (Allen, et. al. 2023).

Repair

Repairing damage or deterioration improves the measurable asset condition and restores function but does not restore or improve structure, capacity, or funcitonality. Examples of repairs include milling and inlaying pavement, bridge deck repairs, and bridge member repairs. These activities may include replacement of parts but not major components. The quantity of repair, rather than the type of activity, is what typically designates an activity as maintenance instead of rehabilitation or preservation (Allen, et. al. 2023).

Unit or Major Component Repair

Unit or component replacement goes beyond repair to remove and replace one or more individual asset components, restoring functionality for that component. Examples include sign panel replacement, striping, and traffic signal component replacement. For some assets, such as ground mounted signs, the entire asset may be replaced under a maintenance action because of the mechanism by which the replacement is delivered or funded (Allen, et. al. 2023).

Organizational Strengthening

Organizational strengthening includes activities that are not directly asset related. These activities may mitigate risk or improve organizational capacity. Examples include training, emergency preparedness, management systems and their use (Allen, et. al. 2023).

Subsection 6.6.2 Capturing Maintenance Cost and Accomplishment Data

This subsection discusses the challenges of capturing maintenance costs for TAMPs, particularly when maintenance work is delivered by in-house crews or through different contract mechanisms. It emphasizes the need to align costs from different sources, such as in-house and contract maintenance costs, both financially and in terms of units of accomplishment. Examples are provided to illustrate approaches for aligning and tracking maintenance costs.

Introduction

The majority of asset management costs, for large transportation agencies, are contract costs for preservation, renewal, and construction of assets. However, maintenance investments have a significant impact on asset conditions and should be accounted for in a TAMP. Capturing maintenance costs for inclusion in a TAMP often poses unique challenges, because maintenance work is often delivered by in-house crews or through different contract mechanisms than major capital projects. These costs may also be tracked through different IT systems than capital costs.

When capturing costs for incorporation into a TAMP, it is also important to capture what is purchased, or accomplished, with those investments. Maintenance accomplishments are typically captured in terms of maintenance activities. However, the units of accomplishment for these activities may not easily align with asset management measures. Further the units of

accomplishment may vary between work performed by in-house crews and work performed by contract.

In-House Maintenance Costs

Maintenance crews commonly report their efforts and accomplishments on a daily basis through a work reporting system. Most State DOTs currently use some form of maintenance management systems (MMS) to report work performed, along with the resulting accomplishments and costs.

In-house maintenance costs commonly include the cost of labor, equipment, materials, and overhead expenses related to work performed by maintenance field crews. These costs are captured through work order or daily report records, in which costs are associated with one or more actions, commonly called "tasks," performed by the crew. Each task has an associated task code, which serves as a unique identifier, and a specific unit of measure for reporting accomplishments. For example, the task of "ditch cleaning" may have a unit of accomplishment of "feet," or the task of "mowing" may have a unit of accomplishment of "acres."

Contract Costs

Maintenance contract costs, like typical construction contract costs, are captured in terms of contract pay items. These pay items commonly do not align with the maintenance. Moreover, the unit of accomplishment may depend on the type of contract used to procure the work. For example, a contract to clean ditches may have a pay item measured in feet of ditch cleaned, cubic yards of material removed, or hours of work performed.

Maintenance contracts may be funded from an agency's Capital program or Maintenance budget. In many cases maintenance contracts funded through different programs are managed with different systems and have different means of tracking both costs and accomplishments. All of these differences can make tracking maintenance costs more challenging than the costs for other work types.

Aligning Costs from Different Sources

To incorporate maintenance costs into a TAMP, the costs from multiple sources need to be aligned in regard to both their financial components and their units of accomplishment.

The primary source of misalignment between in-house and contract maintenance costs is that in-house costs are captured through individual components of labor, equipment, materials, and overhead, whereas contract costs are captured based on pay items that combine each of these components. The labor costs captured through maintenance management systems (MMS) may or may not include an estimate of overhead costs. To facilitate comparison of in-house labor costs to contract costs an overhead multiplier should be applied. Best practices for ensuring in-house costs are accurate includes interfacing the maintenance management systems with the agency's financial or enterprise resource planning (ERP) system.

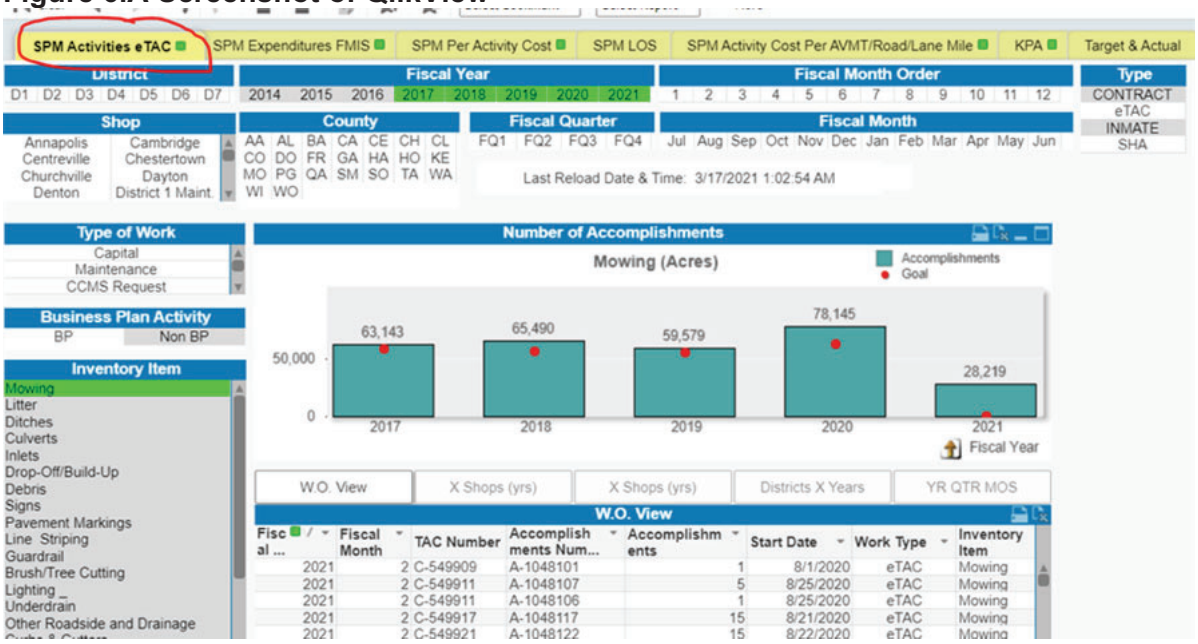
Once the costs are aligned financially, they must be aligned to common units of accomplishment to allow them to be incorporated into asset management analyses. The Maryland DOT State Highway Administration (MDOTSHA) and Texas DOT (TxDOT) offer two examples of how this alignment can be accomplished. These examples are taken from NCHRP Report 1076, *Guide for Incorporating Maintenance Costs into a Transportation Asset Management Plan*. TxDOT's approach requires inspectors on maintenance contracts to enter daily accomplishment

information into both the Capital Program management system, *SiteManager*, and the MMS. MDOTSHA has developed a set of Project Cost Activity (PCA) codes to track in-house maintenance expenses. These codes are incorporated into the records of all maintenance contracts to facilitate alignment of costs and accomplishments.

Practice Example: Maryland State Highway Association's Approach to Tracking Contract Maintenance – Maryland DOT

The MDOT SHA reports labor, equipment, and materials costs for its State forces' work into the electronic team activity cards (eTAC) system. These costs are captured by asset or unit. MDOT SHA enters contract data into the FHWA Financial Management Information System (FMIS) and other contract management software. The contract systems and eTAC assign a Project Cost Activity (PCA) code for each expense. The PCA codes allow the costs from similar work, delivered by different means, to be aggregated. The PCA codes are linked to the twenty-one Maryland Condition Assessment Reporting System (MCARS) elements to align costs with asset performance. MDOT SHA uses QlikView to aggregate the work output, cost data, and MCARS data and associate each to the appropriate PCA code for the work activity accomplished (see Figure 6-B, a screenshot of QlikView provided by MDOT SHA). Data aggregation with QlikView works well if data is accurate with the PCA codes, costs, and accomplishments.

Figure 6.A Screenshot of QlikView



Source: MDOT SHA

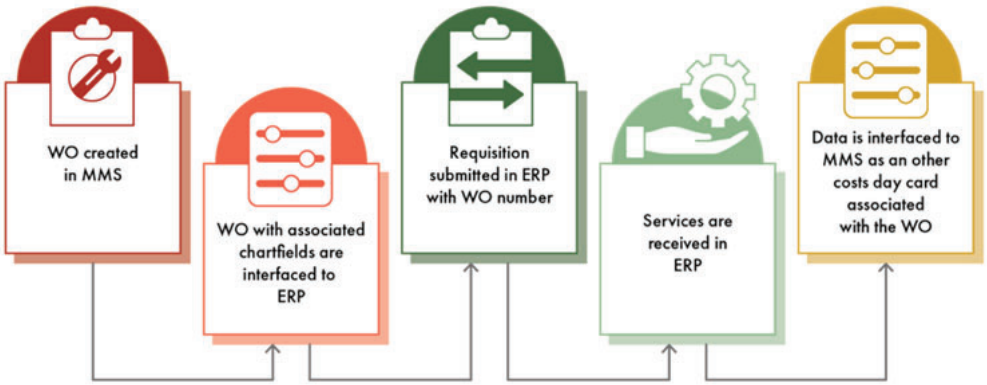
This approach enables MDOT SHA to perform an analysis to determine whether in-house or contracted maintenance provides a more cost-efficient result for the activity or asset. This is an important analysis to consider when developing maintenance work programs as it allows an agency to be strategic with limited resources" (Allen, et. al. 2023).

**Note: This practice example was derived from NCHRP Research Report 1076: A Guide to Incorporating Maintenance Costs into a Transportation Asset Management Plan.*

Practice Example: Approach to Tracking Contract Maintenance Costs in Texas – Texas DOT

TxDOT provides an example of effective contract maintenance cost data collection processes. TxDOT contracts approximately 52 percent ($620 million) of its $1.2 billion maintenance budget for routine maintenance. Contracted work is interfaced into TxDOT's MMS in two ways: from its enterprise resource planning (ERP) software and from its construction contract management software. TxDOT typically uses work orders (WO) for contracts less than $25,000. The process for capturing and reporting contract maintenance costs is shown in Figure 6.B.

Figure 6.B TxDOT Contract Purchase Order Data Collection Process



For larger projects, TxDOT utilizes AASHTOWare Site Manager, including the Routine Maintenance Contract Administration module. Daily work reports allow inspectors to capture work performed at the job site such as personnel, equipment, work items, quantities, descriptions, etc. Over 3,700 pay items are used on routine maintenance contracts and the Maintenance Distribution Window, a custom upgrade to Site Manager, ties the pay item cost to the MMS function code (i.e., what work is being performed) and amount of work performed. The MMS then provides reports by function code for both in-house and contracted work and TxDOT actively monitors data quality to ensure accurate reporting and analysis" (Allen, et. al. 2023).

**Note: This practice example was derived from NCHRP Research Report 1076: A Guide to Incorporating Maintenance Costs into a Transportation Asset Management Plan.*

Subsection 6.6.3 Incorporating Maintenance Costs into TAMP Analysis

This subsection introduces strategies for incorporating maintenance costs into key TAMP analyses, such as lifecycle planning, risk analysis, and financial/investment planning. It also provides insights into addressing unexpected disruptions using historical trends and other data. While many agencies capture maintenance costs and asset conditions within an MMS, few agencies use that data for the type of long-term analysis used to develop a TAMP.

Life Cycle Planning

One benefit of categorizing maintenance activities by their impact on the asset life cycle is that it facilitates incorporation of costs from those activities into Life Cycle Planning (LCP) analysis.

- **Preventive Maintenance, Repair, and Unit Replacement** costs are all critical inputs to LCP analysis. These costs are sometimes considered under the Preservation work type by State DOTs. Assets are typically eligible for each type of maintenance activity at a specific point in their lifecycles. Once a certain level of deterioration has been reached, a given type of activity ceases to be a cost-effective treatment. To incorporate these maintenance activities into LCP for a given asset class, agencies should consider the following:
    a. The size of the asset inventory.
    b. The number (or percentage) of assets eligible for the activity type.
    c. The length of time a typical asset is eligible for the activity type.
    d. The available treatments and their unit costs.
    e. How the application of each treatment impacts asset conditions.
    f. The quantity of each treatment to be applied in each year of the analysis.
- **Operations, routine maintenance, and Organizational Strengthening** costs do not have a direct impact on future conditions and are generally not included in LCP analysis.

Risk Management

Maintenance crews and contracts are often critical components of risk mitigation strategies. The way these resources are deployed to address risks depends on the type of risk, which can be broadly incorporated into two categories: events and trends.

Risk Events

Maintenance resources represent a transportation agency's first responders to major and minor disruptive events. Costs for response to risk events can be captured using normal work reporting procedures. Agencies often apply a code to signify if the work being reported is in response to a specific event. In some cases, the agency may be deploying maintenance resources in response to an event that has not yet been identified. In these cases, staff may need to review past records so they can be associated correctly.

Trends and Long-Term Change

Maintenance can be deployed to address long-term trends that impact asset conditions. Other trends may impact an agency's ability to deploy maintenance. Examples of trends that impact maintenance include the following (Allen, et.al. 2023).

- Changes to regulations, requirements or standards may require a rapid response to replace non-conforming assets, or may impact the cost of future maintenance.
- Changing customer expectations may lead to changes in maintenance performance standards and drive future budget changes.
- Funding fluctuations may provide a boost to or decline in maintenance capabilities. In turn this could lead to changes in asset performance, or vulnerabilities.
- Aging infrastructure can lead to network wide changes in maintenance needs. This can occur cyclically, following large building cycles, such as the interstate construction era from 1960 to 1980.
- Staff turnover due to retirements can create a need for better knowledge management.

- Rapid system expansion can lead to an increased need for future maintenance. Since the need is not immediate, there can be a lag between the need arising and an awareness of that need among executives and legislators who establish maintenance budgets.
- Long-term or gradual environmental changes can impact asset performance by exposing infrastructure to conditions it was not designed to withstand. Maintenance may be required to retrofit or replace poorly performing assets.

Financial Planning

The TAMP Financial Plan should consider all sources of funding used to support maintenance. The Financial Plans should indicate how that available funding is expected to be used over the TAMP time period. This will typically require extrapolation or forecasting beyond established maintenance budgets. The maintenance activity categories can be helpful in determining how to account for this funding within the plan.

- **Preventive Maintenance, Repairs, and Unit Replacements** are often funded and delivered by multiple programs. As such some of these costs may be captured under the Preservation work type, and some captured under Maintenance. Agencies should take care in understanding how this work is funded and delivered to ensure costs are fully captured and not double counted in the TAMP.
- Funding for **Operations and Routine Maintenance** may come from its own budget line or be part of overall maintenance funding. Additionally, some operations expenses may be funded out of capital programming through programs such as the Congestion Mitigation and Air Quality (CMAQ) program. These activities are generally performed in a similar fashion regardless of asset condition. Therefore, these are commonly included as fixed-cost items that reduce the amount of funding available for activities that improve asset condition. Typically, this is included as an average annual cost.
- **Organizational Strengthening** activities can be budgeted separately from the other categories to clearly communicate their importance and show what activities are planned. These activities can be tracked using the time, labor, and material features in a maintenance management system.

A process for developing TAMP financial plans has been established through several documents. Most recently, NCHRP Report 1076, *Guide for Incorporating Maintenance Costs into a TAMP* updated this process to better incorporate maintenance costs (Allen et. al. 2023).

1. Determine the scope of the TAM program.
2. Identify maintenance fund sources.
3. Establish maintenance fund uses.
4. Structure maintenance sources and uses list.
5. Validated the list.
6. Document Constraints.
7. Document assumptions about fixed costs.

Investment Strategies

As described in Chapter 5 of this guide, investment strategies establish a long-term plan for how the agency will apply its resources to achieve its asset management objectives. Agencies typically develop investment strategies through a scenario-based planning process. In this process the agency evaluates costs and benefits of different investment scenarios to choose the most appropriate. Since the majority of TAM funding comes through capital programming that has traditionally been the focus of investment strategy development, incorporating maintenance costs and benefits into this process may require incorporation of additional performance measures, such as those established through Maintenance Quality Assurance (MQA). MQA performance measures are often more directly related to investments in maintenance activities, whether through in-house crews or contracts. NCHRP Report 1076, Guide for Incorporating Maintenance Costs into a TAMP suggests the following steps for developing investment strategies that fully incorporate maintenance investments and benefits (Allen et. al. 2023).

1. Define the role of maintenance in each scenario.
2. Identify existing commitments to future investments in maintenance.
3. Incorporate MMS and MQA data to improve predictions of future conditions.
4. Perform initial budget allocations, including maintenance.
5. Identify candidate projects and field crew capacity.
6. Develop scenarios for analysis.
7. Review predicted future conditions and predicted maintenance needs.
8. Finalize funding levels by use.
9. Document maintenance strategies for addressing performance gaps.
10. Document assumptions and strategies.

Chapter 6 Knowledge Check

Q: Performance measures are used to track progress towards agency goals.

A: True. In addition to tracking progress, performance measures are used to align investment decision with agency objectives. They can also be used to set performance targets.

Q: One component of typical performance management framework is the allocation of funding to achieve agency objectives.

A: True. A typical performance management framework typically includes:

- A clear idea of the agency's strategic objectives.
- The use of performance measures to assess performance.
- Methods to evaluate and monitor performance results.
- The evaluation of factors with capacity to improve long-term performance.
- The allocation of funding to achieve agency objectives.
- On-going processes to monitor and report progress.

Q: When possible, agencies should use lagging performance measures rather than leading measures to influence future decisions.

A: False. A lagging performance measure reports on the outcomes from past expenditures. A leading measure uses past trends to predict the outcomes into the future. For instance, an individual trying to lose weight might track changes in weight over time. But, the readings on the scale are the results

of past dietary and exercise choices (e.g., a lagging measure). To better plan for the future, an individual might plan future calorie intakes as a leading measure to get to their desired weight.

Q: Although there are performance measures for pavements and bridges, there are no measures being used for ancillary assets (such as culverts, signs, or ramp meters).

A: False. As noted in the Checklist titled *Characteristics of Strong Performance Measures for Managing the Condition of Ancillary Assets*, common measures used by maintenance practitioners are captured in NCHRP Synthesis 470, *Maintenance Quality Assurance Field Inspection Practices*.

Q: There is no such thing as having too many performance measures.

A: False. When selecting the appropriate number of performance measures, it is important for an agency to consider the resources available to support regular inspections and analysis of the data. In general, an agency should use the performance measures that are most important to decision making and can be maintained over time. The Pennsylvania Practice Example (Subsection 6.1.2) provides suggestions for determining which measures to keep, which to change, and which to delete.

Q: A performance target can be evaluated using the SMART method, which stands for Specific, Memorable, Affordable, Relevant, and Topical.

A: False. The SMART method is useful for evaluating targets, but the acronym is made up of the words:

- Specific: performance is explicitly defined.
- Measurable: monitored in a consistent manner.
- Achievable: reachable considering conditions, demands, and resources.
- Relevant (or results-oriented): it drives the right outcomes.
- Timely (or time-bound or time-related): There is a stated timeframe for achieving the target.

Q: Trend analysis is important for projecting future revenues.

A: True. A summary of revenue trends by funding source can provide a foundation for projecting the amount of revenue that will be available in future years to address asset needs. Section 6.3.1 summarizes several types of trends that might be useful.

Q: A risk register is a tool used to monitor and manage risks.

A: True. A risk register provides a framework for capturing critical information about potential risks, including the likelihood it will happen and the potential consequence to the agency. Risk registers can also be used to outline mitigation strategies and individuals responsible for monitoring each risk.

Q: Strategic risks are managed at the project level, including risks associated with a project scope, schedule, and quality.

A: False. Strategic risks are managed at the highest level in the organization since they impact an agency's ability to achieve its goals and objectives.

Q: A RACI matrix is a tool that can be used to track roles and responsibilities for monitoring risks and other activities.

A: True. A RACI matrix tracks individuals who are:

- Responsible: getting the work done.

- Accountable: making sure the work is done.
- Consulted: providing feedback to the group completing an activity.
- Informed: needing to be informed of progress.

Chapter 6 References

Continual Improvement Processes for Asset Management: Guidelines
Austroads | May 28, 2018 | https://austroads.com.au/publications/asset-management/ap-r571-18
The guideline seeks to equip asset management practitioners with insights into the factors facilitating and maintaining ongoing enhancement. It addresses existing industry challenges concerning continual improvement and offers a framework for successful implementation.

Case Study 4 – Managing Risks to Assets
FHWA | February 1, 2021 | https://rosap.ntl.bts.gov/view/dot/55725
This case study showcases the methods employed by State Departments of Transportation (DOTs) to mitigate risks to their transportation assets.

Identifying and Managing Financial Risks in a Transportation Asset Management Plan (TAMP)
FHWA | August 1, 2023 | https://www.fhwa.dot.gov/asset/pubs/hif23049.pdf
This report expands upon insights obtained from case studies conducted with State Departments of Transportation on the identification and management of financial risks. It outlines the typical financial risks addressed in State DOT TAMPs and examines how these elements shape the formulation of TAMP investment strategies.

Next-Generation Pavement Performance Measures
FHWA | September 20, 2023 | https://trid.trb.org/View/2259800
This resource summarizes the Federal Highway Administration (FHWA) report Development of Next Generation Pavement Performance Measures and connects the effort to a broader project to develop Performance Management Objectives. Furthermore, the resource describes key findings from the research and explores how they can be used to support agency decision-making strategies.

Next-Generation Transportation Asset Management Methodology
FHWA | September 20, 2023 | https://trid.trb.org/View/2259801
This TechBrief serves as a follow up to Next-Generation Pavement Performance Measures (FHWA-HRT-23-102). It outlines the Federal Highway Administration (FHWA) report Development of Next Generation Pavement Performance Measures and Asset Management in an ongoing effort to develop and refine Performance Management Objectives.

R&T Portfolio: Transportation Performance Management
FHWA | June 9, 2022 | https://highways.dot.gov/research/rtportfolio/infrastructure-performance-management
The project aims to identify, analyze, communicate, and implement a set of leading indicators for transportation performance. It will generate a report detailing how transportation agencies can use these leading indicators to monitor and adjust performance measure targets for national performance-measurement areas, including infrastructure condition. The report also outlines a

method that agencies can employ to identify, analyze, and select their own leading or lagging indicators to guide investment decision-making.

Implementation of the AASHTO Guide for Enterprise Risk Management
Transportation Research Board | June 9, 2022 |
https://nap.nationalacademies.org/catalog/26516/implementation-of-the-aashto-guide-for-enterprise-risk-management
"Implementation of the AASHTO Guide for Enterprise Risk Management" details how various state departments of transportation are incorporating risk management principles and practices.

Effective Methods for Setting Transportation Performance Targets
Transportation Research Board | December 30, 2022 |
https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4788
This research aims to assist state DOTs and Metropolitan Planning Organizations (MPOs) in identifying effective methods for setting transportation performance targets based on established national measures.

Asset Sustainability Index: A Proposed Measure for Long-Term Performance
FHWA | June 28, 2017 |
https://www.fhwa.dot.gov/planning/processes/statewide/practices/asset_sustainability_index/page01.cfm
This resource defines and positions terminology used when discussing the concept of asset sustainability.

Transportation Performance Management
FHWA | December 31, 2020 | https://www.fhwa.dot.gov/tpm/plan/
This resource outlines all the implementation plan activities scheduled for completion between 2018 and 2020. The plan includes 38 activities, 37 of which have been completed.

National Performance Measures for Congestion, Reliability, and Freight, and CMAQ Traffic Congestion
FHWA | June 1, 2018 | https://www.fhwa.dot.gov/tpm/guidance/hif18040.pdf
"National Performance Measures for Congestion, Reliability, and Freight, and CMAQ Traffic Congestion: General Guidance and Step-by-Step Metric Calculation Procedures" provides recommended procedures for calculating the National Highway System performance metrics, the Truck Travel Time Reliability metrics, and the Peak Hour Excessive Delay metric.

Linking Performance and Asset Management
FHWA | July 1, 2019 | https://www.fhwa.dot.gov/asset/etg/pubs/whitepaper2.pdf
This paper explores how the transportation asset management processes outlined in 23 CFR 515, the transportation performance management processes in 23 CFR 490, and the planning requirements in 23 CFR 450 enhance the connection between asset management and performance management.

Guide to Effective Methods for Setting Transportation Performance Targets

Transportation Research Board | January 1, 2023 | https://nap.nationalacademies.org/catalog/26326/integrating-effective-transportation-performance-risk-and-asset-management-practices
"Guide to Effective Methods for Setting Transportation Performance Targets," from TRB's National Cooperative Highway Research Program, is intended to assist state DOTs and metropolitan planning organizations in identifying effective methods for setting transportation performance targets in line with established national measures.

Remaining Service Interval: A White Paper
Transportation Research Board | March 1, 2021 | https://trid.trb.org/view/1833123
This white paper outlines, in simple terms, the fundamental concepts associated with the RSI framework. The document leads the reader through the basic process of RSI application and uses simple examples to illustrate how the RSI framework can be used to support investment decisions.

Managing Performance to Enhance Decision-Making: Making Targets Matter
Transportation Research Board | January 1, 2022 | https://nap.nationalacademies.org/catalog/26600/managing-performance-to-enhance-decision-making-making-targets-matter
"Managing Performance to Enhance Decision-Making: Making Targets Matter" presents a collection of feedback enrichment strategies demonstrated through case studies. These examples show how agencies effectively integrate people- and data-based feedback into decision-making processes for transportation issues, spanning from long-term strategy development to medium-term program planning and daily operations.

Developing a Guide to Effective Methods for Setting Transportation Performance Targets
Transportation Research Board | January 1, 2023 | https://nap.nationalacademies.org/catalog/26764/guide-to-effective-methods-for-setting-transportation-performance-targets
"Developing a Guide to Effective Methods for Setting Transportation Performance Targets," from TRB's National Cooperative Highway Research Program, aims to assist state DOTs and metropolitan planning organizations in identifying effective methods for establishing transportation performance targets aligned with national measures.

Strategic Performance Measures for State Departments of Transportation: A Handbook for CEOs and Executives
AASHTO | March 19, 2004 | https://trid.trb.org/View/696635
This guide connects strategic planning and performance measurement through strategic performance measures, translating organizational vision into a focused set of measurable, meaningful, and accurate indicators.

Construction Economics
Engineering News-Record | October 19, 2013 | https://www.enr.com/economics
This website provides an explanation of the index's methodology and a comprehensive history of the 20-city national average for both the CCI and BCI. Each index includes a materials and labor component. In the second issue of each month, ENR publishes the CCI, BCI, materials index, skilled labor index, and common labor index for 20 cities and the national average.

Beyond the Short Term: Transportation Asset Management for Long-Term Sustainability, Accountability, and Performance
FHWA | September 10, 2010 | https://www.fhwa.dot.gov/asset/10009/tam_topr806.pdf
This report re-evaluates TAM as a method for achieving sustainability and as a system for enhancing accountability and performance. It also offers guidance on Change Management practices to elevate and expand TAM practices within a department of transportation.

Bridge Inspector's Reference Manual (BIRM)
Transportation Research Board | March 1, 2023 | https://trid.trb.org/view/2219426
This document, the Bridge Inspector's Reference Manual (BIRM), serves as an extensive reference guide on the programs, procedures, and techniques for inspecting and evaluating various in-service highway bridges. It is designed to replace the Bridge Inspector's Reference Training Manual (BITM) 90, originally published in 1991, which was developed to train highway personnel in the emerging field of bridge safety inspection.

Transportation Management System Performance Monitoring, Evaluation, and Reporting
FHWA | January 1, 2018 |
https://tmcpfs.ops.fhwa.dot.gov/cfprojects/uploaded_files/tms_pmer_brochure.pdf
Performance measures are employed to prioritize projects, assess the effectiveness of long-term strategies, refine goals and objectives, and enhance the processes for delivering transportation services.

Measuring Transportation Network Performance
Transportation Research Board | September 1, 2010 |
https://nap.nationalacademies.org/catalog/14425/measuring-transportation-network-performance
Measuring Transportation Network Performance examines methods to monitor transportation network performance by creating new performance measures or integrating existing ones from various transportation modes and multiple jurisdictions.

Estimating Life Expectancies of Highway Assets
Transportation Research Board | January 1, 2012 |
https://nap.nationalacademies.org/catalog/22782/estimating-life-expectancies-of-highway-assets-volume-1-guidebook
"Estimating Life Expectancies of Highway Assets, Volume 1: Guidebook" discusses the application of a methodology for estimating the life expectancies of various types of highway system assets. This methodology is tailored for use in lifecycle cost analyses to aid management decision-making.

Benchmarking and Comparative Measurement for Effective Performance Management
Transportation Research Board | January 1, 2019 |
https://www.nap.edu/catalog/25365/benchmarking-and-comparative-measurement-for-effective-performance-managementcoll-by-transportation-agencies
"Benchmarking and Comparative Measurement for Effective Performance Management" by Transportation Agencies offers advice and illustrations on choosing peer groups to ensure the effective application of benchmarking for improving transportation system performance.

Maintenance Quality Assurance Field Inspection Practices

Transportation Research Board | September 1, 2015 | https://nap.nationalacademies.org/catalog/22201/maintenance-quality-assurance-field-inspection-practices
"Maintenance Quality Assurance Field Inspection Practices" provides an overview of the methods employed by state transportation agencies to uphold maintenance investments.

Life-Cycle Cost Analysis for Management of Highway Assets
Transportation Research Board | September 1, 2016 | https://www.nap.edu/catalog/23515/life-cycle-cost-analysis-for-management-of-highway-assets
Life-Cycle Cost Analysis for Management of Highway Assets illustrates the current practices of life-cycle cost analysis (LCCA) and risk-based analysis incorporated into state highway agencies' asset management plans for pavements and bridges on the National Highway System. The project aimed to compile a list of quantitative processes and models, at the asset, project, or corridor levels, for predicting life-cycle costs related to the preservation and replacement of highway assets.

A Methodology for Performance Measurement and Peer Comparison in the Public Transportation Industry
Transportation Research Board | January 1, 2010 | https://www.nap.edu/catalog/14402/a-methodology-for-performance-measurement-and-peer-comparison-in-the-public-transportation-industry
A Methodology for Performance Measurement and Peer Comparison in the Public Transportation Industry investigates the application of performance measurement and benchmarking as instruments to assess the strengths and weaknesses of a transit organization, establish performance goals or targets, and identify best practices for enhancing performance.

Transportation Economic Trends 2017
U.S. Department of Transportation: Bureau of Transportation Statistics | January 1, 2018 | https://www.bts.gov/sites/bts.dot.gov/files/docs/browse-statistical-products-and-data/bts-publications/215901/transportation-economic-trends-2017.pdf
This resource provides a snapshot of the United States Economy as it relates to the transportation industry. Chapter 1 presents the Transportation Services Index, offering a monthly overview of both freight and passenger movement. Chapter 2 delves into the economic contributions of transportation in America. Chapter 3 scrutinizes the costs incurred by households and businesses for transportation. Chapter 4 assesses transportation-related employment. Chapter 5 explores trends in transportation productivity. Chapter 6 analyzes household expenditure on transportation goods and services. Chapter 7 scrutinizes government spending and revenue in transportation. Finally, Chapter 8 discusses transportation assets and infrastructure.

Asset Management
FHWA | May 25, 2023 | https://www.fhwa.dot.gov/asset/10009/tam_topr806.pdf
This resource serves as a database for all case studies, reports, and other publications from the FHWA that pertain to the topic: Asset Management.

The RACI Matrix: Your Blueprint for Project Success
IDG Communication's, Inc. | September 14, 2022 | https://www.cio.com/article/2395825/project-management-how-to-design-a-successful-raci-project-plan.html

A RACI matrix offers a straightforward and efficient method for delineating project roles and 2818 responsibilities. It furnishes a comprehensive chart detailing who is responsible, accountable, 2819 consulted, and informed throughout each phase of the project.

Chapter 7: Information and Systems

Subsection 7.1.5 TAM Data Guide

This subsection highlights the importance of effective data and information systems in supporting Transportation Asset Management (TAM) programs. It introduces the NCHRP Report 956 and AASHTO TAM Data Guide, which offer a structured approach for assessing current TAM data practices, identifying improvements, and planning implementation strategies. The guidance includes practical tips, supporting materials, templates, and real-world implementation examples to help transportation agencies enhance their TAM data management.

Overview

Transportation agencies are facing increasing pressure to make more effective use of data and information systems to support their TAM programs. Addressing this need, NCHRP Project 08-115 produced NCHRP Report 956, a Guidebook for Data and Information Systems for Transportation Asset Management. AASHTO hosts web-based versions of the guidebook and tools, where subsequent implementation guidance and DOT implementation experiences have also been shared.

Built upon a data life-cycle framework which addresses five distinct stages in the use of data for TAM, the NCHRP Report 956 and associated AASHTO TAM Data Guide provide a structured approach for transportation agencies to:

- Assess current TAM data and information system practices and establish a desired state.
- Identify and evaluate data and information system-related improvements.
- Secure agency support for improvements and plan an implementation strategy.

Figure 7.4 Stages in the Use of Data for TAM

This guidance is supplemented with valuable support materials, including:

- Practical implementation tips to support the TAM data and information system assessment, improvement selection and evaluation, and action planning processes.
- Supporting materials and templates (such as assessment scoping guidance, stakeholder engagement and facilitation materials, and assessment summary and action planning templates).
- User guidance, quick reference materials, and tutorial videos to guide tool use and application.
- Research implementation examples based on four real-world implementations of the guidance at the New Hampshire, New Mexico, and Virginia DOTs.

Other Related Methodologies

For those exclusively focused on better understanding and improving how they manage their TAM data, NCHRP Project 20-44(12) was completed in 2022, providing improved tools, supplemental guidance, materials, and detailed case studies on implementation of the NCHRP Report 814 Data Self-Assessment Guidance. The outcomes of this project included detailed agency-specific assessment experiences, including several applications of the data management maturity and data value assessment frameworks in TAM-specific contexts.

Practice Example: NHDOT Bridge Preservation Program Assessment – New Hampshire DOT

The New Hampshire DOT (NHDOT) was interested in improving data and information systems to enable better alignment between bridge preservation decision-making approaches with those used for bridge rehabilitation and replacement. This TAM Data Assessment was conducted in anticipation of advancements in data and modeling detail and better integration of bridge asset management and bridge design systems and models. At the time of the assessment, a new bridge management system was being implemented, presenting a unique opportunity to advance data and information system practices.

*Note: This practice example was derived from NCHRP Final Research Implementation Report 08-115: Guidebook for Data and Information Systems for Transportation Asset Management. More TAM Data Assessment research implementation examples are available at: https://www.tamdataguide.com/research-implementation-examples/

Practice Example: NMDOT Project Evaluation Assessment – New Mexico DOT

New Mexico DOT (NMDOT) had recently implemented a new data-driven methodology to prioritize proposed capital projects. The agency wanted to use the TAM Data Assessment to identify data and information system improvements to advance and sustain District implementation of the new approach and prioritization outcomes.

*Note: This practice example was derived from NCHRP Final Research Implementation Report 08-115: Guidebook for Data and Information Systems for Transportation Asset Management. More TAM Data Assessment research implementation examples are available at: https://www.tamdataguide.com/research-implementation-examples/

Practice Example: VDOT Highway Maintenance Management System Assessment

This TAM Data Assessment examined the Virginia DOT maintenance management system to identify how current functionality could be expanded to support broader asset management of roadside assets.

*Note: This practice example was derived from NCHRP Final Research Implementation Report 08-115: Guidebook for Data and Information Systems for Transportation Asset Management. More TAM Data Assessment research implementation examples are available at: https://www.tamdataguide.com/research-implementation-examples/

Practice Example: VDOT Pavement Management Systems Assessment

Virginia DOT (VDOT) has a long standing and high functioning Pavement Management program. This program is organized around a well-established pavement management system (PMS) and pavement maintenance scheduling system (PMSS). These systems are used by Central Office and District staff to forecast pavement conditions, allocate resources, and plan targeted preventative, corrective, and restorative maintenance projects. Although VDOT staff were confident in their program, they were motivated to identify if further improvement would be possible through data and/or system improvements.

*Note: This practice example was derived from NCHRP Final Research Implementation Report 08-115: Guidebook for Data and Information Systems for Transportation Asset Management. More TAM Data Assessment research implementation examples are available at: https://www.tamdataguide.com/research-implementation-examples/

Subsection 7.3.1 Designing Effective Reports and Visualizations

Video Resource: TAM Communication and Visualization

- AASHTO TAM Webinar #45

Subsection 7.4.1 Fundamental Concepts and Principles

Video Resource: Data Management and the TAM Data Assistant

- Interview with Chris Whipple on Data Management

Section 7.5 Future Applications: Building Information Modeling

Building Information Modeling (BIM) is transforming transportation asset management by providing a digital representation of infrastructure assets throughout their lifecycle. BIM facilitates centralized data management, real-time monitoring of asset condition, efficient maintenance planning, and simulation for performance analysis. The CRP Project TFRS-02, completed in 2023, produced a business case for BIM adoption in infrastructure, emphasizing cost savings, time efficiency, and tools for agencies to assess BIM implementation benefits.

Subsection 7.5.1 Building Information Modeling

This subsection discusses Building Information Modeling (BIM) for Transportation as an emerging practice that integrates asset data across the planning, design, construction, operation, and lifecycle management of transportation assets. BIM's comprehensive digital representation streamlines access to asset information, facilitates condition assessment, supports informed decision-making, and enhances efficiency and safety in managing transportation infrastructure.

BIM Overview

Building Information Modeling (BIM) for Transportation is an emerging practice that supports asset data integration across the planning, design, construction, and lifecycle management and operation of an asset. A robust BIM implementation can support the development and maintenance of a digital twin of an asset, useful in asset maintenance and operations decision-making throughout the life of the asset. A digital twin is defined as a highly detailed virtual representation of a physical asset, reflecting its real-world configurations, historical updates, and maintenance activities throughout its lifecycle. It includes information on rehabilitation and repair actions, as well as the impacts of other related projects. The tool allows transportation agencies to enhance their efficiency in operating, maintaining, planning, scoping, developing, and delivering future investments related to the asset.

In the realm of transportation infrastructure, Building Information Modeling is revolutionizing asset management practices by providing a comprehensive digital representation of assets throughout their lifecycle. BIM's ability to integrate asset data, facilitate condition assessment, and enable informed decision-making is transforming the way transportation agencies manage their valuable infrastructure.

BIM serves as a centralized repository for asset information, encompassing geometric details, material properties, maintenance records, and inspection reports, thereby streamlining access to crucial information, and enabling efficient analysis and better decision-making. Moreover, BIM allows real-time monitoring of asset condition, enabling proactive maintenance and early detection of potential issues. This proactive approach prevents costly failures and extends asset lifespan, optimizing resource allocation and minimizing disruptions to transportation operations.

BIM's ability to simulate maintenance activities allows for more efficient planning and scheduling of tasks, ensuring optimal resource allocation and minimal disruptions to transportation

operations. Furthermore, BIM enables performance analysis and simulation under various scenarios, such as traffic loads, weather events, or natural disasters, thereby identifying potential vulnerabilities and assessing the effectiveness of mitigation strategies. This comprehensive approach to asset management ensures the continued performance and reliability of transportation infrastructure, enhancing safety and resilience.

Video Resource: TAM and BIM

- AASHTO TAM Webinar #42

Subsection 7.5.2 CRP Project TFRS-02

This page discusses the completion of CRP Project TFRS-02 and the resulting publication of CRP Special Release 4, focusing on the application of Building Information Modeling (BIM) in transportation asset management. It outlines key uses of BIM, such as asset data management, condition assessment, maintenance planning, and resilience planning, emphasizing its transformative role and potential cost and time savings.

Video Resource: TAM and TSMO

- AASHTO TAM Webinar #51

CRP Project TFRS-02 was completed in 2023, resulting in publication of CRP Special Release 4: Lifecycle BIM for Infrastructure: A Business Case for Project Delivery and Asset Management. This report presents guidance and resources to advance adoption of BIM in infrastructure as developed based on a request to evaluate the business case for BIM by quantifying how enterprise-wide BIM systems can lead to agency efficiencies and improved cost savings.

BIM can be a powerful tool for transportation asset management, providing a comprehensive digital representation of transportation infrastructure assets throughout their lifecycle. Here are some key applications of BIM in transportation asset management:

1. **Asset Inventory and Data Management:** BIM models can serve as a centralized repository for asset data, including geometric information, material properties, maintenance records, and inspection reports. This centralized data management facilitates efficient access to asset information for decision-making and analysis.
2. **Condition Assessment and Monitoring:** BIM models can be integrated with sensor data and inspection reports to provide real-time monitoring of asset condition. This enables proactive maintenance and early detection of potential issues, preventing costly failures and extending asset lifespan.
3. **Maintenance Planning and Scheduling:** BIM models can be used to visualize and simulate maintenance activities, allowing for more efficient planning and scheduling of maintenance tasks. This can optimize resource allocation and minimize disruptions to transportation operations.
4. **Performance Analysis and Simulation:** BIM models can be used to simulate asset performance under various scenarios, such as traffic loads, weather events, or natural disasters. This helps identify potential vulnerabilities and assess the effectiveness of mitigation strategies.

5. **Decision-Making and Investment Prioritization:** BIM models can provide valuable insights for decision-making regarding asset management investments. By analyzing asset condition, performance, and risk factors, BIM can help prioritize maintenance, rehabilitation, or replacement projects.
6. **Resilience Planning and Adaptation:** BIM models can be used to assess the resilience of transportation assets to extreme events and climate change. This information can guide the development of resilience strategies, such as hardening assets or improving redundancy.

Overall, BIM offers a transformative approach to transportation asset management, enabling informed decision-making, efficient maintenance practices, and enhanced resilience of transportation infrastructure. As BIM technology continues to evolve, its role in transportation asset management is expected to expand further, leading to more sustainable and resilient transportation systems.

TFRS-02 identified benefits for BIM implementation included time savings from improved design efficiency, time saved on completing design quantities, time saved from reusing previous BIM content for future similar work, and cost savings from avoided change orders. These savings represent value typically captured during project design and delivery, however further efficiencies can be captured in asset management and operation where additional in-house agency cost savings, project cost savings, staff time savings, and user benefits can be realized.

The TFRS-02 project also developed a series of complementary spreadsheet tools to assist transportation agencies with identifying costs and benefits for implementing BIM for Infrastructure and evaluating their current BIM maturity. Supporting these tools is a multi-media toolkit with addressing frequently asked quotations, and providing presentation materials directed at various levels of agency staff.

Practice Example: Lifecycle BIM for Infrastructure: A Business Case for Project Delivery and Asset Management – Transportation Research Board

The CRP Special Release 4 multi-media toolkit includes video interviews with TRB panel members and research team members regarding the TFRS-02 study findings and lessons learned.

Further information on the multi-media toolkit & interviews at:
https://www.trb.org/Publications/Blurbs/182837.aspx

Chapter 7 Knowledge Check

Q: All states must provide FHWA with a full asset inventory for all public roads each year.

A: False. States must provide FHWA with roadway characteristics data for all public roads for their annual Highway Performance Monitoring System (HPMS) submittals, but a full asset inventory is not required.

Q: States must provide a data quality management plan for their pavement data to FHWA

A: True. Federal performance management requirements include a requirement for State DOTs to establish a QA/QC plan for pavement data collection.

Q: Data visualizations for asset management should be designed to meet the needs of all possible audiences.

A: False. Different audiences have different information needs. Each data visualization design should be targeted at a specific set of needs.

Q: A DOT's asset data should only be shared outside of the agency if there is a public records request.

A: False. In general, data should be shared unless it is sensitive, protected by law or if sharing it would pose unacceptable risks or cost burdens.

Q: The terms "data governance", "data management" and "data stewardship" are synonyms and can be used interchangeably.

A: False: These three terms are interrelated by not synonymous. Data management encompasses all of the activities carried out to collect, store, share, integrate, protect and archive data. Data governance is a policy and oversight function for data management. Data stewardship refers to responsibilities and accountabilities for managing data.

Q: IF there is no agency-wide data governance function established, TAM groups should consider establishing their own data governance body.

A: True. Though an agency-wide data governance approach is best, TAM groups can establish their own data governance processes and standards in the absence of an agency data governance function.

Chapter 7 References

AASHTO TAM Data Guide
AASHTO | May 1, 2020 | https://www.tamdataguide.com/
This guidebook provides a structured approach to assess current practices and improve use of data and information for TAM. Explore and apply this guidance through this website and the companion TAM Data Assistant digital application.

Building Capacity for Self-Assessment of Data Effectiveness for Agency Business Needs
Transportation Research Board | May 9, 2022 |
https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4669
This research and its final report provide guidance to assist state departments of transportation (DOTs), metropolitan planning organizations (MPOs), and other transportation agencies in evaluating and improving the value of their data and their data management practices.

Data to Support Transportation Agency Business Needs: A Self-Assessment Guide
Transportation Research Board | January 1, 2015 |
https://nap.nationalacademies.org/catalog/23463/data-to-support-transportation-agency-business-needs-a-self-assessment-guide
Data to Support Transportation Agency Business Needs: A Self-Assessment Guide offers techniques to assess and enhance the usefulness of data for decision-making purposes, along with their data management practices.

Lifecycle BIM for Infrastructure: A Business Case for Project Delivery and Asset Management

Transportation Research Board | January 1, 2023 |
https://nap.nationalacademies.org/catalog/23463/data-to-support-transportation-agency-business-needs-a-self-assessment-guide
"Lifecycle BIM for Infrastructure: A Business Case for Project Delivery and Asset Management" centers on creating resources to facilitate the integration of Building Information Modeling by highway agencies.

Building Information Modeling (BIM) for Bridges and Structures
FHWA | August 8, 2023 | https://www.pooledfund.org/Details/Study/624
This resource outlines the adoption of building information modeling (BIM) in transportation structures through an ongoing study conducted by AASHTO.

A New Perspective in the Road Asset Management with the use of Advanced Monitoring System & BIM
EDP Sciences | November 16, 2018 |
https://www.researchgate.net/publication/328992872_A_new_perspective_in_the_road_asset_management_with_the_use_of_advanced_monitoring_system_BIM
This paper discusses various applications that share a common data source: the Automatic Road Analyzer (ARAN) from the Transport Infrastructure Laboratory at the University of Catania. Data collected with ARAN were utilized to create performance indicators for road assets and to construct a BIM model.

Integrating Computer-Aided Dispatch Data with Traffic Management Centers
FHWA | February 1, 2021 | https://ops.fhwa.dot.gov/publications/fhwahop20064/index.htm
This publication outlines the benefits of integrating data from law enforcement and public safety computer-aided dispatch systems with transportation operating systems. This integration enhances incident response, contributes to saving responder lives, and enhances safety for network travelers. The document showcases multiple successful case studies of data-sharing partnerships that have led to enhanced operational information and improved decision-making data for travelers.

Establishing Multisource Data-Integration Framework for Transportation Data Analytics
Journal of Transportation Engineering | February 19, 2020 | https://trid.trb.org/view/1693703
This study presents a transportation data-integration framework centered on a standardized geospatial roadway referencing layer. Within this framework, transportation data are categorized into four groups based on the locations and coverage areas of traffic sensors: on-road segment-based data, off-road segment-based data, on-road point-based data, and off-road point-based data.

Transit Asset Management Systems Handbook
FHWA | October 15, 2020 | https://www.transit.dot.gov/regulations-and-programs/asset-management/transit-asset-management-systems-handbook
This handbook aims to enhance and offer comprehensive information and advice on managing systems and their associated assets within the transit operating environment to comply with the FTA Transit Asset Management (TAM) rule.

National Transit Database

FTA | October 17, 2023 | https://www.transit.dot.gov/ntd/ntd-data
This online database contains extensive information on national transit records.

Collaborative Practices for Performance-Based Asset Management Between State DOTs and MPOs
Transportation Research Board | January 1, 2021 | https://nap.nationalacademies.org/catalog/26337/collaborative-practices-for-performance-based-asset-management-between-state-dots-and-mpos
"Collaborative Strategies for Performance-Based Asset Management Between State DOTs and MPOs" details the collaborative approaches adopted by DOTs to work with MPOs concerning target establishment, investment determinations, and performance tracking of pavement and bridge assets.

Guidebook for Data and Information Systems for Transportation Asset Management
Transportation Research Board | December 31, 2022 | https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4362
The NCHRP project aimed to develop a guidebook and related guidance materials to enhance asset management processes. It focused on principles, organizational strategies, and practical examples to improve data collection, information development, and decision-making. The goal was to ensure usability, awareness, and application of these guidelines in managing transportation system assets effectively.

AASHTO TAM Data Guide: Data and Information Systems for Transportation Asset Management
AASHTO | May 1, 2020 | https://www.tamdataguide.com/
The NCHRP 08-115 Guidebook offers a systematic method for evaluating existing TAM procedures and enhancing the utilization of data and information in TAM endeavors.

AASHTO TAM Data Assistant
AASHTO | October 18, 2023 | https://dataassessment.tam-portal.com/
The AASHTO TAM Data Assistant offers a framework to evaluate current TAM methodologies and enhance the utilization of data and information in TAM processes.

Building Capacity for Self-Assessment of Data Effectiveness for Agency Business Needs
Transportation Research Board | May 9, 2022 | https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4669
This implementation project aims to assist decision-makers and data practitioners in assessing and enhancing their data quality and management practices. The goal of this initiative is to promote the adoption and implementation of the principles and methodologies outlined in NCHRP Report 814: Data to Enhance Transportation Agency Business Needs: A Self-Assessment Guide.

Lifecycle BIM for Infrastructure: A Business Case for Project Delivery and Asset Management
Transportation Research Board | December 31, 2021 | https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4874
The aim of this research was to assess the business rationale for BIM adoption within the United States, analyzing how implementing enterprise-wide BIM systems can enhance agency efficiencies and facilitate comprehensive lifecycle management of enterprise assets.

Life-Cycle Approach to Collecting, Managing, and Sharing Transportation Infrastructure Asset Data
ASCE Library | January 30, 2017 | https://ascelibrary.org/doi/10.1061/%28ASCE%29CO.1943-7862.0001288
This paper proposes collecting asset inventory data as an integrated part of the construction process, providing an example of such a practice in the construction of a transportation project in Indiana. It asserts that collecting inventory during project construction significantly cuts costs by eliminating duplicative data documentation.

Practical Guide for Quality Management of Pavement Condition Data Quality
FHWA | January 1, 2013 |
https://www.fhwa.dot.gov/pavement/management/qm/data_qm_guide.pdf
The Practical Guide offers insights into establishing and executing a Quality Management (QM) program, integrating established QM methods, and presenting examples or case studies utilizing pavement condition data from diverse state DOTs.

Quality Management of Pavement Condition Data Collection
Transportation Research Board | January 1, 2009 | https://www.nap.edu/catalog/14325/quality-management-of-pavement-condition-data-collection
Quality Management for Pavement Condition Data Collection investigates the quality assurance methods utilized by public highway agencies for automated, semi-automated, and manual pavement data collection and distribution.

A Remote Sensing and GIS-enabled Highway Asset Management System Phase 2
Transportation Research Board | February 2, 2018 |
https://trid.trb.org/Results?txtKeywords=%22asset+data+collection%22#/View/1505178
The aim of this project is to confirm the effectiveness of utilizing commercial remote sensing and spatial information (CRS&SI) technologies, including emerging 3D line laser imaging technology, mobile light detection and ranging (LiDAR), image processing algorithms, and Global Positioning System (GPS)/Geographic Information System (GIS) technologies, for enhancing transportation asset data collection, condition assessment, and management.

A Synthesis Study on Collecting, Managing, and Sharing Road Construction Asset Data
Purdue University: Joint Transportation Research Program | September 1, 2015 |
https://docs.lib.purdue.edu/jtrp/1588/
This project aimed to conduct a synthesis study with two objectives: 1) evaluate the existing practices at INDOT concerning asset data collection during construction and its utilization in the operation and maintenance (O&M) phase, and 2) devise a framework for INDOT to utilize the construction inspection and documentation process for asset data collection.

Best Practices in Geographical Information Systems-Based Transportation Asset Management
U.S. DOT Volpe Center | January 31, 2012 |
https://www.gis.fhwa.dot.gov/documents/GIS_AssetMgmt.pdf
This report offers an overview of Geographic Information Systems (GIS) integration with asset management. It examines the adoption of the technology by public agencies, and explores associated benefits and obstacles.

Communicating Performance Management: State DOTs Continuing to "Tell their Story"
Transportation Research Board | September 30, 2015 |
http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-24(93)B02_FR.pdf
The aim of "Communicating Performance Management—State DOTs Continuing to 'Tell Their Story'" is to build a collection of resources to aid communication and performance management (PM) professionals within state departments of transportation (DOTs).

Data on the Web Best Practices
W3C | January 31, 2017 | https://www.w3.org/TR/2017/REC-dwbp-20170131/
This document outlines best practices for publishing and utilizing data on the web, aimed at fostering a self-sustaining digital environment.

Data Visualization Methods for Transportation Agencies
Cambridge Systematics, Inc. | July 1, 2017 | http://vizguide.camsys.com/index.htm#home
This website serves as a tool for transportation professionals aiming to employ illustrations and visual aids to effectively convey their concepts to an audience.

A Practical Guide to GIS in Asset Management
ESRI | May 1, 2017 | https://www.esri.com/content/dam/esrisites/sitecore-archive/Files/Pdfs/library/whitepapers/pdfs/a-practical-guide-to-gis-in-asset-management.pdf
This white paper examines the role of GIS, drawing on the author's experiences at his own utility and insights from customer implementations of the ESRI ecosystem.

Vital Signs Tools
Metropolitan Transportation Commission | August 22, 2023 | https://mtc.ca.gov/tools-resources/vital-signs
Vital Signs is an interactive website by MTC and the Association of Bay Area Governments (ABAG) that offers data, visual representations of that data and written explanations about important trends in the Bay Area.

Successful Practices in GIS-Based Asset Management
Transportation Research Board | September 1, 2015 |
https://nap.nationalacademies.org/catalog/22194/successful-practices-in-gis-based-asset-management
Successful Practices in GIS-Based Asset Management offers guidance for state transportation agencies on utilizing geographic information system (GIS) technologies for transportation asset management (TAM).

Asset Management Data Collection Guide
AASHTO | January 1, 2006 | https://store.transportation.org/Item/PublicationDetail?ID=390
This Asset Management Data Collection Guide provides detailed information on various highway right-of-way assets. It outlines the functional characteristics of each asset type, typical data collected about the asset, general data collection methods, equipment and technology used for data acquisition, formats and standards for data transfer and storage, usage of the information for condition assessment, and proposes performance and condition standards.

The Visual Display of Quantitative Information

Graphics Press, LLC | September 1, 2001 |
http://faculty.salisbury.edu/~jtanderson/teaching/cosc311/fa21/files/tufte.pdf
Guide to statistical graphics, with emphasis on its use as a statistical method and applications in data analysis and mapping – includes chapters on aesthetics and the methodology of preparing graphs and visual aids.

Road Asset Management Manual
PIARC | October 24, 2017 | https://www.piarc.org/en/PIARC-knowledge-base-Roads-and-Road-Transportation/Road-Safety-Sustainability/Road-Assets-Management/Road-Asset-Management-Manual
The new manual by the World Road Association (PIARC) is designed to assist countries at any development stage in maintaining their infrastructure and implementing strategies for road asset management.

TAM Topics: Updates to Topic Area Pages

Workforce

Overview

The compounding effects of COVID-19 and the baby boomer generation leaving the workforce have contributed to the civilian labor force participation rate dropping to below 62.5% (January 2023) — the lowest rate in 45 years — and presenting challenges for DOTs to find workers. Those who remain active in the labor force have higher expectations of their employers in terms of salaries and working conditions, especially flexibility and the ability to work remotely. At the same time, demands on DOTs for personnel trained in asset management have increased, most recently due to the Infrastructure Investment and Jobs Act (IIJA), 2021, also known as the Bipartisan Infrastructure Law (BIL).

In the past 20 years, DOTs have moved from predominantly performing work themselves to contracting more work to be performed by consultants, with management systems and indicators to guide the work. This shift requires new skill sets, but also presents new opportunities for innovation.

This topic Deep Dive provides context and resources for aligning workforce and knowledge management programs to agency transportation asset management practices. There is much research and many practice examples for workforce development, but few tie into asset management specifically. Knowledge management could be the key to integrating asset management into workforce development.

Key Concepts

Core Competencies

- Skills, knowledge, and abilities needed for a specific task or job.

Knowledge Management

- Methods that organizations use to gather, organize, store, manage, and disseminate information needed for conducting its work.

Recruitment/Talent Development Pipeline

- A system that generates a qualified pool of applicants.

Succession Planning

- Developing talent to fill key roles to ensure continuity. Includes forecasting skills and knowledge needs.

Workforce Development

- Practices that help to create, sustain, and retain a pool of workers with the competencies to meet the agency's needs.

Implementation Considerations

1. Identify key processes and establish roles, responsibilities, and competencies. Establish roles and responsibilities for asset management functions — or if already established, review and verify — and then define the key competencies for each.
    a. Resources:
        i. TAM roles, responsibilities, and competencies: https://tamguidecom.stage.site/section/3-1-establishing-tam-roles-responsibilities-and-competencies/
        ii. TAM Roles Checklist: https://tamguidecom.stage.site/checklist/3-1-1-tam-roles/
        iii. A Comprehensive Study of Future Competencies for Transportation Planners, NCHRP 08-125, 2019: http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4657
        iv. Management of Road Assets Manual, Section 1.2.2.4: Asset Management Roles, PIARC, 2017: https://road-asset.piarc.org/en/management-organization-adapting-organization/asset-management-roles
2. Identify gaps in roles/responsibilities and competencies. Compare existing roles/responsibilities and competencies with those needed to successfully implement asset management and identify gaps.
3. Make a plan to address gaps. This step might involve organizational realignments, modification of position descriptions, creation of new positions, training, or other activities to align organization and positions for TAM implementation and management. This step should include workforce predictions, such as attrition and retirement and succession planning.
    a. Resources:
        i. A Guide to Agency-Wide Knowledge Management for State Departments of Transportation, NCHRP Report 813, 2015 https://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_813.pdf
4. Introduce and manage organizational changes. Organizational changes can be difficult for employees, especially when they aren't provided with information about the whys and hows. This step includes introducing and managing organizational changes to support TAM while minimizing disruptions.
    a. Resources:
        i. Developing a communication plan: https://tamguidecom.stage.site/subsection/3-2-3-communication/
5. Review recruitment and talent development pipeline. Evaluate recruitment practices to align with TAM needs and modify as needed. This could include shifting how and where an organization conducts recruitment. It could also include improvements to the talent development pipeline with activities such as partnering with key universities, community colleges, and other technical and vocational partners to align curriculums with evolving TAM needs or sponsoring fellowships and internships (including field and technical internships). It could further include an assessment of university, community college, and vocational education partners to ensure a diverse talent pool is being developed.
    a. Resources:

i. Defining the TSMO Workforce Pipeline, National Operations Center of Excellence, 2021 (operational focus): https://transportationops.org/tools/defining-tsmo-workforce-pipeline
ii. Developing a School to Workforce Pipeline in North Carolina, Volpe Institute, 2022: https://www.volpe.dot.gov/news/us-dot-volpe-center-supports-ncdot-equity-and-innovation-initiatives

6. Review workforce development/knowledge management activities. Evaluate workforce development activities and offerings and onboarding processes to ensure they align with core competencies needed to implement, maintain, and manage TAM. This step includes knowledge management and developing talent from within the organization to fill key future roles.
    a. Resources:
        i. Assessing and Measuring the Business Value of Knowledge Management, NCHRP: https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=5002

How To Guides

Adapting the Organizational Structure to Support TAM

Creating an organization that supports asset management requires significant transformation in transportation agencies, necessitating strong leadership and commitment from the start. The following are steps an organization can follow to make the transformation to support TAM.

1. Get Leadership Support

Leadership greatly shapes an organization's culture and actions. By setting a clear direction, leaders can align decisions, from major to minor, with the organization's strategy to meet business objectives. This includes making investment decisions that reflect an asset management approach.

2. Conduct a TAM Gap Assessment Using the TAM Gap Analysis Tool to Identify Needed Changes

The TAM Gap Assessment evaluates the organization's current asset management maturity and suggests ways the agency can improve practice. Its goals are to unify agency perspectives on asset management status, recognize strengths and weaknesses, and identify pressing priorities. This forms the basis for the agency's asset management improvement strategy and the changes that are needed.

3. Organize the Needed Changes

Use the list of the changes suggested by the gap assessment to determine the ease of implementation and the priority based on the impact it can make. This will make it easier to identify the actions that your agency wants to take to strengthen your organization to support TAM.

4. Consider the Leadership and Culture Needs

Leadership is an important ingredient in impacting an organization's culture and actions, guiding all levels of decision-making to align with business goals, including those that shape the asset management strategy.

Key points on leadership's role in asset management culture are:

- Top management must exemplify a commitment to asset management, fostering an agency-wide culture dedicated to this approach.
- Leadership should permeate all levels, ensuring asset management activities support a unified strategy.
- A culture of asset management encourages organization-wide coordination for long-term network management, aligning team and individual activities with collective goals.
- It's vital to avoid mixed signals, misunderstandings, or a lack of teamwork within an asset management culture.
- Effective leadership depends on understanding asset management's core issues and advantages, which asset management professionals should communicate clearly and accessibly.

5. Identify a Champion

In the initial phase of creating a TAM organization, a champion is often essential. This individual, driven by interest and possessing the necessary influence, advocates for the required organizational shifts. Whether appointed by upper management or rising organically from the engaged teams, a champion is focused on pursuing the successful completion of the mission.

6. Define TAM Roles

Understanding what roles and responsibilities are most important for your TAM program is key to getting your agency ready and aligned to achieve TAM-related goals.

7. Define Capability Building Requirements

Senior leaders need to pinpoint the skills needed for effective asset management implementation. If these skills are missing internally, options include staff training, hiring new talent, mentoring, or partnering with external bodies. It's crucial for your agency to ensure its asset management team is knowledgeable enough to make informed decisions.

Building a Stronger TAM Organization

Having a strong workforce to own and carry out your agency's TAM program is key to your success. Workforce challenges are being felt across all transportation agencies. These needs range from finding staff with the needed technical knowledge to just filling vacant positions. The following steps will help you with addressing these needs.

Note: This How-To was derived from an FHWA fact sheet detailing the need for improved Strategic Workforce Development in the transportation industry. Additional information on workforce development can be found here.

1. Work with Your Partner

Approach your workforce and organizational needs as a system that includes your partners who help you deliver TAM in your region. Your goal is to have people stay in the TAM system and continue to build their knowledge.

2. Organize Your Workforce for Success

The most successful agencies have the deepest bench. Recruit as far and wide as possible from potential partners. At a minimum involve the consultants; federal, state, and local agencies; and educational institutions.

3. Focus on Fundamentals

Transportation agencies historically train workers to the specific trade skills of their jobs. Successful TAM involves good judgement across a wide range of topics. Provide your workforce with a fundamental understanding of these topics.

4. **Communicate the Value of TAM Careers**
Use the communication material you have for TAM to target it for future employees. Making the case that TAM has an important impact to your agency, region, and state makes a difference in how your current and future team members value their jobs.

5. **Work with Universities, Colleges, and High Schools**
Maintain a good pipeline of future workers with your education providers. Work with them to help build curriculum that will better prepare the student for their future work. Create exercises that connects students to your work so your current team could meet future teammates.

6. **Start with Proven Strategies**
Existing programs and products provide the fastest way to tackle local transportation workforce development gaps. It is highly likely that a training and education solution already exists and can be replicated.

7. **Keep Your Focus and Make it Sustainable**
Keeping your TAM organization strong will not be a short-term undertaking. Stay focused on the mission, maintain the commitment, and work with partners to sustain the effort.

How to Better Communicate TAM Throughout the Organization

Having your transportation organization better understand your TAM program, it's goals and objectives, and specific business needs is an important element of TAM success. Proactive communication will increase awareness, knowledge, and ownership of TAM across the agency.

1. **Define the TAM Communication Scope**
Having a focus on what elements of the TAM program has priority and needs the support of the broader agency is important to have in a communication effort. It may be best to start with a strategic planning effort for TAM and use the results of this for communications.

2. **Create a TAM Communications Working Team**
Build a core group of influential players in your agency who will be the lead communicators. This group will help shape your communication strategy and lead the implementation of the plan.

3. **Identify the Target Audience**
Determine who in your agency are the people who you want to better understand TAM and support its success. If it's agencywide, organize the audience in a way that makes it easier to develop an implementation plan for your communications.

4. **Develop the TAM Communication Approach and Framework**
Once you know what you want to communicate and who you want to communicate to, how you want to communicate and the key messages that need to be communicated should be developed. A matrix of the messages and target audiences may be a product of this exercise.

5. **Build TAM Communications Resources**
Build a library of communication resources that can be used to better communicate TAM and the specific focus that was determined in Step 1. This could include flyers, base presentations that can be customized, videos, and references. Communicators can be more effective by having these resources at their fingertips.

6. **Develop a TAM Communications Implementation Plan**

An implementation plan will help your agency implement a targeted communication cycle and to sustain it over time. This can include specific tasks, a schedule/roadmap, and a mechanism for tracking progress on the plan.

7. **Implement and Monitor the TAM Communication Implementation**

It is important to monitor the communication plan implementation to both encourage further communication and to make sure that progress is being made. Another important element is to share the lessons learned as communicators are carrying out the plan so that plans can be adjusted and improved.

8. **Consider a Mechanism to Share Resources and Experiences**

Developing a place where all communication actions are logged and the resources that they used are shared is a good way to share knowledge and to share progress. The Minnesota DOT's TAM Communication Plan is a good example of this in practice.

Onboarding New TAM Staff

There are many resources available to help onboard new TAM staff. Some resources may need to be adapted and/or curated in a way to make it easier for the person who has no TAM knowledge to digest the information. The following are steps that can be taken to maximize the learning and building readiness for the role.

1. **Understand the Roles and the Skills**

   There are many different TAM roles needed in your agency so clearly document what you think are the skills needed to be successful at the role. It's also important to clearly define the tasks that the role needs to carry out. One technique for defining a job role is to create a job book. There are several examples of job books at transportation agencies.

2. **Understand the New Staff and their Skills**

   When onboarding a new staff, it's also important to understand their background and know what skills they have already. One person may already be coming into the role with some TAM knowledge while another may not have any but bring specialized skills that are needed. This knowledge will help you shape the resources you use to onboard the new staff.

3. **Inventory the TAM Resources Related to the Skill Needs for the Role**

   Build an inventory of TAM resources that will help a new TAM staff get started in their role. This library of resources should be maintained with each new employee who starts. It will include customized approaches for staff with different skills. It will include an online training course and other training materials. These resources will be useful with each new employee.

4. **Develop an Onboarding Plan for Each Employee**

   Use the combination of the first three steps to develop an onboarding plan for each new employee. This onboarding plan will align each person's schedule with the sequence of material they should consume. It will be timed with trainings that are offered by others with the timing of the offerings.

5. **Direct New Employee to Specific Resources and Provide Guidance on How They Should Use It**

Be clear with the new staff on why each resource is important to their job. Describe its importance and how they should be used to carry out their job tasks. Communicate that building knowledge about TAM is an ongoing process where understanding TAM concepts unlocks new knowledge that they will be learning.

6. Evaluate Learning Progress and Adjust Onboarding Plan

Make sure the TAM staff's onboarding is a continuous process that monitors their learning and what knowledge has been built. The onboarding plan should transition to a training plan that continues their knowledge building.

7. Add Resources to Your TAM Resources Base

With each new TAM staff, it is likely that new TAM resources are discovered. You may also learn of new resources through your contact with peers and through national activities such as webinars and peer exchanges. When a new resource is identified, be sure to add it to your onboarding resources inventory in Step 3. This will make it easier to onboard your next new TAM staff.

Regulations and Requirements

Note: This topic area page was derived from the FHWA publication: Considerations in Managing Pavements and Bridges in Fair Condition. More in-depth information is available in the full report.

Overview

State Departments of Transportation (DOT) are required to develop and update Transportation Asset Management Plan (TAMP) for pavements and bridges on the National Highway System (NHS) under 23 U.S.C.119(e). Other assets may be included in the TAMP at each state's discretion. TAMPs are certified by the Federal Highway Administration and must be updated and recertified at least every 4 years. The minimum requirements for a TAMP include [U.S.C. 119(e)(4)]:

- A summary listing of the pavement and bridge assets on the National Highway System (NHS) in the State, including a description of the condition of those assets.
- Asset management objectives and measures. Performance gap identification.
- Life-cycle cost and risk management analyses.
- A financial plan.
- Investment strategies.

The Bipartisan Infrastructure Law (§11105), commonly known as BIL, amended the TAMP requirements by requiring that States take into consideration extreme weather and resilience in their life-cycle cost and risk management analyses [23 U.S. C. 119 (e)(4)(D)]. FHWA Order 5520 defines resilience as "the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions."

Agencies use strategic performance objectives to guide investment priorities, including those outlined in a TAMP. To determine whether an agency is making progress towards those objectives, agencies monitor performance and adjust priorities or programs as needed. On the Federal level, target setting and performance monitoring are part of the Transportation Performance Management (TPM) requirements under 23 U.S.C. 150[1].

Key Concepts

Additional FHWA Context

The FHWA provides guidance on several key aspects of developing a TAMP, including those listed below.

- State TAMPs under BIL.
- 23 CFR Part 667 planning memo.
- TAMP consistency determination guidance.
- Guidance on developing TAMP financial plans.
- Guidance for incorporating risk management into a TAMP.
- Guidance on using life cycle planning to support asset management.

The FHWA also provides information on TPM statutes and regulations on its website. A summary of the six elements used to organize the TPM information is provided with links to the relative information.

Measures

FHWA-established measures to assess performance/condition in carrying out performance-based Federal-aid highway programs.

- https://www.fhwa.dot.gov/tpm/about/statutes.cfm#measures
- https://www.fhwa.dot.gov/tpm/about/regulations.cfm

National Goals

Congressionally established goals or program purpose to focus the Federal-aid highway program into specific areas of performance.

- https://www.fhwa.dot.gov/tpm/about/statutes.cfm#national
- https://www.fhwa.dot.gov/tpm/about/regulations.cfm

Plans

Development of strategic and/or tactical plans by Federal funding recipients to identify strategies and investments that address performance needs.

- https://www.fhwa.dot.gov/tpm/about/statutes.cfm#plans
- https://www.fhwa.dot.gov/tpm/about/regulations.cfm

Reports

Development of reports by Federal funding recipients that document progress toward target achievement, including the effectiveness of Federal-aid highway investments.

- https://www.fhwa.dot.gov/tpm/about/statutes.cfm#reports
- https://www.fhwa.dot.gov/tpm/about/regulations.cfm

Targets

Targets established by Federal-aid highway funding recipients for the measures to document future performance expectations.

- https://www.fhwa.dot.gov/tpm/about/statutes.cfm#targets
- https://www.fhwa.dot.gov/tpm/about/regulations.cfm

Transparency and Accountability

FHWA-developed requirements for Federal funding recipients to use to achieve or make significant progress toward targets.

- https://www.fhwa.dot.gov/tpm/about/statutes.cfm#account
- https://www.fhwa.dot.gov/tpm/about/regulations.cfm

Implementation Considerations

This section describes the intent of each portion of a TAMP and the criteria the FHWA uses for certification. The topics will include:

- Describing asset management objectives.
- Summarizing the inventory and condition information.
- Conducting life cycle planning.
- Analyzing risks and establishing mitigation plans.
- Developing financial plans and investment strategies.
- Completing a performance gap analysis
- Obtaining needed information for non-state NHS owners.
- Implementing the TAMP

For each topic the text provides a summary of what should be included to be certifiable and examples from certified TAMPs to illustrate the way different topics have been handled.

Funding–Costs associated with the development of a risk-based asset management plan are eligible for Federal funding. Specifically, these costs are eligible for both National Highway Performance Program (NHPP) and Surface Transportation Program (STP) funds pursuant to 23 U.S.C. 119(d)(2)(K) (MAP-21 § 1106) and 133(b)(24) (MAP-21 § 1108). These activities include data collection, maintenance, and integration and the cost associated with obtaining, updating, and licensing software and equipment required for risk-based asset management and performance-based management. (23 USC §§ 119(d)(2)(K), 133(b)(24), MAP-21 §§ 1106, 1108)

State Planning and Research (SPR) funds may also be used for asset management plans and processes for the NHS (23 U.S.C. § 505(a)(3), MAP-21 § 52005). Additional guidance will be provided separately.

Note: For additional information on funding and resource allocation, refer to the FHWA website's Q&A page on Asset Management: https://www.fhwa.dot.gov/map21/qandas/qaassetmgmt.cfm

Risk Management and System Resilience

How to Guides

How to Prioritize Ancillary Assets for Inclusion in Your Asset Management Program

Transportation agencies own and operate a multitude of infrastructure assets. Prior to implementing a formal asset management program, assets other than pavements and bridges, or ancillary assets, are often managed reactively. This means actions are only taken when assets are damaged, fail (maintenance), or when they reach the end of their service lives (replacement). Agencies often have little or no inventory or condition data for these assets and have no means of evaluating the impacts of different management approaches or investment strategies. When looking

to incorporate these assets into an asset management program, the cost of collecting all the data, and developing the analysis methods can be beyond the agency's means, particularly in the short term. The FHWA Handbook for Including Ancillary Assets in Transportation Asset Management Programs, provides a framework to support agencies in this effort through the three primary activities:

- **Asset Prioritization** through a strategic review of risk, value, and criticality.
- **Data Needs Assessment** to define needed and desired data and identify opportunities to bundle data collection to reduce cost.
- **Data Management** to ensure data is available to users in the right format and at the right time.

1. Asset Prioritization

Asset prioritization involves a seven-step process that results in assets being grouped into tiers. This approach recognizes that agencies will typically expand their asset management programs in waves or initiatives that involve multiple assets at a time.

Table A.1 Seven-Step Process for Asset Prioritization

1. Get Organized	○ Identify a champion to provide direction. ○ Identify a project manager to push for progress. ○ Assemble a project team that represents all relevant business areas. ○ Incorporate Input from Stakeholders
2. Select Criteria	○ Criteria used to objectively rate assets. ○ Reflect factors important to the agency, e.g.: ▪ Value. ▪ Cost of failure. ▪ Impact of failure on safety or system performance. ▪ Cost or effort to collect data. ▪ Agency readiness to use the data.
3. Establish a Rating System	○ Objective scales are preferred, e.g. 1-5 or 1-10. ○ Yes/no criteria can be used to augment ratings. ○ Subjective ratings may best be used in step 7.
4. Establish Relative Weights	○ Some criteria may be more important than others. ○ Weighting is only appropriate for criteria on a common scale. ○ Additional guidance can be found in NCHRP Report 806, Guide to Cross-Asset Resource Allocation and the Impact on Transportation System Performance.
5. Set Rating Values	○ Include all team members in the process. ○ Workshop initial ratings to develop a consensus for each asset and each criterion.
6. Calculate Scores	○ Final Score = (Rating 1) x (Weight 1) +… + (Rating n) x (Weight n)
7. Develop Priority Tiers	○ Rating scores are just one input. ○ Opportunity to consider subjective ratings.

	○ Can be revised once more information is known on data collection costs and methods.

Source: FHWA. 2017. Handbook for Including Ancillary Assets in Transportation Asset Management Programs. https://www.fhwa.dot.gov/publications/research/infrastructure/19068/19068.pdf

2. **Data Needs Assessment**

Agencies should understand the data required to make investment decisions for an asset class before data collection begins. This will help minimize data collection costs while supporting important business processes.

- **Data elements:** Data Needs are largely dependent on the life-cycle approach adopted for the asset class. Assets managed reactively may only require inventory data, while assets managed by condition may require robust condition data assessed through multiple measures.
- **Data Quality:** Agencies should also consider the quality of data needed to support decision making. It is important to involve stakeholders from all stages of the asset lifecycle, e.g., planning, design, construction, maintenance, and operations, to understand the breath of data needs. For example, location data to support planning efforts, may not need to be as precise as location data needed to support operations.
- **Collection methods:** Data collection techniques continue to evolve and improve quality while reducing cost. However, not all techniques are appropriate for all asset classes. Understanding the available options for each class will allow for opportunities to bundle data collection efforts. Collecting data for multiple asset classes in a single effort can reduce costs and may impact the priority tiers developed in the prior activity.

3. **Data Management**

Understanding how data will be managed and shared will help inform the prior two activities. Additional information on data management can be found in chapter 7 of this Guide.

Methods of Monitoring Financial Risks in a TAMP

An agency's Transportation Asset Management Plan (TAMP) includes a 10-year financial plan that details planned investments to achieve its performance and condition objectives. Included in the financial plan are forecasts of future funding from various funding sources and projected levels of investment needed based on forecasts of asset conditions and repair costs. Proactively managing the uncertainty associated with these 10-year forecasts enables agencies to better understand the risks and identify strategies to reduce the likelihood that future performance objectives will not be met.

1. **The FHWA published a report on identifying and managing financial risks in 2023. It recognized three types of financial risks (Zimmerman et al. 2023):**
    - Uncertainty in Future Revenue: Includes concerns with Federal funding, the availability of adequate State matching funds, and inaccuracies in future revenue projections.
    - Uncertainty in Agency Costs: Includes fluctuations in labor and material costs that impact the cost of work and the level of service that can be provided.

- Other Financial Risks: Includes the agency's ability to design and construct projects on a timely basis, accelerated asset deterioration, and shifts in funding from asset preservation to other strategic objectives (e.g., mobility, freight, resilience).

2. **The FHWA offers four strategies for managing financial risks, as described below:**
    - Strategy 1: Monitor revenue, inflation, costs, and other parameters to help identify situations calling for adjustments to the plan. Suggestions are provided for tracking and interpreting changes in revenue and cost trends.
    - Strategy 2: Develop forecasting and scenarios to evaluate the long-term impacts caused by different situations. Potential outcomes for each scenario can be estimated so that an agency can consider uncertainty and plan possible responses.
    - Strategy 3: Ensure a steady investment in asset preservation to slow asset deterioration and defer the need for costly repairs. This strategy recognizes the importance of ongoing investments in asset preservation to both lower life cycle costs and to control future investment needs.
    - Strategy 4: Explore alternative revenue sources such as discretionary grants, increased vehicle registration fees, bonds, or shifts in revenue between programs. While alternate revenue sources might not be considered by all agencies, being aware of available options may uncover an unexpected revenue stream to help offset shortfalls.

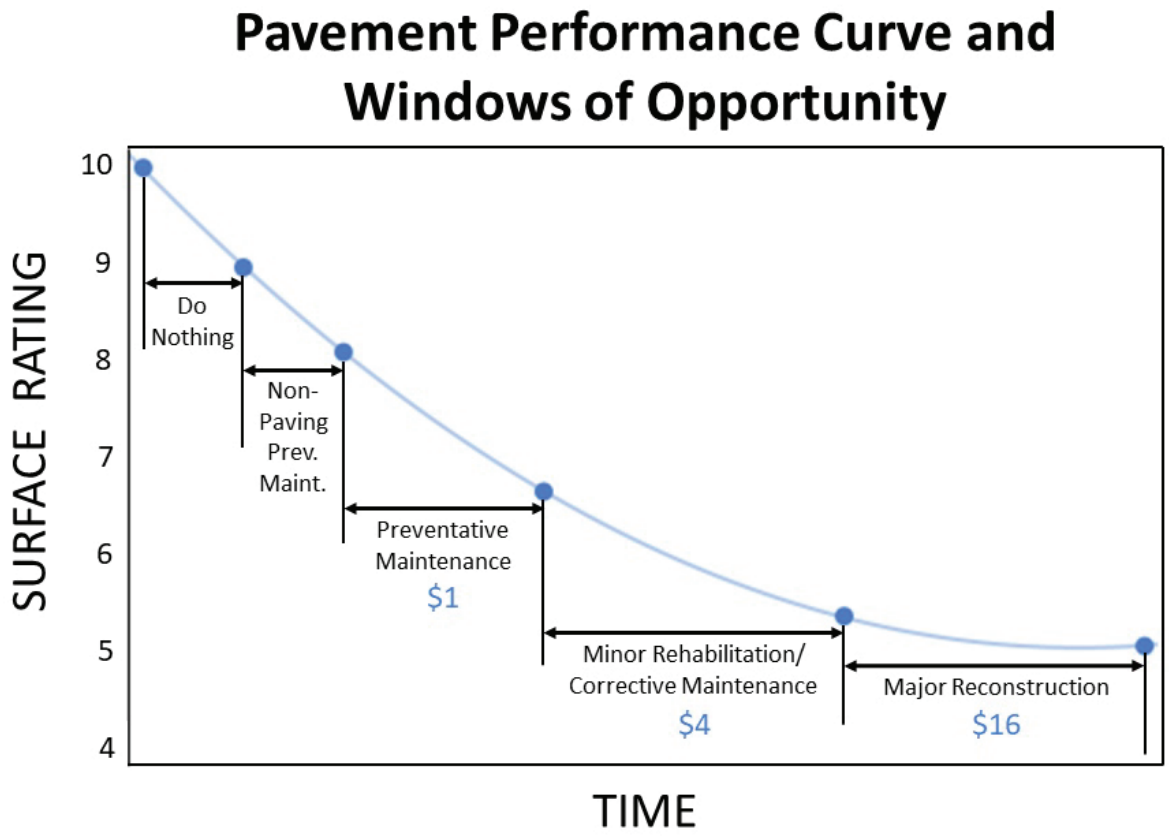
Performance Management

How to Guides

How to Optimize Treatment Timing

Most infrastructure assets deteriorate over time, either through use or weathering, passing through different stages of condition as they age. Assets in more advanced stages of deterioration generally require more extensive and expensive treatments. The period during which a treatment is recommended to address deterioration is referred to as the treatment's "window of opportunity." The following figure, from the 2023 New York State Department of Transportation (NYSDOT) TAMP illustrates windows of opportunity for pavement assets.

Figure A.1 Relationship of Pavement Performance Curve and Windows of Opportunity



Source: 2023 New York State Department of Transportation TAMP.

Windows of opportunity are treatment-specific. As demonstrated in the figure, the window of opportunity for a preventive maintenance overlay is approximately one third the length of a mill and inlay's window. As explained in NYSDOT's TAMP, "The dollar amounts shown in [the figure] represent the ratio of typical costs between treatments that are appropriate in each window of opportunity."

If a treatment is delivered too late, its service life may be significantly shortened. If a treatment is delivered too early, then benefits from prior treatments may be lost. In most cases, delivering a treatment in the beginning of its appropriate window is more efficient than deferring it to the end. Slow delivery may reduce service life while increasing the risk of missing the window entirely. To improve timing, it is necessary to consider the expected duration of treatment development and delivery phases. While some treatments may be delivered within weeks, others may take years of planning, design, and procurement.

Beyond delivering a treatment within the proper window of opportunity, the optimal timing of a treatment can be evaluated through analysis of benefit and cost. There are many different approaches to this benefit-cost (b/c) analysis. Below are two examples of varying complexity.

Remaining Service Life (RSL) Evaluation

Agencies with an understanding of the service lives for its treatments can use the concept of remaining service life to understand the best mix of treatments either at the present time or over

the course of a given planning horizon. The approach is based on the premise that each asset loses one year of service life for each year in service. With some basic information, an agency can determine the best balance of investments across treatment types to minimize future costs. This information typically includes:

1. The appropriate treatment for an asset, given its age or condition.
2. The remaining years in its current window of opportunity.
3. The cost of each treatment.

This approach will often lead to maximizing the application of lighter treatments to avoid the need for more extensive and expensive treatments. The National Center for Pavement Preservation (NCPP) has developed an approach to RSL evaluation for pavements. Additional information, and a free analysis tool can be found on the NCPP website.

Maximizing Benefit Over Time

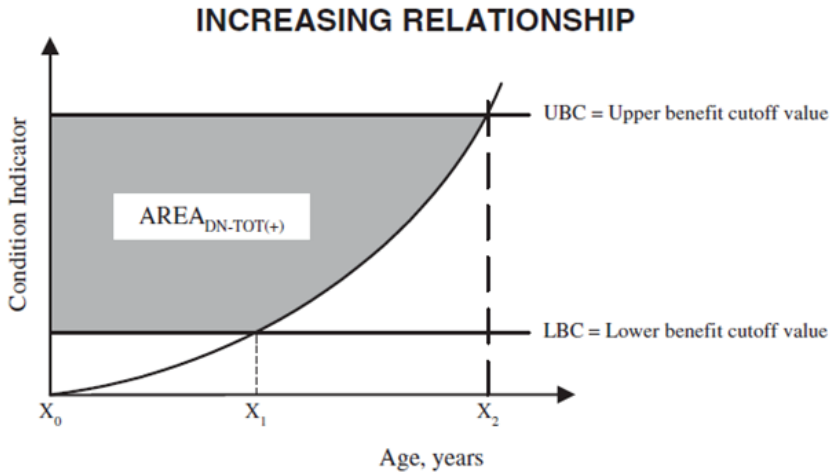
NCHRP Report 523 provides a process for optimizing the timing of pavement preservation using benefit cost analysis. Most commercial asset management systems use some variation of this modeling approach. Although the original research, and the examples below, are based on pavements, it can be applied to other assets. By iteratively performing the following steps at different points in time, an optimal treatment timing can be determined through the model (NCHRP 2004).

1. **Analysis Setup**
   Develop a catalog of relevant treatments, windows of opportunity, and measures of benefit.

2. **Selection of Benefit Cutoff Values**
   Determine thresholds for benefit measures where the agency will see diminishing returns. For example, if the agency determines that an International Roughness Index (IRI) value of 60 inches per mile is excellent, and a given treatment is determined to decrease IRI to 50 inches per mile, there will be no additional benefit modeled for a treatment that improves ride from 60 to 50 inches per mile.

3. **Computation of Area Associated with the Do-Nothing Case**
   Calculate the area bounded by the upper cutoff, lower cutoff, and the expected performance curve. The following figure provides an example of calculating the benefit of a do-nothing treatment for a performance measure that increases with age, e.g., IRI.

Figure A.2 Area Associated with the Do-Nothing Case



Source: NCHRP 2004

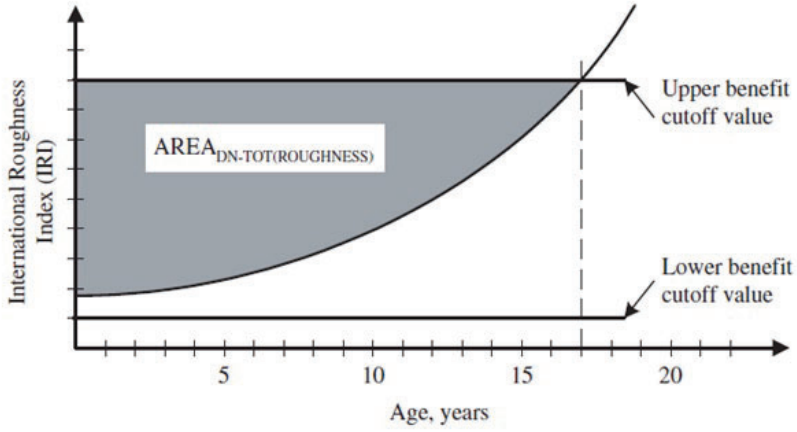
4. Computation of the Overall Expected Service Life of the Do-Nothing Case

Estimate the number of years before the asset reaches a failed condition state without treatment.

5. Computation of Expected Service Life of the Post-Treatment Case

Estimate the number of years before the asset reaches a failed condition state after the treatment. This is illustrated for IRI in the following figure.

Figure A.3 Calculating Remaining Service After Treatment

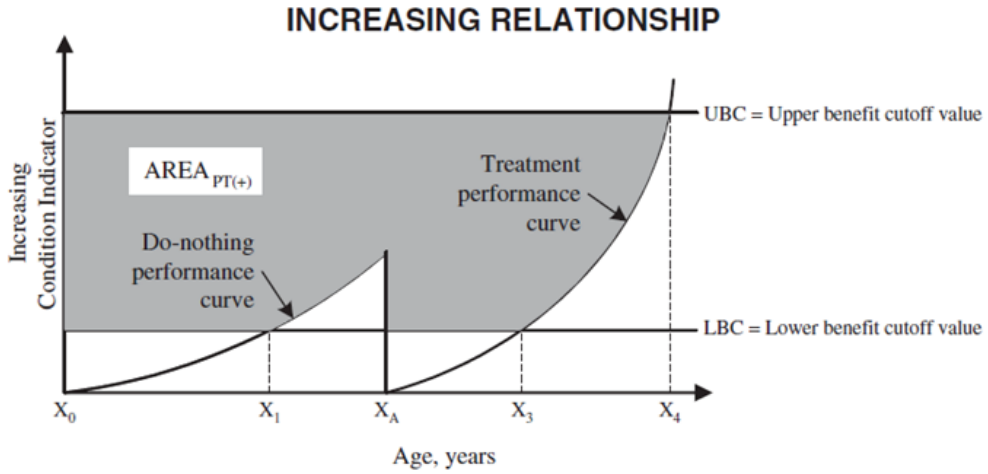


Source: NCHRP 2004

6. Computation of Areas Associated with the Post-Treatment Case

Calculate and compare the post treatment area with the do-noting area to determine the net increase in benefit. A graphical example of this net benefit area is shown in the figure below.

Figure A.4 Comparing Do-Nothing and Post-Treatment Cases



Note: for this case, $X_2 = X_A$ as X_A is less than the projected intersection of the do-nothing curve and the LBC.

Source: NCHRP 2004

Benchmarking Performance Using the FHWA's TPM Dashboards

The AASHTO TPM Portal offers a benchmarking tool that allows state DOTs to compare outcomes and practices with peer organizations (https://benchmarking.tpm-portal.com/). It uses FHWA's TPM dashboards for the data. The platform was originally developed under NCHRP Project 20-118. Three types of analyses are supported:

- Peer analysis, in which an agency can compare performance to its peers.
- Trend analysis, in which an agency can track changes in its performance over time.
- Peer trend analysis, in which an agency's performance can be compared to the performance of its peers over the same time period.

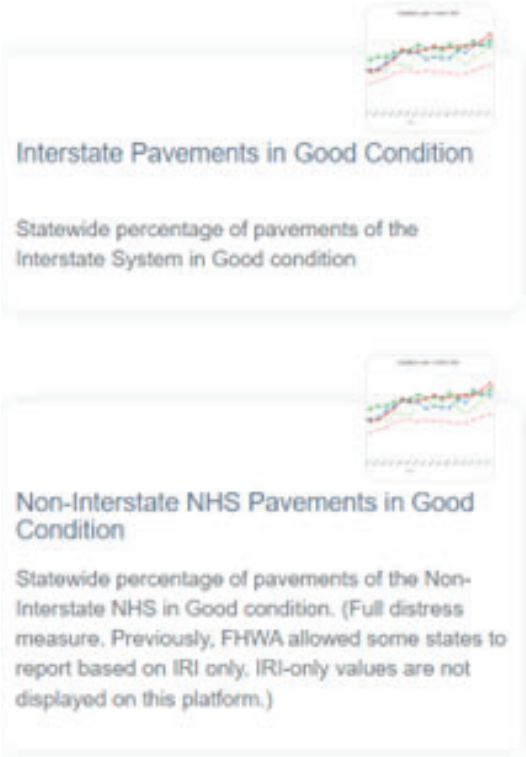
The platform also facilitates the exchange of information between users to support continued improvement.

The TPM platform facilitates benchmarking through a 3-step process.

1. **Step 1: Find Peers**
   Using the Peer Selection tool provided, agencies can select a particular state DOT to compare to or can create a group of peer agencies using available characteristics such as annual budget, mileage, percent of urban miles, AASHTO region, climate, or population.

2. **Step 2: Compare Performance**
   The platform supports the comparison of the FHWA's national performance measures, including any of the safety measures, pavement and bridge condition measures, or system reliability and freight movement measures. Graphs present trends based on the selected performance measures and peer agencies.

Figure A.5 FHWA's National Pavement Performance Measures



3. **Step 3: Learn and Improve**
   Member agencies can use the platform to reach out to peer agencies to learn more about noteworthy practices. The benchmarking network supports sharing of best practices. Users appreciate the ability to contact peers to discuss common issues or to identify strategies for improvement.

Selecting a Method for Setting Effective Performance Targets

Performance management is now an integral part of managing a transportation network. Agencies recognize the importance of selecting effective performance measures and have established processes to monitor system performance regularly to support outreach efforts both internally and externally. One of the challenges to performance management has been setting performance targets from both the technical and policy perspectives. NCHRP Project 23-07 sought to develop and disseminate a guidebook on target setting using the national performance measures for safety, infrastructure condition, and system performance (e.g.travel time reliability, freight reliability, and congestion) to test the recommended methods.

The final report (NCHRP Research Report 1035, Guide to Effective Methods of Setting Transportation Performance Targets) provides guidance on four target setting methods for safety, five methods each for pavement and bridge infrastructure condition, six methods for reliability, and six methods for traffic congestion.

1. **Using infrastructure condition to illustrate the considerations involved in setting performance targets, the following factors are considered:**

- If the agency does not have confidence in its data to support condition projections, the "targeted change" method may be considered.
- If an agency has an effective method of forecasting changes in asset performance over time, a "time-series" trend may be used.
- With a pavement or bridge management system that can evaluate changes in condition under different funding scenarios a "time-series trend plus future funding" approach may be used. This approach may be based on the models included in the pavement or bridge management systems.
- A more advanced version of the prior approach is to use the management system to forecast conditions for multiple funding scenarios and treatment strategies. This is likely the most sophisticated of the target-setting methods for pavement and bridge conditions.

2. **The steps involved in target setting generally included the following:**
    1. Convene stakeholders, including asset managers, planners, program managers, and DOT executives. External participants, such as members from an MPO, may also be included.
    2. Identify the long-term goal so that short-term targets can be established.
    3. Calculate target year performance and evaluate whether the target can be met.
    4. Adjust results if needed until the targeted performance can be met.

Perform a Data Management Maturity Assessment

NCHRP Report 814 provides tools and guidance for transportation agencies wishing to organize and lead a data value assessment. A subsequent research implementation project (NCHRP 20-44(12) produced a detailed facilitators manual providing instruction for potential application of the Report 814 Data Value Assessment.

Agencies can use the steps below to complete a four-phase assessment of their current and desired capabilities for managing data. This assessment methodology can be applied at either an agency-wide or program-specific basis. See the NCHRP 20-44(12) Building Capacity for Self-Assessment of Data Effectiveness for Agency Business Needs Final Report and Facilitators Guide for more detailed instructions.

1. Initial Preparation

Initial assessment preparation is required to scope, plan, and engage the targeted participants in the data management maturity assessment. This assessment methodology can be applied at either an agency-wide or program-specific basis. See the NCHRP 20-44(12) Facilitator Manual provides detailed guidance on each step in the initial Preparation phase.

- Step 1.1 – Engage a Core Planning Team: Identify a small group (3-4 individuals) to support the initial preparation process and assist with future assessment steps.
- Step 1.2 – Scope the Assessment: Decide how far you will want to take the assessment process – will a simple gap analysis be sufficient or do you need a detailed plan to support immediate improvement actions? Identify your targeted participants and establish an assessment timeline.
- Step 1.3 – Develop a Work Plan: Plan out the assessment process with your Core Planning Team – make sure you are aligned with the desired outcomes and consider the workload and schedules of your participants.

- Step 1.4 – Configure the Spreadsheet Tools: Download and configure the Data Value Assessment tools. Use the Group Consensus Building Tool to support group discussion and improvement and action planning activities.
- Step 1.5 – Organize a Kickoff Meeting: Use the Kickoff presentation template to organize a kickoff meeting, addressing the assessment objectives, data value assessment framework and tools, and anticipated next steps. Be sure to leverage your Core Planning Team and consider inviting an executive sponsor to demonstrate agency commitment to the assessment process and outcomes.

2. Value Assessment

Complete the data value process, referring to the detailed guidance provided in the NCHRP 20-44(12) Facilitator Manual for the Data Value Assessment and Consensus Building phase:

- Step 2.1 – Support Individual Assessment (optional step): This optional step allows you to collect individual assessments as a basis for subsequent group discussion. This can be skipped for repeat assessments, expert stakeholders, or small teams.
- Step 2.2 – Develop Group Consensus Building Materials: Consolidate individual assessment responses (if applicable), create a plan for group discussion, and prepare yourself for your facilitation responsibilities.
- Step 2.3 – Organize and Conduct Group Consensus Building Meetings. Plan and execute two (90 minute) group consensus building meetings. As the facilitator, use the Group Consensus Building Tool to capture group discussion outcomes. Aim for weekly meeting to ensure a regular cadence to the assessment process.
- Step 2.4 – Summarize Group Consensus: Prepare high-level summary materials and review, reconcile, and expand upon assessment ratings, comments, and improvement notes and summarize data gaps for each business activity.

3. Improvement & Action Planning

Complete the improvement and action planning process as required to meet your desired assessment outcomes. Refer to the detailed guidance provided in the NCHRP 20-44(12) Facilitator Manual for the Data Value Assessment and Consensus Building phase:

- Step 3.1 – Identify Improvements: Organize a meeting of your assessment team to review and finalize the assessment summary materials and to identify the group's improvement recommendations. Work with the Core Planning Team to refine the assessment summary, and supporting communication materials.
- Step 3.2 – Develop a General Action Plan: As desired, expand upon the gap analysis to document a general action plan intended to address the priorities identified through the assessment process.
- Step 3.3 – Finalize a Detailed Action Plan. As desired, expand upon the general action plan to set specific implementation action leads, set realistic schedules or deadlines for action, and establish and set expectations for progress monitoring and reporting.

4. Assessment Closeout

Complete the assessment closeout process to finalize assessment summary materials and engage key stakeholders and decision-makers to communicate assessment outcomes and initiate implementation next steps:

- Step 4.1 – Develop Assessment Closeout Materials: Create a presentation useful to outline the assessment process, outcomes, implementation recommendations, and next steps.

- Step 4.2 – Organize and Conduct Closeout Meetings: Gather the assessment sponsor, core team members, key decision-makers and management to share the assessment outcomes and confirm understanding and buy-in to the recommended next steps. Encourage questions and feedback from key stakeholders.
- Step 4.3 – Finalize Assessment Summary Materials: Follow up with key stakeholders and subject matter experts to address any outstanding items or issues raised during the assessment closeout. Update and package materials and communicate next steps and key responsibilities.

Evaluate Current Maturity to Support BIM and Identify a Future Target

CRP Special Release 4: Lifecycle BIM for Infrastructure: A Business Case for Project Delivery and Asset Management developed a maturity matrix and supporting spreadsheet tool which provide transportation agencies a framework with which to identify the current level of BIM maturity and to assess opportunities to better integrate BIM within their organizations.

This Organizational BIM Assessment Matrix can be utilized to evaluate current and target desired maturity through a three-step process.

1. **Identify the Planning Timeframe**
   Focus your evaluation on either short-term goals (1-2 year outlook) or on developing a long-term roadmap (5-10 year horizon).

2. **Complete the Maturity Assessment**
   Download the spreadsheet Assessment Matrix tool and work either individually or with targeted stakeholders to enter the Current and Target maturity level for each of the 20 elements.

3. **Summarize and Communicate Results**
   After completing the maturity assessment, use the Summary tab of the tool to view a summary of each of the six BIM Planning Element Areas assessed (Strategy, BIM Uses, Process, Information, Infrastructure, and Personnel). Develop summary materials to communicate current vs. target level and support executive/decision-maker engagement and plan next steps.

Perform a TAM Data Value Assessment

NCHRP Report 956 provides tools and guidance for transportation agencies wishing to assess and improve how they use data and information systems to support their transportation asset management programs. This guidance is also available in a web format in the AASHTO TAM Guide, which provides a six-step approach to assess current practices and improve use of data and information for TAM.

1. **Selecting a Focus**
   Establish a specific scope for the TAM data assessment, following the NCHRP Report 956 guidance to address the known needs and priorities of the agency and sponsoring business or technical area. TAM Data assessments are typically focused on improving a specific asset program or data area. Undertaking an assessment of multiple data areas without narrowing the focus to an individual asset program is not recommended – achieving meaningful results will be impractical at best.

2. **Assessment Planning**

Organize a kickoff meeting to share context, prepare participants for upcoming assessment activities and establish an assessment schedule. Meetings should be kept to a maximum of 90 minutes with 1 meeting per week to allow for preparation and avoid participant fatigue.

3. **Benchmarking and Improvement Selection**
Working with the AASHTO TAM Guide and support TAM Data Assessment Tool, work through the assessment framework to benchmark current and desired performance and identify potential improvements. Coordinate schedules and communicate focus areas prior to individual benchmarking meetings and capture group consensus and supporting notes during the discussion.

4. **Improvement Evaluation (Optional Step)**
If desired, support improvement action planning by evaluating priority improvement actions for implementing challenges and improvement impact and effort, capturing group consensus and supporting notes.

5. **Summarizing and Communicating Results**
After completing the benchmarking, improvement identification and optional improvement evaluation processes, work with the project sponsor and core team to engage executive management and/or other key stakeholders and decision-makers to garner support for implementation priorities and next steps. Prepare summary materials utilizing the guide, supporting tools, and provided presentation templates.

6. **Implementation and Implementation Resources**
As needed, refer to the NCHRP Report 956, AASHTO TAM Data Guide, and supporting case studies, implementation examples, organizational practices and challenges guidance to overcome organizational roadblocks and other barriers or resistance faced during planning and execution of targeted improvement actions.

Maintenance and Preservation

Overview

Maintenance and preservation activities serve vital roles in supporting the lifecycle management of infrastructure assets. Preservation activities are performed to prevent or address asset deterioration, extending the functional life of the asset. Maintenance encompasses a wide range of activities that are delivered at every stage of an asset's life cycle. Some maintenance activities prevent, delay, or correct deterioration or damage to assets. Other maintenance activities are done to ensure assets perform as they were designed.

Neither maintenance nor preservation activities enhance the capacity, strength, or performance of an asset beyond its original design. These actions, nonetheless, significantly enhance the overall performance or condition of the transportation facility. The spectrum of maintenance and preservation activities encompasses strategic planning, the establishment of performance metrics, regular monitoring of asset conditions, data collection and documentation, data storage and management, and the delivery of work.

Key Concepts

Asset Condition

Asset condition measures are fundamental components of transportation asset management. While the specific metric used to assess the condition of each asset can vary greatly, they support common functions within asset management analysis and decision making. Condition measures serve as crucial determinants of an asset's remaining useful service life, performance capabilities, and maintenance needs. They are used to predict when an asset may require maintenance, rehabilitation, repair, renewal, or replacement, enabling agencies to allocate resources efficiently and minimize costly downtime. Moreover, asset condition plays a pivotal role in assessing operational risks associated with asset failure, optimizing maintenance schedules, ensuring regulatory compliance, and evaluating long-term asset strategies, all of which are essential for effective and cost-efficient transportation asset management practices.

Asset Deterioration

Transportation infrastructure deterioration refers to the decline in the physical condition or functionality of transportation assets, such as roads, bridges, railways, and airports, over time due to exposure to factors such as weather, traffic, environmental stressors, and natural wear and tear. It encompasses the deterioration of structural components, surface quality, safety features, and overall operational efficiency.

Life Cycle Management

Life cycle management is a strategic investment approach that carefully considers options such as maintenance, renewal, repair, or replacement throughout an asset's operational lifespan, with the primary goals of optimizing the asset's service life while minimizing risks and costs. This approach relies on data related to asset condition, available treatment alternatives, cost analyses, deterioration patterns, replacement schedules, and other pertinent factors to assess the trade-offs among various investment strategies to optimize the type and timing of treatments.

Life Cycle Management Approaches

Life cycle management encompasses various approaches tailored to different types of assets. Each approach caters to specific asset types and their unique maintenance needs.

- Condition-based management revolves around assessing an asset's condition to predict and preempt failures.
- Interval-based (i.e., cyclical) management is typically applied to operational assets like striping, signs, and guardrails, where condition assessments may be impractical. It relies on time intervals or manufacturer-recommended lifespans to determine when to perform interventions.
- Reactive management defers actions until an asset reaches an unacceptable condition, often reserved for low-value or redundant assets. Defining minimum condition thresholds and ensuring timely response mechanisms are essential for this approach, which is used for assets like fences, lighting, and impact attenuators.
- Lastly, some strategies use risk assessments as direct measures to set objectives, make decisions, or gauge progress, particularly when an asset's condition doesn't directly reflect its performance level, and the broader impact on system performance needs consideration. This approach is prevalent in managing geotechnical assets like slopes.

Maintenance Level of Service

Maintenance Level of Service (MLOS) is a framework used by transportation agencies to systematically assess and manage the condition and performance of diverse assets and features,

such as roadways, bridges, drainage systems, vegetation, and more. The framework allows agencies to compare disparate assessments of condition (e.g., height of turn, pieces of litter present, or sign visibility) on a common scale, by associating each measure to a common scale. Typically, the common scale is a letter-grade rating. This uniform grading system ensures consistency in rating performance across various services and geographic regions and facilitates effective communication with stakeholders through visual representations. MLOS can operate on an outcome-based approach, focusing on maintenance results rather than just budgetary and planning inputs, allowing agencies to predict achievable service levels based on budgetary decisions and adjust maintenance priorities and budgets annually to meet evolving system needs and stakeholder expectations.

Reliability Centered Maintenance

Reliability centered maintenance (RCM) is a systematic approach used to select the most suitable maintenance strategies for complex assets based on safety, operational efficiency, and economic considerations. By analyzing assets from an RCM perspective, agencies can enhance cost-effectiveness, reliability, asset longevity, and risk understanding. Using RCM the asset owner determines the overall approach for establishing the appropriate timing of maintenance treatments, e.g., condition-based, cyclical, or reactive. RCM defines a comprehensive maintenance regimen by preserving critical functions through cost-effective tasks while addressing dominant failure causes.

Implementation Considerations

- Formulate well-defined agency policies and objectives, rooted in strategic planning informed by historical insights, expert assessments, and established agency protocols.
- Establish practices for collecting, managing, and safeguarding asset inventory and condition data.
- Use RCM to establish a lifecycle approach for each asset class.
- Develop specific criteria to assess and report the condition of each asset class.
- Use historical data to develop performance models and expectations to facilitate forecasting and scenario analysis.

How to Guides

Quantifying the Effects of Preservation Treatments on Pavement Performance

NCHRP Report 858 establishes a framework for quantifying the impact of pavement preservation. The framework is rooted in the methodology originally formulated for the Indiana DOT by Ong et al. in 2010. This methodology takes into account two critical factors as shown in figure A.6.

By considering these elements, the framework provides a comprehensive approach to assessing and addressing the impact of treatments on infrastructure longevity and performance. Through these systematic evaluations, the agencies can make informed decisions about the long-term efficacy and sustainability of the chosen pavement treatment.

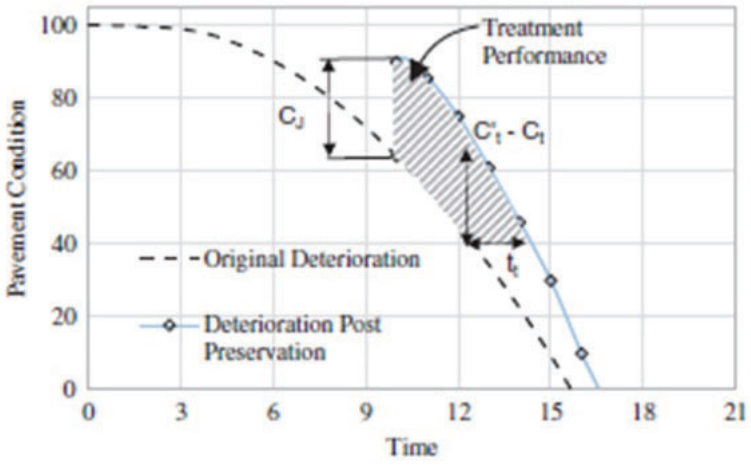
1. **Determine the Initial Condition Jump**

   In Step 1, determine the initial condition jump by evaluating the immediate change in pavement performance resulting from the treatment application. This step serves as a baseline to gauge the treatment's immediate impact on the road's condition.

2. **Determine the Influence**

In Step 2, track the influence of the treatment over time by continuously monitoring the performance of the treated pavement section and comparing it to an untreated control section.

Figure A.6 Effects of Preservation Treatments on Pavement Condition (NCHRP 858)



Life Cycle Planning

Overview

Transportation agencies manage a plethora of infrastructure assets, such as pavements, bridges, drainage structures, intelligent transportation systems, within the right of way of highways. Per Bureau of Economic Analysis estimates, public ownership of highways and streets was valued at around $4.5 trillion in 2021. Overall, this multi-trillion-dollar valuation of highway assets underscores the critical importance of adopting a comprehensive life cycle management approach. Through the implementation of the Transportation Asset Management (TAM) framework, DOTs strategically preserve their investments by applying life cycle management principles to ensure optimal preservation, renewal, and replacement decisions over the asset's life cycles.

Life Cycle Planning (LCP) is an integrated continuous approach to manage assets over their whole life from initial construction to renewal or disposal. Title 23, CFR, Section 515.5, defines LCP as "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." LCP is applied at both asset and program levels: At the asset level, the main objective is to identify an optimal maintenance strategy for the lowest life-cycle costs by selecting the right treatment at the appropriate time under performance and resource constraints. At the program level, the main objective is to create a program of projects that maximizes network performance with given budgetary constraints. In essence, LCP balances cost (investment), risks, and performance to achieve an optimal balance between maximizing service delivery outcomes (e.g., asset condition, performance) and minimizing life-cycle costs.

State DOTs employ a variety of practices for life cycle management that differ among asset classes within an agency and also across various agencies. The extent of maturity in implementing life cycle management practices is influenced by factors, such as data availability, tool utilization, and technological capabilities. Given this diversity, no one-size-fits-all approach to life cycle planning is

feasible. A unified set of principles and high-level processes, that can be universally applied across agencies and assets, irrespective of their varying levels of practice maturity, would serve this purpose.

Key Concepts

Note: These Key Concepts were derived from NCHRP Web-Only Document 365: Implementation of Life-Cycle Planning Analysis in a Transportation Asset Management Framework. Further information is available in the full report.

Recommendations

It is recommended that a Life Cycle Planning Analysis be seamlessly integrated into the Transportation Asset Management Framework through a structured approach involving the following four high-level steps, each of which encompasses multiple detailed work steps.

Setting Up Lifecycle Planning for Both Asset and Network Levels

This high-level step sets up the policies, enablers, and controls for conducting LCP at both the asset and network levels Work tasks under this high-level step include:

1. Select asset classes and subgroups of asset classes. Define homogeneous asset groups by asset families that have similar characteristics, deterioration patterns, and system hierarchy.
2. Establish performance measures, criteria for intervention needs, and life-cycle analysis parameters.
3. Update asset-level histories and forecasts, including condition and inspection data, traffic volumes, truck weights, construction history, crash history, hazard history, and environmental demand. Update condition deterioration models as necessary.
4. Formulate feasible asset-level LCP strategies and network-level LCP scenarios.

Establish Intervention Needs at Asset Level

The primary objective of this step is to identify the timing of the next intervention need.

1. Compare the current condition states against their corresponding performance targets to screen for deficiencies.
2. Forecast the future condition state using appropriate techniques.

Treatment Planning and Selection at Asset Level

The focus is on selecting the “right treatment type at the right time” that results in the lowest practical life-cycle costs.

1. Identify feasible asset-level LCP strategies, including potential treatment types, costs, condition resets, and effectiveness. Select the preferred treatment type using a life-cycle cost-based treatment selection model.
2. Incorporate resilience planning, which includes climate change-induced accelerated deterioration, extreme weather, bridge collision, rock falls, and other stochastic threats, into the treatment selection process.

Develop Network Level Work Program, Conduct Performance Gap Analysis, and Report to Financial Planning (NLCP)

1. Develop an unprioritized list for the work program for the network.
2. Establish objective functions for prioritization (or optimization).

3. Perform prioritization (or optimization) to develop a work program based on funding levels and resource allocation policies.
4. Conduct a performance gap analysis to evaluate the consequences.
5. Revisit the assumptions and rerun prioritization (or optimization) for various scenarios.
6. Select the preferred profile of the work program.
7. Prepare a final, multi-year profile of work program, conditions, and costs as inputs to financial planning.

Implementation Consideration

The implementation considerations recognize three levels of practice maturity:

- *Emerging Level*: This stage involves early enhancements in TAM practices and employs historical life-cycle strategies. However, asset-level life-cycle decisions are not implemented.
- *Strengthening Level*: Notable advancements are made in LCP enablers, utilizing predictive modeling for individual asset assessment. Investment needs across the network are aggregated.
- *Advanced Level*: Here, asset-specific life-cycle decisions are prioritized, incorporating risks and uncertainties into the decision-making process. Treatment choices are modified based on the current asset conditions.

Additionally, an incremental approach for improvement activities is recommended to ensure systematic and manageable progress.

The implementation process entails the following high-level steps:

- Establishing a steering committee is essential for effective implementation. This committee's primary function is to ensure alignment with business goals, allocate resources, support implementation, approve improvements, and monitor progress. It includes key decision-makers, asset program managers, and engineering experts familiar with asset behavior. Representation from other agency divisions can address common gaps in life-cycle analysis. Outreach strategies like workshops and surveys can aid engagement with stakeholders.
- Conducting a benchmark analysis involves internally assessing the current LCP approach, processes, and capabilities, determining their maturity levels, and identifying improvement opportunities. The agency analyzes LCP practices for selected asset classes, prioritizing based on AASHTO TAM Guide criteria, reviewing current practices, evaluating enabler maturity aligned with business objectives, gaining insights into gaps and potential improvements, and identifying enhancement opportunities for prioritization.
- Developing a work plan involves the agency detailing current and desired capabilities, activities, sequencing, costs, schedule, and mitigation following the prioritization of improvement actions. The agency conducts an impact assessment on draft products to evaluate effects and identify errors. Comparing the outputs of proposed changes with current capabilities ensures explainable differences. After each improvement, the agency documents procedures, ensures quality, updates relevant sections of guidance, and initiates rollout.
- Managing change entails securing of internal buy-in, forming a steering committee for coordination, executing a communications plan, establishing standardized procedures, providing necessary training, and consistently monitoring progress.

How to Guides

How to Relate Lifecycle Management to the Customer Experience

Performance measures and levels of service for life cycle management are commonly related to physical asset conditions. While these measures are essential in determining the most cost-effective strategies for identifying treatments and their timing, they often have little or no relationship to how highway users experience the network. This is because user experience is typically related factors such as the following, and not asset condition:

- Sensory input such as ride quality, appearance, and noise.
- Operational factors such as delays or detours.
- Safety factors such as friction or visibility.

1. **Identify condition measures or indicators that relate to customer experience:**

Relating lifecycle management to customer experience starts with identifying the measures of performance that quantify these factors related to what customers feel or how well the system meets customer needs. The relationship between the measure and customer experience may be direct or indicate a risk of impacts. Indicators may be based on condition data or inventory data.

- Measures that are directly related to customer experience are typically related to something customers sense, i.e., see, hear, or feel.
- Measures indicating a threat to operations or safety. Some condition measures may indicate a risk of impacting user experience. For example, a scour-critical bridge or substandard guardrail section may not directly impact the experience to users. However, the presence of those conditions poses a significant risk to the safe operation of the system. These include:
  - Condition thresholds that indicate a significant risk of asset failure.
  - The presence of elevated threat to an assets service life, e.g., scour critical.
- Asset features that do not meet current requirements for operational purposes. In addition to measures, some features may also indicate a risk to safety or operations. This may include appurtenances that no longer meet regulations, or assets that risk failure due to no longer meeting design standards, e.g., undersized culverts.

2. **Establish thresholds for considering action for each identified measure or indicator:**

For measures this is typically set to the point at which the measure indicates failure or imminent risk of failure. For indicators, the threshold is binary in that either an unacceptable indicator is present, or it is not. The threshold may vary based on specific roadway attributes, e.g., speed limit, functional class, surrounding land use, or other factors, not directly related to the asset itself.

3. **Identify actions or treatments that can prevent, delay, or mitigate an asset from exceeding the identified thresholds:**

Remediation of unacceptable conditions are typically made through repairs, replacement, or enhanced monitoring of the asset. Exact treatments will vary based on the asset class.

4. **Incorporate measures, thresholds, and treatments into asset management analyses:**

Measures, thresholds, and indicators can be incorporated into asset management systems to support deterioration modeling and treatment selection. Unit costs may need to be developed to support benefit/cost analysis or other means of prioritization.

5. **Monitor Conditions:**

As part of continual improvement, the measures, and indicators should be incorporated into ongoing data collection efforts. Agencies should also monitor the performance of treatments. As new data is collected, it can be used to improve the asset management tools and analyses.

6. **Engage with Stakeholders:**
As the agency works to better consider user experience, continued dialogue with user groups can provide helpful feedback on these efforts. Not all customers have the same needs of the system, so it is important to work with as broad a coalition of stakeholders as possible. Outreach can be performed through direct surveys via websites or kiosks or can be performed through interactions with industry organizations.

Financial Stewardship

Overview

In this guide and in the context of TAM, the term 'financial stewardship' refers to a set of practices for responsibly administering public funds to make progress towards TAM goals. One key financial stewardship practice is to develop strong alignment between transportation investments and priorities, focusing on how investments drive performance measures in various strategic goal areas. A related practice is to link an agency's TAM financial plan and life cycle strategy, with the financial plan supporting the life cycle strategy. Also, as the stewards of public assets, good financial stewardship requires a level of transparency to the public about decision-making and resource allocation. Asset valuation and related measures can help communicate how the agency decisions impact the transportation network and ultimately the users.

Aligning transportation investments with priorities is a fundamental element of financial stewardship. An agency must first establish clear goals and objectives that address the challenges of their state, developing these priorities based on research and stakeholder feedback and defining them in a long-range plan. Progress toward each objective may be measured using multiple performance measures. In the capital planning process, the key is to allocate funding according to goal areas or objectives, directly linking the priorities with investment decisions. At a more granular level in the STIP, ideally projects would be tagged by priority or performance measure, and the agency could predict how certain investments would impact future performance. Thus, by aggregating expected spending, the agency could estimate future performance and progress towards the goal areas. An agency would then be able to adjust investments to achieve the desired performance outcomes across the network.

Another element of financial stewardship is integration of an agency's financial plan and life cycle strategies. The financial plan should include all funding reasonably expected to be available for asset management over the plan period, while the life cycle strategies represent the collection of treatments and costs over the life cycle of an asset class. By applying the available funding from the financial plan to deterioration models and treatment options, an agency can identify the ideal life cycle plan for an asset class. In addition, the financial plan can include funding for activities to mitigate risks identified in the life cycle of an asset. Linking the financial plan and life cycle plans helps an agency maximize asset life at minimum cost, resulting in efficient use of public funds.

Asset valuation can be a valuable tool for financial stewardship by providing a clear summary of an agency's assets and demonstrating fiscal responsibility through related performance measures. Asset value is a simple way to measure an agency's inventory and helps provide context for all other financial figures related to asset management. For example, $100 million in capital

investment represents only 1% of a $10 billion network, but 20% of a $500 million network. In addition, performance measures related to asset value can help measure the effectiveness of a TAM program and investments. An asset sustainability ratio (ASR), the ratio of annual asset expenditures to the cost to maintain current value, summarizes trends in asset spending and can indicate where an agency is investing sufficiently to maintain asset value and where an agency needs additional investment. A similar measure is the Asset Funding Ratio (AFR), the ratio of planned TAM investments to the investments required to achieve a desired SGR over a period of time. The AFR indicates whether an agency is investing sufficiently to achieve the desired SGR. A benefit of these measures is that they can be used to compare across assets, systems, and agencies.

Key Concepts

Asset Funding Ratio

The ratio of asset preservation, rehabilitation and replacement funding planned over a 10-year period to the total funding required over the same period to achieve and maintain the agency's desired state of good repair.

Note: This definition was derived from the web version of NCHRP Web-Only Document 335: A Guide to Computation and Use of System Level Valuation of Transportation Assets. More detailed information on asset valuation is available in the full NCHRP Report.

Asset Sustainability Ratio

The ratio of annual asset expenditures, omitting improvements, to the cost to maintain current value.

Note: This definition was derived from the web version of NCHRP Web-Only Document 335: A Guide to Computation and Use of System Level Valuation of Transportation Assets. More detailed information on asset valuation is available in the full NCHRP Report.

Asset Valuation

The process of calculating asset value.

Asset Value

The discounted stream of future benefits that the asset is expected to yield.

Note: This definition was derived from the web version of NCHRP Web-Only Document 335: A Guide to Computation and Use of System Level Valuation of Transportation Assets. More detailed information on asset valuation is available in the full NCHRP Report.

Financial Plan

A plan that describes the sources of an organization's funds and their planned uses of funds over time.

Financial Stewardship

Responsible management and administration of public funds to maintain the transportation network and deliver on transportation goals.

Life Cycle Planning

A process to estimate the cost of managing an asset class, or asset sub-group over its life with consideration for minimizing cost, while preserving or improving the condition (23 CFR 515.5).

Life Cycle Strategy

A standard, documented approach, resulting from LCP, that applies maintenance, preservation, and capital investment actions at each appropriate stage of the asset life cycle to maximize asset performance with available funding.

Implementation Considerations

- **Align Investments and Priorities**
  - Identify transportation goals and objectives
  - Allocate funding according to transportation goals and objectives
  - Link projects to performance measures
  - Estimate future performance based on resource allocation
  - Adjust investments to achieve desired performance outcomes
- **Linking Lifecycle Planning and Financial Planning**
  - Define funding available for asset management
  - Develop deterioration models and identify treatments and costs for each asset class
  - Identify asset risks
  - Apply available funding to deterioration models and treatments to identify optimal life cycle strategies
- **Asset Valuation**
  - Define analysis scope
  - Establish initial value
  - Determine treatment effects
  - Calculate depreciation
  - Calculate value and supporting measures
  - Communicate and apply the results

Data Management, Analytics & Visualization

Overview

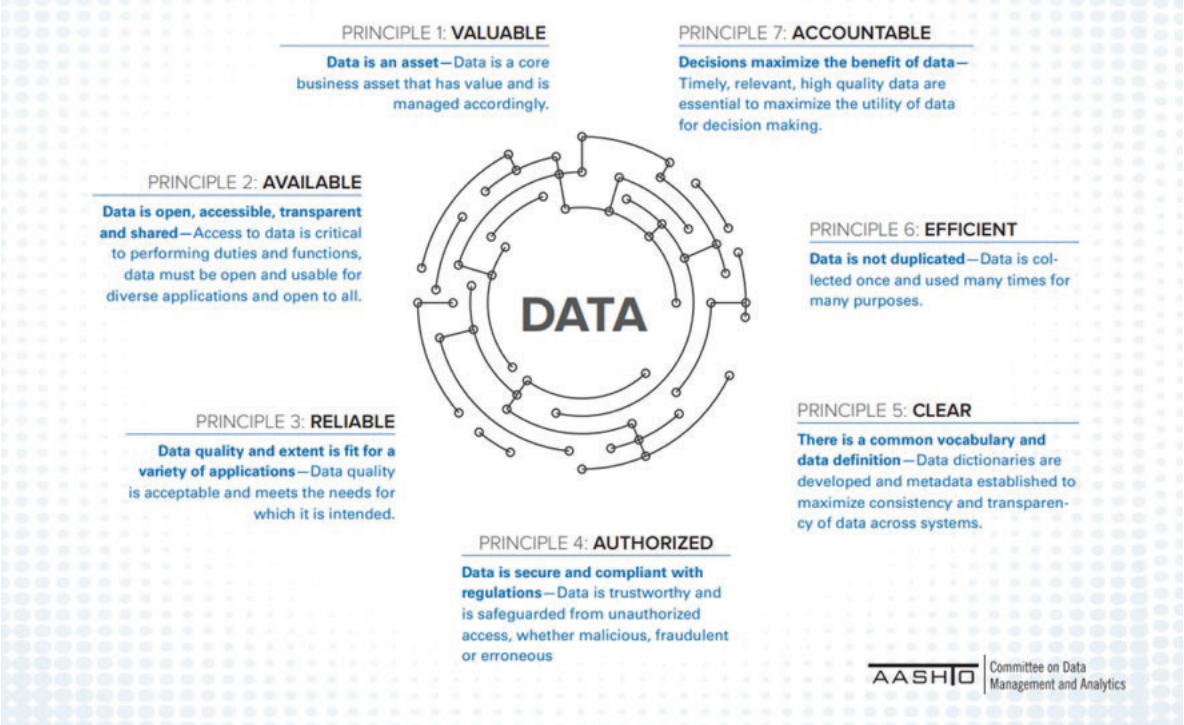
Transportation asset management is by its nature a data intensive activity. State DOT's and other transportation agencies are facing increasing pressures to do more with their limited TAM resources. Whether you want to monitor data more effectively, bolster your data collection system, advance your data modeling, or improve your data-driven communication, you can find what you need here.

Defining Data Management

Data management is the set of activities carried out to manage data across its lifecycle. Data management activities include data governance, planning and specification, data collection and documentation, data organization and storage, data sharing and use, as well as data disposition.

To support robust data management, AASHTO has established a set of seven Core Data Principles. You are encouraged to consider and adopt these principles as you work to advance your agency's data management and use.

Figure A.7 AASHTO's Seven Core Data Principles



As DOT TAM programs have grown increasingly complex and data rich, the need for effective data analysis and visualizations has never been greater. Data analysis and visualizations are integral to how a modern TAM program drives results and decisions and shares insights with stakeholders. These practices have also never been more accessible; many DOT's are integrating powerful, configurable business intelligence and analytics tools into regular use across their agencies. However, crafting succinct, engaging, powerful analytics and illustrations is a challenge that is not solved by data and technology alone, effective practices are required to recognize your audience and purpose, to select an appropriate visualization type, and deliver an effective, easily interpreted topic.

Implementation Considerations

TAM practitioners have a vital role to play in their agency's data management programs and processes. As leaders and subject matter experts in critical agency business areas, you should partner with data program leadership and technical staff to support data value and use throughout its lifecycle. Key areas for business attention include:

- Data Specification. Prepare for new or adjusted databases with consideration of how data will be used, paying attention to ensure you can provide precise, unambiguous data specifications, aligned with agency data standards. Also, avoid duplication of data that is already collected elsewhere.

- Metadata Management. Coordinate with technical staff to document the business and technical context of your data, necessary to support data understanding.
- Data Security Management. Help prevent unauthorized access to or use of data by documenting intended uses of your data and identifying private, confidential or otherwise sensitive data partnering with technical staff to ensure appropriate access controls.
- Data Quality Management. Work to ensure data is fit for purpose, defining business rules for collection, quality processing, and use, measuring quality, and planning for improvement.
- Reference and Master Data Management. Establish and use authoritative sources for shared data.
- Data Integration. Combine data from authoritative sources, in alignment with acceptable uses, to support analysis, reporting and decision-making. Provide clear requirements for technical staff who support extract, transform, and load scripts, and double check that outcomes are meaningful.
- Data Retention Planning. Keep data for its useful life and as required, but eliminate unnecessary data when it is no longer useful.
- Data Use. Be cognizant of good data analysis and visualizations, ensuring data is used appropriately and the intent and meaning of analytics and illustrations are clear to targeted audiences.

How to Guides

Evaluate Return on Investment for BIM

CRP Special Release 4: Lifecycle BIM for Infrastructure: A Business Case for Project Delivery and Asset Management provides a framework for calculating the return on investment for adopting BIM.

The BIM ROI Workbook and User Guide are intended to help transportation agencies understand the business case for investing in BIM. Agencies can perform two-levels of analysis using this tool: 1) Default Analysis – a quick ROI analysis based on rule-of-thumb data; or 2) Detailed Analysis – an in-depth ROI analysis specific to the agency's context and including all quantifiable benefits and costs identified in the study.

There is a three-step process required to utilize the tool:

1. **Start**
   Download the BIM ROI Workbook and Guidance and use it to fill out User Inputs. Update default values for Staffing, Benefits, Costs, and parameters data as desired for agency specific analysis.

2. **Results Summary**
   Review the Results Summary and/or ROI Results Detailed sheets for key summary metrics and total discounted benefits of BIM adoption. Iterate as necessary to ensure meaningful results for your agency and context.

3. **Summarize and Communicate Results**
   Utilize the results to develop and support engagement of executive management or other decision-makers to make the business case for BIM adoption. Consider use of other guidance and tools by the CRP Special Release (such as the BIM Maturity Assessment) provided to enhance messaging and planning of next steps.

Perform a Data Value Assessment and Develop a Data Value Improvement Action Plan

NCHRP Report 814 provides tools and guidance for transportation agencies wishing to organize and lead a data value assessment. A subsequent research implementation project (NCHRP 20-44(12) produced a detailed facilitators manual providing instruction for potential application of the Report 814 Data Value Assessment.

Agencies can use the steps below to complete a four-phase assessment of their current and desired capabilities for managing data. This assessment methodology can be applied at either an agency-wide or program-specific basis. See the NCHRP 20-44(12) Building Capacity for Self-Assessment of Data Effectiveness for Agency Business Needs Final Report and Facilitators Guide for more detailed instructions.

1. **Initial Preparation**

Initial assessment preparation is required to scope, plan, and engage the targeted participants in the data management maturity assessment. This assessment methodology can be applied at either an agency-wide or program-specific basis. See the NCHRP 20-44(12) Facilitator Manual provides detailed guidance on each step in the initial Preparation phase:

- Step 1.1 – Engage a Core Planning Team: Identify a small group (3-4 individuals) to support the initial preparation process and assist with future assessment steps.
- Step 1.2 – Scope the Assessment: Decide how far you will want to take the assessment process – will a simple gap analysis be sufficient or do you need a detailed plan to support immediate improvement actions? Identify your targeted participants and establish an assessment timeline.
- Step 1.3 – Develop a Work Plan: Plan out the assessment process with your Core Planning Team – make sure you are aligned with the desired outcomes and consider the workload and schedules of your participants.
- Step 1.4 – Configure the Spreadsheet Tools: Download and configure the Data Value Assessment tools. Use the Group Consensus Building Tool to support group discussion and improvement and action planning activities.
- Step 1.5 – Organize a Kickoff Meeting: Use the Kickoff presentation template to organize a kickoff meeting, addressing the assessment objectives, data value assessment framework and tools, and anticipated next steps. Be sure to leverage your Core Planning Team and consider inviting an executive sponsor to demonstrate agency commitment to the assessment process and outcomes.

2. **Value Assessment**

Complete the data value process, referring to the detailed guidance provided in the NCHRP 20-44(12) Facilitator Manual for the Data Value Assessment and Consensus Building phase:

- Step 2.1 – Support Individual Assessment (optional step): This optional step allows you to collect individual assessments as a basis for subsequent group discussion. This can be skipped for repeat assessments, expert stakeholders, or small teams.
- Step 2.2 – Develop Group Consensus Building Materials: Consolidate individual assessment responses (if applicable), create a plan for group discussion, and prepare yourself for your facilitation responsibilities.
- Step 2.3 – Organize and Conduct Group Consensus Building Meetings. Plan and execute two (90 minute) group consensus building meetings. As the facilitator, use the Group

Consensus Building Tool to capture group discussion outcomes. Aim for weekly meeting to ensure a regular cadence to the assessment process.

- Step 2.4 – Summarize Group Consensus: Prepare high-level summary materials and review, reconcile, and expand upon assessment ratings, comments, and improvement notes and summarize data gaps for each business activity.

3. **Improvement & Action Planning**

Complete the improvement and action planning process as required to meet your desired assessment outcomes. Refer to the detailed guidance provided in the NCHRP 20-44(12) Facilitator Manual for the Data Value Assessment and Consensus Building phase:

- Step 3.1 – Identify Improvements: Organize a meeting of your assessment team to review and finalize the assessment summary materials and to identify the group's improvement recommendations. Work with the Core Planning Team to refine the assessment summary, and supporting communication materials.
- Step 3.2 – Develop a General Action Plan: As desired, expand upon the gap analysis to document a general action plan intended to address the priorities identified through the assessment process.
- Step 3.3 – Finalize a Detailed Action Plan. As desired, expand upon the general action plan to set specific implementation action leads, set realistic schedules or deadlines for action, and establish and set expectations for progress monitoring and reporting.

4. **Assessment Closeout**

Complete the assessment closeout process to finalize assessment summary materials and engage key stakeholders and decision-makers to communicate assessment outcomes and initiate implementation next steps:

- Step 4.1 – Develop Assessment Closeout Materials: Create a presentation useful to outline the assessment process, outcomes, implementation recommendations, and next steps.
- Step 4.2 – Organize and Conduct Closeout Meetings: Gather the assessment sponsor, core team members, key decision-makers and management to share the assessment outcomes and confirm understanding and buy-in to the recommended next steps. Encourage questions and feedback from key stakeholders.
- Step 4.3 – Finalize Assessment Summary Materials: Follow up with key stakeholders and subject matter experts to address any outstanding items or issues raised during the assessment closeout. Update and package materials and communicate next steps and key responsibilities.

Equity

Overview

Equity in transportation can be broadly defined as the equitable distribution of benefits and costs, considering whether this allocation is both fair and appropriate. Transportation planning decisions wield significant and diverse impacts on equity, as transportation agencies frequently encounter the challenge of trading off between candidate projects, each linked to multiple competing objectives while grappling with limited resources.

These trade-offs yield outcomes that may exhibit positive effects on certain objectives or measures, yet simultaneously, generate negative consequences for other objectives or measures. For instance, augmenting funding for new construction aimed at enhancing mobility for a specific

population segment could trigger a chain reaction, resulting in diminished resources for transit initiatives that address diverse objectives and metrics for a separate segment of the populace. Consequently, this scenario can lead to a situation where one population segment reaps benefits, while another perceives no tangible advantages from the decisions made.

Historically, investments in transportation have primarily centered around enhancing infrastructure conditions and upholding levels of safety and mobility. However, these decisions often neglected to account for the wide-ranging impacts linked to diversity, equity, and inclusion (DEI), operating within limited considerations or even entirely without such considerations. In more recent times, a shift has occurred, marked by various endeavors to incorporate an array of pertinent and influential performance metrics. These metrics encompass areas like socioeconomic implications, sustainability, accountability, transparency, and innovation, all of which now play pivotal roles in the decision-making process. What stands out is the growing realization among agencies that certain transportation planning and programming practices can yield adverse effects on marginalized communities.

At the core of transportation's mission lies the aspiration to foster a tapestry of social and economic opportunities. This lofty objective hinges on the provision of access that is not only widespread but also characterized by equity. This translates to ensuring that all segments of the population, especially those historically marginalized, gain ready access to transportation options that are both affordable and dependable. The bedrock of this endeavor is the identification and fulfillment of the specific needs of the communities being served. USDOT is actively working towards more equitable transportation by elevating equity as one of its six strategic goals.

Key Concepts

Equity Defined

Executive Order 13985 provides the following definition for equity:

“The term equity means the consistent and systematic treatment of all individuals in a fair, just, and impartial manner, including individuals who belong to communities that often have been denied such treatment, such as Black, Latino, Indigenous and Native American, Asian American, Native Hawaiian, and Pacific Islander persons and other persons of color; members of religious minorities; women and girls; LGBTQI+ persons; persons with disabilities; persons who live in rural areas; persons who live in United States Territories; persons otherwise adversely affected by persistent poverty or inequality; and individuals who belong to multiple such communities''. – Executive Order 13985 (2021).

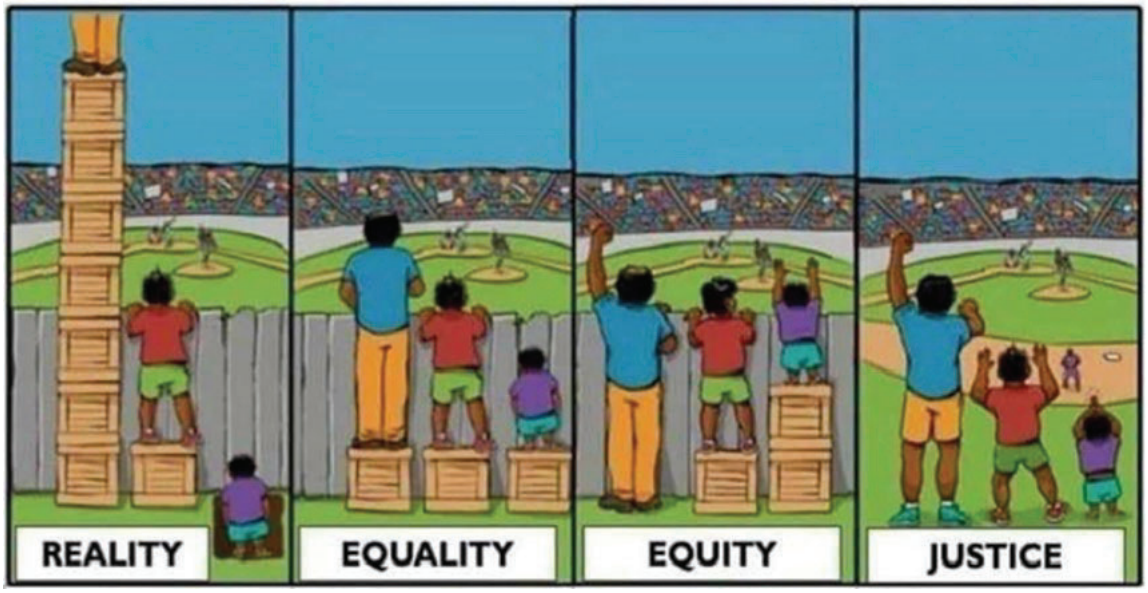
Additionally, the term “underserved populations is defined as:

“… those populations as well as geographic communities that have been systematically denied the opportunity to participate fully in aspects of economic, social, and civic life, as defined in Executive Orders 13985 and 14020”. – Executive Order 13985 (2021).

In transportation, the notion of equity in the broad sense has been applied to encompass a diverse range of populations. In certain instances, it signifies environmental justice, often relating to low-income and minority populations. It is crucial to discern the distinctions between equality, equity, and justice. These concepts are interrelated terms that pertain to distinct notions within the realm of fairness and social equilibrium.

- ***Equality*:** this concept centers around the idea of treating everyone the same, regardless of their circumstances or needs. In an equality-based approach, everyone is given the same resources, opportunities, and support without considering individual differences or historical disadvantages. This approach could perpetuate inequality in cases where certain group need additional resources.
- ***Equity*:** is about recognizing that different individuals or groups have different needs, and it involves distributing resources and opportunities to ensure fairness. In an equity-based approach, individuals are provided what they need to have an equal chance at success, taking into account their unique circumstances. This approach acknowledges and aims to rectify historical disadvantages and systemic barriers that have led to disparities in society.
- ***Justice*:** this concept encompasses a broader notion of fairness and addresses deeper structural issues. It involves rectifying historical injustices and ensuring that systems, laws, and policies are designed to treat all individuals and groups fairly and equitably. Justice goes beyond simply providing equal or equitable treatment; it seeks to dismantle systemic barriers that perpetuate inequality and discrimination. Social justice seeks to achieve a state where all individuals have the opportunity to reach their full potential, irrespective of their background.

Figure A.8 Comparing Reality, Equality, Equity, & Justice



Source: A collaboration between Center for Story-based Strategy & Interaction Institute for Social Change. Original illustration by Agus Maguire

Approach to Equity in the United States

The United States has embraced an equity-oriented strategy in shaping its transportation infrastructure, underscored by an impact-driven framework. In this strategy, funding allocations are purposefully structured to avert the uneven distribution of benefits. This approach is underpinned by regulations and legislative measures crafted to rectify gaps and oversights that have historically led to imbalanced benefit distributions. For instance, the enactment of Title VI stands as an illustration of this approach. Title VI was put into effect to directly tackle challenges stemming from

the exclusion of marginalized populations from decision-making processes that receive support from Federal funds.

Over the span of years, a series of Executive Orders emanating from the Presidents of the United States have notably built upon the foundational principles entrenched within the Civil Rights Act. These executive directives have been instrumental in guiding Federal agencies to incorporate policies and procedures that bear direct relevance to civil rights as they execute their operational functions. A prominent illustration of this proactive approach can be found in Executive Order 12898, titled "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations." Originating in 1994, this pivotal order explicitly charges each Federal agency with a decisive task: to engrain the pursuit of environmental justice within its very mission. This mandate entails the identification and responsible addressing of disproportionately elevated and adverse human health or environmental impacts stemming from the agency's programs, policies, and activities on minority populations and low-income segments. Moving along the timeline, the trajectory of progress continues.

A more recent milestone came in the form of Executive Order 13985, inked in 2021 with the resolute aim of propelling forward racial equity and extending robust support to marginalized communities via the auspices of the federal government. On 2021, the USDOT took a progressive stride by issuing a revamped Environmental Justice Order, officially designated as DOT 5610.2C (USDOT 2021). This document introduces a spectrum of enhancements aimed at refining internal management practices. Within its comprehensive scope, the Order establishes guidance for each Operating Administration and the responsible officials for other DOT components to “determine whether programs, policies, or activities for which they are responsible will have an adverse human health or environmental effect on minority and low-income populations and whether that adverse effect will be disproportionately high” (USDOT 2021).

Transportation Inequalities

Transportation inequity can be broadly categorized into three interrelated types:

- **Spatial or Geographic Inequities**: Rooted in the unequal distribution of transportation and infrastructure across different geographical groups. It is often related to historical discrimination or rural underinvestment.
- **Modal Inequity**: revolves around disparities in the availability, accessibility, and quality of different transportation modes. Certain communities might have limited access to public transit, walking paths, or cycling lanes, forcing them to rely on less efficient or more expensive modes of transportation. Modal inequity can disproportionately affect individuals who cannot afford private vehicles or those with mobility challenges.
- **Social and Economic User Inequities**: This type of inequity is closely tied to socioeconomic factors. Marginalized and vulnerable groups, such as individuals with disabilities, racial and ethnic minorities, women, members of religious minorities, older adults, youth/children, LGBTQ+ people, low-income people, and/or essential workers, might experience discrimination or safety concerns.

These three categories of transportation inequity are interconnected and often reinforce each other. Addressing transportation inequity requires comprehensive strategies that consider the unique challenges faced by different communities, prioritize accessibility, and promote sustainable and inclusive transportation solutions. Equitable transportation outcomes occur when users’ needs are met, and one group is not overburdened with negative project impacts.

Implementation Considerations

Integrating equity frameworks in transportation requires a systematic approach that addresses disparities and promotes fairness, inclusivity and community engagement. The following presents steps that could be considered:

1. Define Equity: Defined to clarify the meaning and intent behind the words we use to describe transportation equity in the context of your organization.
2. Equity in Policies and Planning Processes: Embed equity considerations into transportation policies, plans, and guidelines to ensure all decisions consider fairness and inclusivity.
3. Establish clear equity objectives: Set objectives that address disparities and align with the needs of underserved communities, as well as with the strategic goals of the agency.
4. Identify Measurable Criteria: Define performance measures or indicators that are both objectively measurable and conducive to achieving equity goals.
5. Identify performance gaps (inequities): Collect data to identify existing disparities in transportation access, services, and outcomes among different communities. Conduct equity analyses to evaluate how transportation policies, plans, and projects impact various groups, considering factors such as income, race, gender, age, and ability. Furthermore, ensure that evaluation is integrated into planning processes, prioritization schemes, and other related procedures.
6. Engage community: Solicit feedback from underserved communities and respond to their interests by crafting investment strategies with equity goals at the forefront. Employ diverse engagement tactics, including public meetings, surveys, focus groups, and online platforms, to ensure that all voices are heard.
7. Implement Equity Considerations: Continuously assess the impact of implemented initiatives on reducing disparities and enhancing access for marginalized communities. Identify areas for improvement in the process.

How to Guide

Incorporating Equity into Resource Allocation

This guide summarizes the steps involved in performing an equity analysis to support the resource allocation process. Agencies can use this guide to help inform their approaches for measuring, analyzing and ensuring equity in decision-making. Note that this guide is a summary of the materials presented in TCRP Report 214, Equity Analysis in Regional Transportation Planning Processes. This report has additional details on each of the steps described here. Also, Section 2.6.2 of this document discusses basic concepts and considerations in evaluating equity.

Prior to and throughout performing the steps described here, an agency should engage its stakeholders in the process of defining and evaluating equity. TCRP Report 214 describes this overarching step as “Lay the Foundation with Public Engagement” and Section 2.6.2 discuss this consideration.

1. **Step 1. Identify Populations for Analysis**

Identify the groups for which equity will be analyzed. An analysis must include required populations and population groups. Federal regulations related to Title VI and Environmental Justice identify specific groups for which certain types of analyses are required, such as in development of an MPO’s long range plan. States and local agency may have additional

requirements regarding populations and groups for which equity should be analyzed. Required groups may be defined by race, ethnicity, income, English proficiency, or other factors.

An agency may wish to include other underserved persons or communities in its analysis of equity in TAM. For instance, it may be desirable to perform an analysis specific to persons with disabilities if evaluating pedestrian infrastructure.

2. **Step 2. Identify Needs and Concerns**

In this step the agency should gather input on what specific needs and concerns should be considered in the equity analysis. TCRP Report 214 describes the following sub-steps:

- Gathering input from the populations included in the analysis.
- Assessing the burdens imposed by the transportation system.
- Assessing access to the benefits of the transportation system.
- Validating the findings using stakeholder input.

For a TAM-related analysis an agency should consider, at a minimum, differences in asset condition between different populations. Typically, TAM investments are not assumed to change accessibility to the transportation network. However, it may be the case that if assets are allowed to deteriorate, they may fail or impede access to the transportation system.

3. **Step 3. Measure Impacts of Proposed Agency Activity**

The next step is to measure impacts of agency activity. TCRP Report 214 describes the following sub-steps for this step:

- Select indicators.
- Differentiate project types for evaluation.
- Measure outputs.
- Measure outcomes.
- Document the task, outputs, and outcomes.

For a TAM-related analysis it is recommended that an agency establish performance measures that support this step, including, but not limited to, measures of asset condition. An agency may wish to include additional measures in this step, such as measures of accessibility defined for an agency's broader analysis of the projects in its Transportation Improvement Plan (TIP). The agency should document existing measures for each population included in the analysis, and the predicted values for each measure, population, and resource allocation scenario being evaluated.

4. **Step 4. Determine Whether Impacts are Disparate or Have Disproportionately High and Adverse Effects (DHAE)**

Once the agency has quantified the impacts of each resource allocation scenario, it is next necessary to determine whether the impacts are disparate, or have DHAE. Essentially, this step involves comparing the measures calculated for specific populations in Step 3 to the entire population served by an agency. Ideally, the result is that the agency finds that the measures and any changes in the measures are consistent across different populations. However, where there are differences in the results between different populations, it is necessary to consider whether the differences are large enough to merit adjustments to the investment scenario or some other action.

For analyses that are Federally-required, such as in development of a TIP, there are specific legal criteria for this step. For other analyses an agency should establish and document its criteria for evaluating impacts, along with the results of its assessment.

5. **Step 5. Develop Strategies to Avoid or Mitigate Inequities**

The final step is to make adjustments in an agency's investments as needed to avoid or mitigate inequities. For TAM resource allocation this may involve:

- Reallocating resources to either reduce negative impacts of investments or improve asset conditions and accessibility to benefits for the populations included in the analysis.
- Rescoping or revising specific projects to reduce their negative impacts or increase their benefits to underserved populations.
- Working with underserved populations to establish other approaches for avoiding or mitigating impacts and improving accessibility to benefits.

Plan Coordination

Overview

Transportation Planning is a broad field that ensures transportation decisions are made with a comprehensive consideration to transportation needs, land use, development, safety, security, and fiscal responsibility. The planning process incorporates analysis results and the evaluation of possible impacts to develop a variety of plans that document transportation agency priorities, assumptions, objectives, targets, and planned actions to support the local, rural, tribal, metropolitan, statewide, national, and international transportation of people and goods. For state and regional transportation agencies, the primary planning products are Statewide Long-Range Transportation Plans (23 USC 135), and Metropolitan Transportation Plans (23 USC 134). However, agencies may engage in other planning efforts at the corridor (e.g., Planning and Environmental Linkages), or project level (23 USC 168). In addition to traditional transportation planning, transportation agencies develop various performance management plans to establish and communicate policies, strategies, and planned investments in areas of performance such as safety, resilience, congestion mitigation, maintenance, and more.

These various planning products can vary greatly in terms of timeframes, scopes, and how they are used by the agency. However, each planning product or performance area involves or is impacted by the physical condition of transportation infrastructure assets. This means there is a relationship between each of the various long-range and performance-based plans developed by a transportation agency and that agency's Transportation Asset Management Plan (TAMP). In some cases, the various plans may also be related to the TAMP by the funding sources involved.

Key Concepts

Federal Aid Programs

Metropolitan Planning

Performance-Based Planning

Statewide Planning

Transportation Performance Management

Implementation Considerations

The following are steps agencies can take to improve the alignment between planning efforts and the TAMP. Each plan has requirements that are established in statute, regulations, or policy. These requirements may be set at the federal, state, or agency level. The steps presented below are intended to be general enough to apply to most agencies. As agencies work to implement these steps, they will need to be adjusted to address each agency's specific needs.

1. Review plans for alignment opportunities.
    - Timing of the development or next update.
    - Assets addressed in each plan.
2. Identify a lead or liaison for each plan.
3. Identify document elements of each plan presents an opportunity for alignment.
4. Perform necessary analysis.
5. Incorporate improvements into the plans.
6. Involve plan liaisons in implementation activities.

Federal Program Support

Several Federal funding sources require plans for their use. These fund sources also typically allow their use to develop the required plans. Examples of Federal fund sources that can be used for plan development, or have requirements for plans are listed below. This list is not intended to be completely accurate. Agencies must work with their FHWA Division Offices to ensure the proper use of Federal aid.

- State Planning and Research (SPR) - Can be used for a wide array of planning purposes (23 USC 505).
- National Highway Performance Program (NHPP) - Funds can be used for the development of risk-based Transportation Asset Management Plans (23 USC 119).
- National Highway Freight Program - Funds can be used for the development of State Freight Plans (23 USC 167).
- Highway Safety Improvement Program - Funds can be used for the development of Strategic Highway Safety Plans (23 USC 148).
- Promoting Resilient Operations for Transformative, Efficient, and Cost-saving Transportation (PROTECT) Program, "Of the funds apportioned to a State under section 104(b)(8) for each fiscal year, not less than 2 percent shall be for activities described in subsection (d)(3)" (23 USC 176(c)(2)).

The programs of funding described above are established through federal law and supported with additional regulations and guidance. The following list of key legal citations is provided by program area to illustrate the connection between the legal requirements and plans developed by state DOTs and other agencies and planning organizations.

- Asset Management
    - 23 USC 119 National Highway Performance Program
    - 23 CFR 515 Transportation Asset Management Plans
- Statewide and Metropolitan Planning
    - 23 USC 134 Metropolitan Transportation Planning
    - 23 USC 135 Statewide Transportation Planning
    - 23 USC 168 Integration of Planning and Environmental Review

    - 23 USC 505 State Planning and Research
    - 23 CFR 450 Planning Assistance and Standards
        - Subpart B Statewide and Nonmetropolitan Transportation Planning and Programming
        - Subpart C Metropolitan Transportation Planning and Programming
- Federal Programs Requiring Plans
    - 23 USC 148(c)(1) Highway Safety Improvement Program
    - 23 USC 149(l) Congestion Mitigation and Air Quality
    - 22 USC 167(g)(4) National Highway Freight Program
    - 23 USC 176(d)(3) Promoting Resilient Operations for Transformative, Efficient, and Cost-saving Transportation (PROTECT) Program
    - 49 USC 70202(a) State Freight Plans, "Each State that receives funding under section 167 of title 23 shall develop a freight plan that provides a comprehensive plan for the immediate and long-range planning activities and investments of the State with respect to freight."
- Other Plans
    - 28 CFR §35.150(d) Americans with Disabilities Act Transition Plans

Case Study Spotlights

Several case studies have been written that explain how agencies have worked to coordinate planning efforts with the TAMP and integrate asset management within the broader planning framework. FHWA and AASHTO have also published several resources to help agencies understand performance-based planning, which can be a key framework to support this type of coordination.

In 2016, The Northeast Ohio Areawide Coordinating Agency (NOACA) developed a transportation asset management plan to better integrate asset condition forecasts into metropolitan planning and programming practices in the greater Cleveland metropolitan area. TAMP development coincided with implementing a pavement management system that allowed NOACA staff to evaluate multiple investment scenarios in support of achieving and sustaining a desired state of good repair for pavements. Details can be found in the report, Integrating Asset Management into the Transportation Planning Process - A Case Study.

The 2020 report, Case Study 2 - Linking Asset Management to Planning and Programming, published by FHWA, highlights efforts by six state DOTs to better integrate TAMPs with other statewide planning efforts.

- **Missouri DOT** has developed district level TAMPs for pavements and bridges that are updated more frequently and allowed the agency to better tie programming to asset management objectives.
- In developing its TAMP, the **Maine DOT** simulated funding strategies using its pavement and bridge management system. The selected strategies were used to develop project lists for the agency's 3-Year Work Plan and 4-Year STIP.
- **Utah DOT's** TAMP includes an objective of incorporating asset management into immediate and long-range planning processes.
- **Ohio DOT** develops district work plans to achieve asset management objectives. These work plans, in turn, are used to develop the Statewide Transportation Improvement Program (STIP).

- **Wyoming DOT** uses its pavement management system to establish long-term investment strategies to optimize pavement conditions. Those strategies are used to identify projects at a district level, which then inform the STIP development process.

The **Montana Department of Transportation's** 2019 TAMP identified performance gaps for pavement and bridge conditions. The TAMP then established a cyclical process for addressing the performance gap through planning and programming efforts.

Process Followed to Update the Digital TAM Guide

Overview

The project was accomplished in two phases. The first phase involved eight tasks to identify new content and create a blueprint for updating the digital TAM Guide. The second involved four additional tasks to build the content and document the results of this effort. At the completion of each task, a web meeting was hosted by NCHRP to present the deliverables to the project panel and NCHRP. The following describes each of the project tasks.

Phase 1: Plan and Design the Updated Digital TAM Guide

Task 1. Kick-Off Call and Brainstorming Session

A kickoff web conference was conducted to review the project objectives and work plan and brainstorm ideas for updates to the digital TAM Guide. This discussion and brainstorming session helped shape the design for the updated digital Guide. The kickoff call was used to begin planning for the TAM Guide Workshop and discuss both meeting location and potential participants.

Table P.1 - Brainstorming Session Plan Used

1. **Start with an open discussion of what the group wants to achieve through the project.**
    - Use the content from the RFP and the proposal as a starting point (projected on screen)
    - Ask the group to build on what is on the screen
2. **Magic Wand Exercise**
    - Use the chat to have everyone share what they would want in the digital Guide if there were no constraints (imagine into the future of what could be)
3. **Small Group Ideas Generation**
    - Break into the following three groups
        - TAM Strategy and Planning, Organization and People, Information and Systems
        - Maximizing Asset Performance, Resource Allocation, Monitoring and Adjustment
        - Digital Techniques and Cross-Chapter Needs
    - Each session will start with ideas from the RFP and the proposal and ask the group to:
        - Discuss what gaps exist that the digital TAM Guide can support
        - Generate additional ideas for the digital Guide
        - Add more details to the ideas (i.e., for new videos suggest topics and subjects)
        - Prioritize the ideas
    - If there is time, run the breakouts again with new groups and build on the initial ideas
4. **Full Panel Discussion**
    - Present a quick summary of the results of the exercises (they will be available on the web conferencing platform)
    - Discuss if this represents the collective wishes of the panel
        - Are there items missing
        - Are there items that people don't like
        - Are the priorities right

Following this meeting, panel comments and decisions made were documented and a final amplified work plan reflecting the kickoff meeting results was produced.

Deliverables (September 2022)

- Project Kick-Off and Brainstorming Call Notes
- Amplified Work Plan

Task 2. Research and Practice Review

Task 2.1 Review Research and Practice

This task involved producing an annotated list of resources and practice examples which were considered for inclusion in the updated digital TAM Guide. Resources and practice examples were identified through the following activities:

- Literature searches to identify new TAM-related guidance, case studies and tools
- Interviews with practitioners to identify both noteworthy new practices as well as gaps where additional guidance and examples would be helpful
- Solicitation for ideas via the AASHTO TAM Portal (a request will be posted throughout the project)

The literature review included the following sources:

- TRB TRID (the TRIS and ITRD database) and ROSA P
- TAM Research Management System - to identify completed, active and proposed research
- TAM Portal Library - to identify new resources added since the development of the TAM Guide
- Presentations and summary report from the 2021 TRB TAM Conference, as well as recent TAM webinars and peer exchanges - to identify practice examples as well as topics of general concern

The literature review was supplemented with 4-6 interviews or focus groups to obtain additional information on cutting-edge practices, particularly with regard to other modes. Potential interview/focus group participants included:

- FHWA TAM Expert Task Group (ETG) members
- Transportation Research Board (TRB) Joint Subcommittee on Transit State of Good Repair
- American Public Transit Association (APTA) TAM/SGR Working Group
- IPWEA
- Project Team and Panel for Aviation Cooperative Research Program (ACRP) Project 09-20 on Quantifying the Impacts of Delayed Maintenance of Airport Assets
- Transportation agency representatives (e.g. WSDOT Ferries, SEPTA)

The results of the research and practice review were documented in Technical Memo 1. This memo included summaries of each interview, a synthesis of feedback on where new content is most needed, and an annotated listing of the resources and practice examples that were gathered. This annotated listing describes notable aspects of the resource/example, identify how and where (which chapter) the resource/example were incorporated into the Guide (e.g. supplement an existing checklist or highlight a new TAM tool.)

Task 2.2. Monitor Bipartisan Infrastructure Law Rulemaking

The review included, as an appendix, a concise summary of rulemaking associated with asset management requirements contained within the 2021 Bipartisan Infrastructure Law. The progress of this rulemaking was continuously monitored over the course of the project and updates were provided periodically to inform the development of enhanced Guide content.

Deliverables (October 2022)

- Technical Memo 1

Task 3. TAM Guide Workshop

A TAM Guide Workshop was held to provide an opportunity for TAM community members to share their knowledge and insights for the updated digital TAM Guide design and identify priority needs for the enhancements. The design of the workshop was informed by the results of the Task 1 brainstorming exercise and the Task 2 Research and Practice review. An agenda for the workshop was developed based upon the work-to-date and the input received from the panel at the kickoff call. The table below shows a possible strawman version of the workshop agenda. The panel was engaged to refine the agenda topics and discuss the engagement techniques which were employed during the workshop.

Table P.2 - Example Agenda – TAM Guide Workshop

8:00 AM: Welcome and Introduction

- Welcome from key TAM leaders
- Overview of the workshop charge and agenda
- Self introductions
- Share event logistics

8:30 AM: Background and Context

- Updates to the digital TAM Guide objectives (use Menti polls to get reactions to the ideas)
- Work-to-date summaries
  - New content ideas by chapter
  - New technique ideas
  - New tool ideas
  - Additional ideas and cross cutting needs

9:30 AM: New Content Dialogue – Use Fishbowl Format

- Room setup with 3 – 4 seats for people to share their views. Go through the content topics and ask the participants to share their views on what would be most helpful to them and document all responses.
- Facilitators will get all participants to go into the "fishbowl" to share their views
- The session will end with polling on the most important ideas that were generated during this session

10:15 AM: Break

10:30 AM: Ideas Development Session – Use World Café Technique

- The chapters of the TAM Guide (minus the Introduction) will be used to organize into six groups
- Participants will be organized into groups of approximately 4 - 6 people
- There will be three rounds so that each participant can weigh in on three of the chapters
- There will be a host for each table who is responsible for guiding the discussion and documenting the results
- During each round, specific questions will be asked to develop content ideas further for each of the chapters

Noon: Lunch

1:30 PM: Group Reports

- The host for each table/chapter will report on the final results of the ideas development

- There will be an open discussion after each host report (use Menti poll to prioritize ideas for each chapter)

3:30 PM: Break

3:45 AM: Ideas Specification

- Participants will be organized into the six chapters to further develop the priority ideas from previous sessions
- Assignment will be to specifications for the additional content to be added to the digital TAM Guide
- A paper and online format will be provided for the assignment. Different formats will be used for different types of enhancements (new practice examples, new templates, new checklists, new videos, etc.)
- Participants will be encouraged to use the existing digital TAM Guide as a resource for this exercise

4:45 PM: Workshop Wrap Up

- Review of workshop accomplishments and next steps

Event logistics and hotel arrangements for workshop participants were managed by the research team. The research team worked with participants to support travel logistics, including identifying cost-effective travel options and coordinating reimbursements. The research team also provided full logistical support for participants' accommodations and the coordination of local travel options. A hotel was chosen to align with federal per diem rates for the number of participants anticipated for the workshop. Travel reimbursement guidelines were based on current federal travel guidance. Throughout the run-up to the workshop, the team communicated reimbursement guidelines and responded to participants' questions promptly. The team also coordinated the production and distribution of all necessary support material. The team worked with the event facility to coordinate the workshop needs. Throughout the planning process they were proactively engaged with the panel in order to obtain input. This included the ability to quickly produce material for review and to respond to and edit in an iterative fashion so as to make most efficient use of panel members' time.

The research team provided all of the logistical support required during the workshop including:

- Meeting logistics including, but not limited to, accommodations for participants and local travel options for participants
- Workshop facilitation and organization
- Transporting/shipping of all necessary materials to the conference venue
- Ensuring that all needed equipment and materials are available including, but not limited to, markers, flip charts, name tags, name tents, computers, polling app, etc.
- Ensuring that the meeting room is fully set up with all necessary materials on hand and all audio/video equipment in working order
- Professional note-taking and documentation of all presentations, discussions, and breakouts

Following the workshop, a summary of the workshop discussions was produced. This information was then presented in a format that led to a design and specification for the updated digital TAM Guide.

Deliverables (November-December 2022)

- Workshop Agenda and Participants List

- Pre-Workshop Package
- Workshop Delivery
- Workshop Summary Report

Task 4. TAM Guide Survey

A survey of relevant public agencies and private sector organizations was conducted to get reactions to the ideas developed to date and to identify new ideas. A web-based survey was developed to obtain the information. The following types of questions were considered for inclusion in the survey:

- Questions that characterize the respondent (type of agency, type of position or responsibilities, familiarity with the TAM Guide)
- Questions that ask the respondent to indicate their primary areas of interest related to TAM
- Questions that ask the respondent to rate the need for new guidance or resources on a topic
- Questions that identify the respondent's level of interest in specific types of Guide additions
- Open ended questions asking the respondent to identify specific recent research or other resources that they think should be referenced in the Guide
- Open ended questions asking the respondent to identify notable practices (in their organization or others) that should be referenced in the Guide

A draft version of the proposed questions was submitted to the panel for review. As the survey questions were developed, target organizations were identified and email distribution lists compiled for the survey. Target organizations included:

- State DOTs - asset management leads, pavement and bridge management leads, maintenance management leads, BIM leads, others (work with AASHTO and FHWA to identify contacts)
- MPOs and local agencies (work through AMPO and APWA to identify contacts)
- Transit Agencies - asset management leads (work through APTA to identify contacts)
- Asset Management Researchers (work through TRB to identify contacts)
- Asset Management System vendors (identify based on project team knowledge)
- Asset Data Collection Vendors (identify based on project team knowledge)
- Private Asset Owners such as tolling authorities (identify based on project team knowledge)

Once the questions were finalized, they were formatted using SurveyMonkey, a web-based survey tool, and distributed to the Panel to verify that the tool is operating as intended. Once verified, the questionnaire was emailed to the identified target participants. The responses were monitored and steps were taken to maximize participation. The questionnaire results were analyzed and summarized for use in developing the blueprint for the updated digital TAM Guide.

Deliverables (November-December 2022)

- Compiled Survey Results
- Synthesis of Survey Findings

Task 5. Topic Deep Dives Design

This task identified and designed a series of Topic Deep Dives to provide all-new, in-depth treatments of priority topics. Topics for Deep Dives were proposed based on the results of Tasks 1-4. The Deep Dives follow a consistent text-based template, but also contain embedded checklists, case studies, data visualizations and other relevant material. They were produced as stand-alone resources but were also linked and referenced within the existing Guide chapters. This approach allowed for development of significant new content without disrupting the flow, structure, and organization of the Guide. This approach was similar to the previous version of the digital Guide's treatment of 'TAM Topics' but was enhanced to provide greater depth and focus, easier navigation, and a flexible template for additional updates.

A two-hour virtual panel meeting was scheduled to review the list of proposed Topic Deep Dives and discuss the results of the first five tasks.

Deliverables (December 2022)

- List of Proposed Topic Deep Dives
- Standard Template for Topic Deep Dives
- Outline of Content for Each Topic Deep Dive
- Panel Meeting Summary

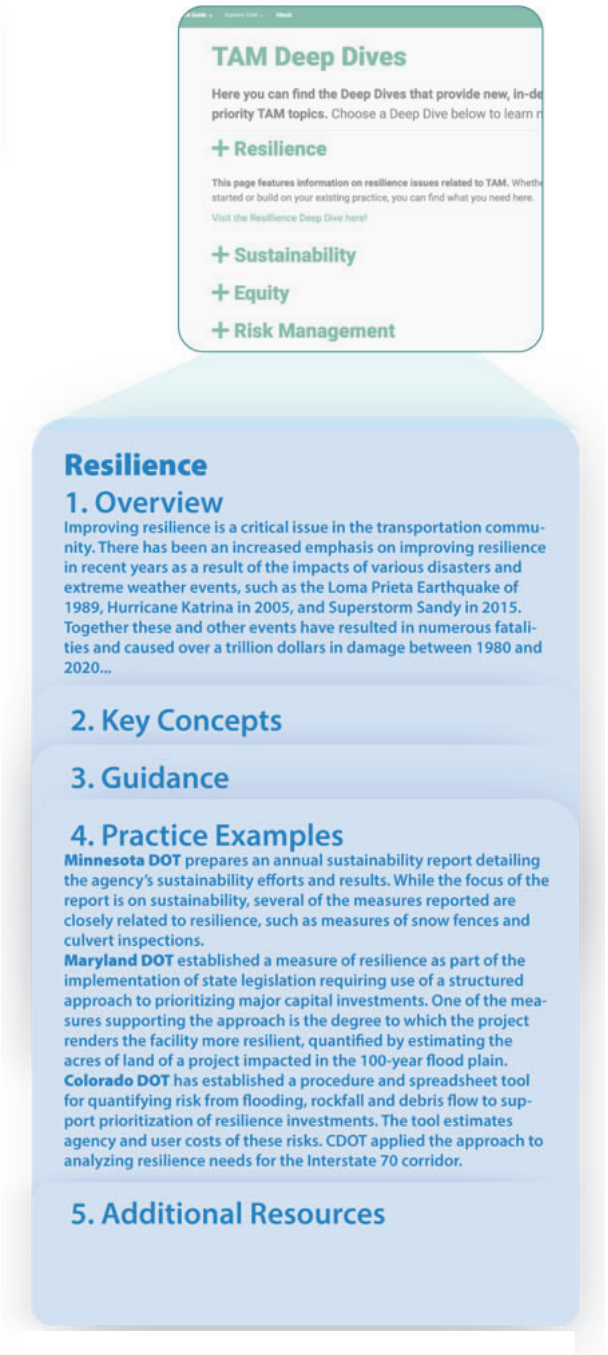


Figure P.1 – Topic Deep Dive Design

Task 6. TAM Gap Analysis Tool Design

This task involved the design of modifications to the AASHTO TAM Gap Analysis tool. The prototype Excel-based Gap Analysis Tool was developed alongside the 2011 AASHTO TAM Guide and was updated in 2014 under NCHRP Project 08-90. The current tool expanded and enhanced the prototype's basic functionality and added substantial new content addressing MAP-21 and related rulemaking.

A project was initiated to revisit the tool, further enhancing its core functionality and once again updating its content to address recent and ongoing TAM-related rulemaking. As in the prior updates completed under NCHRP 08-90, close attention was given to DOT institutional and technical practices related to TAM. This ensured the guidance returned via the Gap Analysis Tool was practical and readily-implementable by DOTs and other transportation agencies.

The tool was converted from the spreadsheet format to a web format. The team had recently completed development of a closely-related web application, the TAM Data Assistant Tool (https://dataassessment.tam-portal.com/). The TAM Data Assistant was developed using a generic assessment framework that was readily adapted to new content areas and assessment formats. The TAM Data Assistant Tool was leveraged to provide a technical platform for TAM Gap Analysis Tool development. This approach streamlined the tool development and deployment path for the updated TAM Gap Analysis Tool.

1. **Review and update the assessment elements and language.** This step involved a review of the spreadsheet-based tool to identify areas where the assessment structure or contents should be updated to account for recent advancements in practice. The basic TAM Gap Analysis structure of TAM Assessment Areas, Elements, and Criteria was retained, revising these as needed for consistency with the TAM Guide Framework while incorporating factors and considerations including:
   - Risk Management and Resiliency
   - Financial Planning and Asset Valuation
   - Applying Multi-Objective Decision Analysis
   - TAM Communication and Data Visualization

   All necessary revisions were made prior to developing a functional design. The required revisions were documented in an updated TAM Gap Analysis Tool outline including all questions, definitions and analysis options.
2. **Produce a high-level design.** This step involved using the TAM Data Assistant as a model to develop high-level design specifications for the updated TAM Gap Analysis Tool. A high-level design document was developed, including updated content and outline supplemented by user flow diagrams, wireframes, and example page views. A TAM Gap Analysis focus group meeting was designed and delivered in order to obtain practitioner input on the proposed updates and enhancements.
3. **Produce a functional design.** This step involved producing a functional specification that was sufficiently detailed to guide the development of the TAM Gap Analysis Tool. The high-level design was updated in order to produce a final functional design specification for the updated TAM Gap Analysis Tool.

Deliverables (December 2022-January 2023)

- Updated TAM Gap Analysis tool outline
- High-Level Design of the Web Tool
- Functional Design of the Web Tool

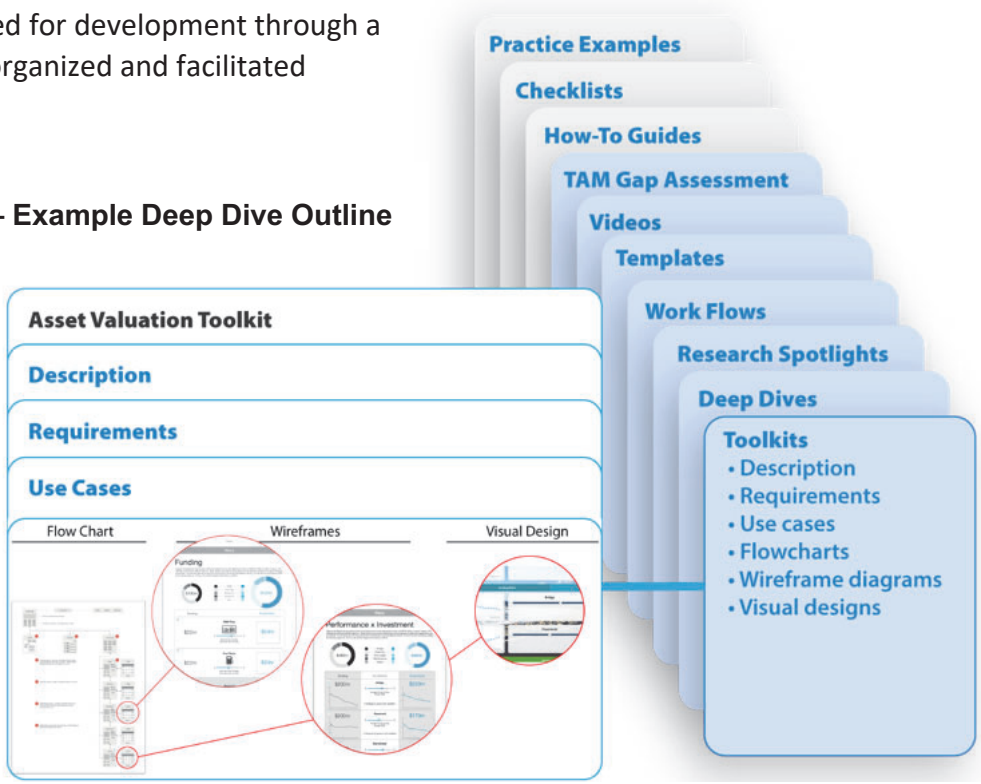
Task 7. Updated Digital TAM Guide Blueprint

The Digital TAM Guide Blueprint served as the master plan for extending the Guide to include new topics and new functionalities. It was built on input collected and synthesized from the Task 3 workshop and Task 4 survey to help define core requirements and use cases – and provide the technical, functional, and design documentation for the enhancements and additions that were later developed in Task 9.

The blueprint defined the overall user experience, design, and information architecture of the updated site. It contained sections addressing each individual new or enhanced element of
the Guide: Deep Dives, Checklists, How-To Guides, Practice Examples, Templates, Tools, Videos, Research Spotlights. The blueprint also included the functional design specification of the TAM Gap Analysis Tool.

Separately, the Blueprint provided the plan for content development for the updated Guide. It proposed a core set of specific checklists, how-to guides, practice examples, and other elements which were developed – and defined lead authors, key information sources, and development timeframes for each. Selected elements were identified for development through a Hackathon – that was organized and facilitated during Phase 2.

Figure P.2 – Example Deep Dive Outline



TAM Guide Content Development Examples

Figure P.3 – TAM Guide Blueprint Dive

The Blueprint was developed as a technical memorandum. A *Digital Blueprint* for the Digital TAM Guide was produced: a special area of the digital Guide site to host interactive wireframes, design schematics, and prototypes. Once the new features entered development (performed as part of Task 10) this provided users with the ability to opt-in to demos and provide instant feedback on beta versions as well as release candidates of new features. The Blueprint presented in Technical Memorandum 2 was revised based upon panel input and later integrated into the Task 8 Interim Report.

Deliverables (December-January 2023)

- Technical Memorandum 2 – Digital TAM Guide Blueprint
- Digital Blueprint

Task 8. Interim Report and Panel Meeting

An interim report was produced that summarized the results of tasks 1 - 7. The report was designed with the following guidelines in mind:

- Describe the results of project activities to review recent research and practice, identify priority gaps and needs based on stakeholder feedback and include appendices documenting results of the brainstorming session, the research and practice review, the Guide Workshop, and the survey.
- Describe and reference the design for the updated TAM Gap Analysis Tool
- Describe and reference the design for the Topic Deep Dives
- Describe and reference the Digital TAM Guide Design Blueprint
- Provide an updated work plan for Phase 2, reflecting the results of Phase 1.

A virtual panel meeting was scheduled to review the interim report and the work plan for Phase 2. The input from the panel was used to finalize the plans for Phase 2.

Deliverables (February-March 2023)

- Interim Report
- Updated Phase 2 Work Plan
- Panel Meeting Summary

Phase 2: Develop and Implement the Updated Digital TAM Guide

Task 9. Online Hackathon

An online hackathon was designed to engage a broader audience and crowd-source the development of selected blueprint elements for the updated digital TAM Guide. This hackathon was targeted at graduate studies programs, as well as interested staff at transportation agencies. This task involved the following steps:

1. **Develop a TAM Guide Hackathon flyer/website** that describes the event, purpose, and logistics
   - Objective is to connect with new audiences, expand stakeholder base, capture new ideas, develop tools and innovations that meet the needs of younger practitioners.
   - Focus on enhancements that can produce functional results (new data visualizations, adaptation of an existing DOT tool or technology, applying natural language processing to enhance site-wide search, etc.)
2. **Reach out to channels** such as the university transportation centers (UTCs), TRB, AASHTO, and transportation agencies to advertise the event
   - Solicit participation from universities that are active in asset management by reaching out to the TRB Subcommittee AJE30(4) Asset Management Education
   - Registration will include options to join teams assigned a specific challenge, open-ended teams
3. **Develop the "quest" package** for the hackathon
   - Purpose/objectives
   - Team formation logistics
   - Judging criteria and process
     - Conclusion will include presentation, videos, code repository
     - Prizes to be awarded
   - Description of the quest/challenge
   - Instructions/guidelines

Deliverables (April-May 2023)

- Hackathon Flyer/Website
- Quest Package

- Final Hackathon Results Summary

Task 10. Design and Build Additional Content

This task involved development and integration of the new content for the digital TAM Guide, based on the Blueprint developed in Task 7, updated based on the input received in Task 8, and results of the hackathon in Task 9. For each individual Guide element (Deep Dives, Checklists, How-To Guides, Practice Examples, Templates, Tools, Videos, Research Spotlights, etc.) technical development and content development was conducted in parallel and results were produced in an iterative manner.

Technical Development. For each element the following was conducted:

1. **Update Blueprint specification.** Prepare an updated specification document based on the Blueprint. The updated document will reflect input received since the Blueprint was developed and will refine the Blueprint specification as needed to provide additional detail.
2. **Develop interactive prototype.** Develop prototype of the new functional element. Deploy the prototype(s) via the digital blueprint development environment for panel review and/or opt-in testing.
3. **Review prototype.** Review prototype with the panel or designated stakeholders and collect feedback via online forms and review roundtable web-meetings. Reviews will be coordinated to include multiple prototype elements developed in parallel.
4. **Deploy new or enhanced element.** Complete all updates to the prototypes, based upon input received, necessary to deploy the new or enhanced element to the site.
5. **Populate new or enhanced elements.** Once the new or enhanced element is deployed to the TAM Guide site, the fully-vetted content produced through the Content Development process defined in this task will be populated.

Content Development. In parallel with the technical development of the Guide elements, the new and enhanced content to populate the Guide was developed. Content development (e.g. authoring text, producing video, developing data displays) followed the sequence and timeframes specified in the Blueprint. The Blueprint also provided the set of specific checklists, how-to guides, practice examples, and other elements that formed the core of this effort. The specific content creation and review process depended on the content type (text, video, data visualization, etc.) but included the following steps:

1. **Develop an annotated outline.** The process begins with a comprehensive outline for each guide element, specifying the organization of content and the key points to be communicated.
2. **Outline review.** Review outlines with other project team members, panel members and (where appropriate), designated stakeholders.

3. **Develop new or enhanced content.** Using the outlines and incorporating review feedback, develop each new or enhanced Guide element.
4. **Populate new or enhanced elements.** Once the new or enhanced element is developed, the TAM Guide site will be populated with the new elements.
5. **Global content review and update.** Once all new content is populated, review and adjust to reduce overlaps and provide additional links or cross references as appropriate.

Deliverables (April 2023-January 2024)

- Annotated Outlines for Updated Content
- Updated Digital TAM Guide Website
- TRB TAM Conference Workshop Summary (optional)

Task 11. TAM Gap Analysis Tool

The TAM Gap Analysis Tool was developed based on the design completed in Task 6. Following a round of internal project team testing, staff were recruited to conduct a pilot implementation of the tool. Based on the feedback obtained, the tool was updated and finalized.

Deliverables (November 2023-January 2024)

- Draft TAM Gap Analysis Tool
- Final TAM Gap Analysis Tool

Activities Required to Keep the Digital Guide Updated

The American Association of State Highway and Transportation Officials (AASHTO) Committee on Performance-Based Management (CPBM) is responsible for keeping the Digital TAM Guide up to date. This task will be a part of the CPBM project to update and support their other online portals, including: the AASHTO Transportation Performance Management Portal, AASHTO Enterprise Risk Management Portal, and AASHTO Agency Capability Building Portal.

To fulfill this responsibility, the CPBM should occasionally review the content within the Digital TAM Guide and determine when new asset management practices within have been implemented in the industry. These updates may include capturing and integrating new webinars, documenting new approaches to asset management, including more recent Practice Examples, or linking additional resources to the guide. The CPBM will have the option to incrementally update the guide with small changes, or wait to implement a large project to revise the Digital TAM Guide.

Appendix A: References from All Chapters

Chapter 2 References

Guide to Asset Management Overview Part 2: Managing Asset Management
Austroads | July 10, 2018 | https://austroads.com.au/publications/asset-management/agam02
Part 2 of the Guide to Asset Management covers the 'management of asset management', a crucial subject for senior managers, leaders, and those who influence organizational culture. The governance of asset management is a shared responsibility between senior management and the corporate governance tiers of the road agency.

Asset Management Strategy for Road-Related Assets (Safety Infrastructure)
Austroads | May 9, 2018 | https://austroads.com.au/publications/road-safety/ap-t309-18
This report offers guidance on managing safety infrastructure assets to maximize service levels at minimal life-cycle costs, reduce risks to road users, and aid in the continuous improvement of planning, maintenance, and operations.

Asset Management Guide for Local Agencies
Minnesota Local Road Research Board | November 1, 2019 |
https://mdl.mndot.gov/items/2019RIC06
This document aims to guide the development of an asset inventory and condition assessment, the establishment of performance measures and goals, the identification and rating of risks, the determination of lifecycle planning and funding strategies, and the creation of asset management plans as well as programs using both existing and new resources.

Integrating Effective Transportation Performance, Risk, and Asset Management Practices
Transportation Research Board | January 20, 2022 |
https://www.trb.org/Publications/Blurbs/182511.aspx
Research and practice in transportation performance, risk, and asset management have enhanced the tools, methods, and strategies available to state departments of transportation and other agencies. Transforming the culture of a transportation agency and integrating these changes into traditionally siloed management practices demand the dedicated effort of the entire organization, involving nearly every individual.

Implementation of the AASHTO Guide for Enterprise Risk Management
Transportation Research Board | January 1, 2022 |
https://nap.nationalacademies.org/catalog/26516/implementation-of-the-aashto-guide-for-enterprise-risk-management
The TRB National Cooperative Highway Research Program's NCHRP Research Report 986: Implementation of the AASHTO Guide for Enterprise Risk Management details how several state departments of transportation are incorporating risk management principles and practices.

Right-Sizing Transportation Investments: A Guidebook for Planning and Programming
Transportation Research Board | January 1, 2019 |
https://nap.nationalacademies.org/catalog/25680/right-sizing-transportation-investments-a-guidebook-for-planning-and-programming
The TRB National Cooperative Highway Research Program's NCHRP Research Report 917: Right-Sizing Transportation Investments: A Guidebook for Planning and Programming offers guidance on identifying right-sizing opportunities. This approach aims to enhance social and economic value by repurposing, reusing, or fundamentally resizing existing transportation system assets.

The Relationship Between Transit Asset Condition and Service Quality
Transportation Research Board | January 1, 2018 |
https://nap.nationalacademies.org/catalog/25085/the-relationship-between-transit-asset-condition-and-service-quality
TRB's Transit Cooperative Research Program (TCRP) Research Report 198: The Relationship Between Transit Asset Condition and Service Quality outlines the creation of a quantitative method for assessing service quality and illustrates how this measure fluctuates with changes in asset condition. It offers guidance on the relationship between asset condition and transit service quality concerning investment prioritization.

Identification of Effective Next Generation Pavement Performance Measures and Asset Management Methodologies to Support MAP-21 Performance Management Requirements
FHWA | January 17, 2017 | http://www.pdth.com/images/NextGenTAMphase1.pdf
This study aims to identify or conceptually create methodologies for fully implementing a comprehensive asset management plan. It includes trade-off analysis from a unified perspective among various assets, typically assessed and managed separately. The proposed framework begins with the fundamental objectives and management considerations shared by most highway agencies. These form the basis for a unified set of methodologies across assets to aid decision-making in all the essential business processes required for implementing TAM Plans.

Case Study 2 - Linking Asset Management to Planning and Programming
FHWA | May 1, 2020 | https://rosap.ntl.bts.gov/view/dot/54455
This case study showcases how asset management is connected to long-term plans, the statewide transportation improvement program (STIP), and state planning and programming practices. It includes examples drawn from the TAMPs in Missouri, Maine, Utah, Ohio, Wyoming, and Montana.

Linking Performance and Asset Management
FHWA | July 1, 2019 | https://rosap.ntl.bts.gov/view/dot/67127
This paper explores the correlation between transportation asset management processes outlined in 23 CFR 515, transportation performance management processes detailed in 23 CFR 490, and planning requirements specified in 23 CFR 450. It aims to expand upon previous research and investigate how the regulations in 23 CFR 450, 490, and 515 endorse a nationally implemented performance-based asset management approach.

Case Study 6 - Communicating Asset Management Strategies
FHWA | May 1, 2020 | https://austroads.com.au/publications/road-safety/ap-t309-18

This case study showcases the communication methods utilized by State departments of transportation (DOTs) to involve and interact with internal and external stakeholders. These communication strategies enhanced collaboration within the DOTs and with crucial external partners, including National Highway System (NHS) asset owners and metropolitan planning organizations (MPOs).

Case Study 1 - Asset Management Practices and Benefits
FHWA | May 1, 2020 | https://rosap.ntl.bts.gov/view/dot/54454
This case study showcases methods employed by State departments of transportation (DOTs) to communicate and involve both internal and external stakeholders. These communication approaches fostered greater coordination within the DOTs and with significant external collaborators, including National Highway System (NHS) asset owners and metropolitan planning organizations (MPOs).

Integrating Effective Transportation Performance, Risk, and Asset Management Practices
Transportation Research Board | January 1, 2022 |
https://nap.nationalacademies.org/catalog/26326/integrating-effective-transportation-performance-risk-and-asset-management-practices
Integrating Effective Transportation Performance, Risk, and Asset Management Practices is structured as a process framework. The source is designed to be resilient to the expected evolution of an agency as it matures throughout its management integration.

How to Develop an Asset Management Policy, Strategy and Governance Framework
Federation of Canadian Municipalities | January 1, 2018 |
https://fcm.ca/en/resources/mamp/guidebook-how-develop-asset-management-policy-and-strategy
This guide demonstrates the steps to create an asset management policy, strategy, and governance framework tailored for a Canadian municipality. It advocates for a unified approach to planning and decision-making to effectively oversee municipal infrastructure assets.

Georgia DOT Asset Management Policy
Georgia Department of Transportation | February 19, 2021 |
http://mydocs.dot.ga.gov/info/gdotpubs/Publications/4B-1.pdf
The objective of this policy is to officially embrace Transportation Asset Management as the institutional approach for overseeing and preserving infrastructure assets and determining capital investment choices at the Georgia Department of Transportation (GDOT).

Building a Better Tomorrow: An Infrastructure Planning, Financing and Procurement Framework
Ontario Ministry of Public Infrastructure Renewal | January 1, 2004 |
https://books.google.com/books/about/Building_a_Better_Tomorrow_an_Infrastruc.html?id=u9KenQAACAAJ
This document establishes a framework for planning, financing, & procuring public infrastructure in Ontario. The framework encompasses: an outline of the government's infrastructure planning procedure; essential aspects to be tackled in the planning, design, funding, and administration of public infrastructure projects; the duties and obligations of government ministries and agencies, municipalities, broader public sector collaborators, and the private sector in the planning, funding, and procurement of public infrastructure assets; an introduction to optimal practices in

infrastructure procurement; and a summary of the provincial government's asset management guidelines.

Integrated Planning and Reporting Manual
Government of Western Australia: Department of Local Government, Sport, and Cultural Industries| September 1, 2021 | https://www.dlgsc.wa.gov.au/local-government/strengthening-local-government/integrated-planning-and-reporting
The council, community, and administration each possess distinct roles and responsibilities in formulating efficient and enduring integrated plans for the local area, as well as reporting on the advancement of those plans.

City of Townsville Strategic Asset Management Plan
Townsville City Council | January 1, 2023 |
https://www.townsville.qld.gov.au/__data/assets/pdf_file/0034/193885/SAMP_23-24.pdf
This Strategic Asset Management Plan (SAMP) delineates the Asset Management System Model, Asset Management Framework, and Asset Management Capability Delivery Model for the Townsville City Council. The Asset Management System Model illustrates the key components of the Council's asset management system and how they relate.

Chapter 3 References

Attracting, Retaining, and Developing the 2030 Transportation Workforce: Design, Construction, and Maintenance
Transportation Research Board | January 1, 2022 |
https://nap.nationalacademies.org/catalog/26768/attracting-retaining-and-developing-the-2030-transportation-workforce-design-construction-and-maintenance
The TRB National Cooperative Highway Research Program's NCHRP Research Report 1008, titled "Attracting, Retaining, and Developing the 2030 Transportation Workforce: Design, Construction, and Maintenance," offers a comprehensive guide with detailed strategies and action plans. These resources are designed to assist agencies in identifying and addressing their workforce needs up to and beyond 2030.

Transportation Workforce Planning and Development Strategies
Transportation Research Board | March 12, 2021 |
http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4657
The TRB National Cooperative Highway Research Program's NCHRP Synthesis 543, "Transportation Workforce Planning and Development Strategies," summarizes the current practices used by state departments of transportation (DOTs) as well as local and tribal technical assistance programs (LTAPs/TTAPs) in implementing workforce planning and development strategies.

Attracting, Retaining, and Developing the Transportation Workforce: Transportation Planners
Transportation Research Board | December 6, 2021 |
https://austroads.com.au/publications/asset-management/agam02
This report assesses the current and emerging factors influencing transportation planning practices and the planning workforce. The research aims to identify talent profiles for state, regional, and local transportation planners that align with current and future agency needs, and offers guidance on how agencies can attract, develop, manage, and retain planning talent.

Defining the TSMO Workforce Pipeline

FHWA | November 14, 2021 | https://transportationops.org/tools/defining-tsmo-workforce-pipeline
This report emphasizes the importance of diversifying the workforce pipeline sources for the TSMO industry. Best practices for developing the TSMO workforce pipeline involve forming innovative partnerships, broadening the scope of current development activities, and targeting a range of diverse communities.

Attracting, Retaining, and Developing the Transportation Workforce: Design, Construction, and Maintenance
Transportation Research Board | April 4, 2022 | https://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_1008Summary.pdf
NCHRP Research Report 1008 serves as a comprehensive guide to help agencies develop and maintain a high-quality workforce in transportation design, construction, and maintenance. It includes a roadmap and decision tree to assist agencies in assessing their specific workforce needs and implementing the practical strategies outlined in the guide.

Assessing and Measuring the Business Value of Knowledge Management
Transportation Research Board | June 13, 2023 | https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=5002
With 40% of the workforce in many DOTs nearing retirement eligibility within a few years, this report emphasizes the importance of knowledge management (KM) techniques and practices. These methods can assist transportation agencies in identifying, capturing, and transferring institutional knowledge, thereby fostering continuous learning and development.

Lessons Learned from State DOTs on Innovation and Knowledge Management Programs
U.S. DOT Volpe Center | March 1, 2021 | https://connect.ncdot.gov/projects/Value-Management/CLEARProgram/Documents/Lessons%20Learned%20from%20State%20DOTs%20on%20Innovation%20and%20Knowledge%20Management%20Programs.pdf
This report presents a summary of interviews conducted with state DOTs, offering a comprehensive overview of their approaches to managing innovation. It details the methods used for collecting and disseminating knowledge and identifies common themes and challenges faced by various DOTs.

Asset Management Manual: Organization
PIARC | October 16, 2023 | https://road-asset.piarc.org/en/management/organization
This chapter covers various topics on modifying a road organization's structure to maximize asset management potential and support its goals. These include leadership and culture, evaluating current asset management practices, the importance of asset management champions in driving necessary changes, and an organizational structure conducive to implementing asset management.

Developing a School to Workforce Pipeline in North Carolina
U.S. DOT Volpe Center | July 15, 2022 | https://connect.ncdot.gov/projects/research/RNAProjDocs/School%20to%20Work%20Pipeline%20Recommendations_FINAL.pdf
This report provides several actions for North Carolina Department of Transportation to consider pursuing while developing a school-to-career pipeline that focuses on minority students.

Workforce Management in Transportation

Transportation Research Board | October 5, 2021 |
https://onlinepubs.trb.org/onlinepubs/webinars/211005.pdf
This presentation gives a strategic overview on how to develop or refine an agency workforce plan.

Strategic Workforce Development Toolkit
FHWA | October 16, 2022 |
https://www.fhwa.dot.gov/innovativeprograms/centers/workforce_dev/hcwp/toolkit/
The Strategic Workforce Development (SWD) Toolkit offers a range of resources and inventive approaches aimed at involving organizations seeking to recruit, train, and employ individuals in construction roles vital for the advancement of the nation's highway system.

ADKAR: A Model for Change in Business, Government and our Community
Prosci Learning Center Publications | July 10, 2018 | https://austroads.com.au/publications/asset-management/agam02
This resource explores the ADKAR Model, a framework facilitating change management planning. Describes the objectives and achievements associated with implementing successful, extensive change initiatives.

The Balanced Scorecard: Step-by-Step for Government and Nonprofit Agencies
John Wiley & Sons, Inc.; 2nd Edition | June 1, 2003 | https://www.wiley.com/en-us/Balanced+Scorecard+Step+by+Step+for+Government+and+Nonprofit+Agencies-p-9780471475446
The Balanced Scorecard serves as a methodology for instituting performance management systems and enhancing operational effectiveness. Tailored specifically for the public and not-for-profit sectors, this book offers guidance to these organizations in surmounting the distinct hurdles encountered during the implementation of a Balanced Scorecard.

The Balanced Scorecard: Translating Strategy into Action
Harvard Business Review Press | August 2, 1996 | https://hbr.org/product/the-balanced-scorecard-translating-strategy-into-action/6513-HBK-ENG
The Balanced Scorecard converts the vision and strategy of an organization into a unified collection of performance metrics. Its four perspectives—financial measures, customer knowledge, internal business processes, and learning and growth—provide equilibrium between short-term and long-term goals, between desired outcomes and the factors influencing them, and between quantifiable metrics and qualitative assessments.

Building a Winning Culture in Government: A Blueprint for Delivering Success in the Public Sector
Mango Publishing | April 15, 2018 | https://mango.bz/books/building-a-winning-culture-in-government-by-patrick-r-leddin-and-shawn-d-moon-376-b
The book offers a systematic guide for reshaping governmental entities, delivering invaluable perspectives on change management, strategic blueprinting, and fostering vibrant workplace environments.

Project Route Map Organizational Design and Development Module – Improving Infrastructure Delivery
Infrastructure and Projects Authority | June 1, 2014 |
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/529336/ODD_Module.pdf

Authored by the UK government, this handbook delineates the Organization Design and Development module. The model aims to facilitate strategic decision-making, particularly concerning coordination between sponsors and clients, as well as project initiation and execution.

HBR's 10 Must Reads on Change Management
Harvard Business Review Press | March 7, 2011 | https://hbr.org/product/hbr-s-10-must-reads-on-change-management-with-featured-article-leading-change-by-john-p-kotter/12599E-KND-ENG
This source contains a compilation of articles that delve into optimal strategies for change management. They reframe change as a progressive process marked by distinct phases, rather than a singular occurrence.

Advancing Workforce Development: Leading a Performance-Based Culture
FHWA | July 1, 2020 | https://highways.dot.gov/public-roads/summer-2020/advancing-workforce-development-leading-performance-based-culture
Introduces the National Highway Institute's Maintenance Leadership Academy (MLA), a workforce development program that combines technical and leadership training to prepare new managers and supervisors in transportation maintenance. The MLA emphasizes a performance-based maintenance culture, covering topics such as leadership skills, pavement and bridge preservation, environmental protection, and more. The flexible course structure includes self-paced online study and instructor-led classroom training to efficiently equip participants with the necessary skills for effective maintenance practices.

Fact Sheet: Technical Assistance and Workforce Development
FHWA | December 6, 2021 | https://www.transit.dot.gov/funding/grants/fact-sheet-technical-assistance-and-workforce-development
This resource provides a fact sheet on the funding allocation for Technical Assistance and Workforce Development under the Bipartisan Infrastructure Law (IIJA) for fiscal years 2022 to 2026. The program aims to support effective transportation service delivery, compliance with federal laws, and workforce development through various activities, including technical assistance, standards development, and human resource programs. Eligible recipients include government entities and organizations with demonstrated capacity in public transportation.

Primary/Secondary/Post Secondary and Professional Development
FHWA | January 1, 2018 |
https://www.fhwa.dot.gov/innovativeprograms/centers/workforce_dev/education_professional_development.aspx
The Center for Transportation Workforce Development (CTWD) actively promotes initiatives aimed at cultivating curiosity and enthusiasm for prospective careers in transportation among K-12 students. Its array of programs and resources equips individuals with the essential skills required to excel in the transportation workforce of the future. Furthermore, the CTWD oversees endeavors that embed transportation themes into college and university curricula, fostering a greater interest among post-secondary students in pursuing careers in transportation-related fields. By offering management, leadership, and coordination, the Center spearheads student transportation education programs, contributing to the cultivation of a highly skilled workforce in the transportation sector.

A Guide to Agency-Wide Knowledge Management for State Departments of Transportation

Transportation Research Board | January 1, 2015 |
https://nap.nationalacademies.org/catalog/22098/a-guide-to-agency-wide-knowledge-management-for-state-departments-of-transportation
Providing comprehensive advice tailored to state transportation agencies, "A Guide to Agency-Wide Knowledge Management for State Departments of Transportation" offers insights into establishing a deliberate knowledge management (KM) strategy and showcases various approaches adopted by organizations. KM encompasses diverse methods aimed at safeguarding and enriching the collective knowledge of an organization's workforce, thereby harnessing it as a valuable asset for productivity.

Lessons Learned from State DOTs on Innovation and Knowledge Management Programs
U.S. DOT Volpe Center | March 1, 2021 | https://connect.ncdot.gov/projects/Value-Management/CLEARProgram/Documents/Lessons%20Learned%20from%20State%20DOTs%20on%20Innovation%20and%20Knowledge%20Management%20Programs.pdf
The document provides insights into innovation and knowledge management initiatives in state Departments of Transportation (DOTs). It outlines program structures, challenges, successes, and future plans, emphasizing the importance of communication, empathy, and staff recognition for program success, and highlights strategies such as establishing innovation centers, updating submission structures, and enhancing organizational involvement for future development. The document features lessons learned from various state DOTs, including California, Idaho, Illinois, Iowa, Michigan, Utah, and Wisconsin.

Michigan Boosts Local Construction Workforce Through Innovative Training Strategy
FHWA | January 1, 2022 |
https://www.fhwa.dot.gov/programadmin/contracts/sep14mi202201_casestudy.pdf
The following case study offers a comprehensive examination of the implementation, advantages, challenges, and tactics employed in the Michigan Department of Transportation's On-the-Job Training Voluntary Incentive Program.

Chapter 4 References

Case Study 3 - Life Cycle Planning Practices
FHWA | May 1, 2020 | https://rosap.ntl.bts.gov/view/dot/50768
Several TAMPs were commendable for detailing how they manage assets using life cycle plans. This case study includes examples from the DOTs in Minnesota, Ohio, Tennessee, and New Jersey. The asset management plans highlighted an increasing focus on the whole life of assets and utilizing life-cycle strategies to maintain a state of good repair (SOGR). Additionally, the plans underscored the importance of pavement and bridge management systems in supporting life-cycle strategies.

Case Study 7 - Managing Assets Beyond Pavements and Bridges
FHWA | May 1, 2020 | https://rosap.ntl.bts.gov/view/dot/54335
This case study summarizes 2019 asset management plans, highlighting how U.S. transportation departments are extending their efforts beyond pavements and bridges. These efforts have spurred innovations in developing inventories, identifying life cycles, and adopting investment strategies.

Using an LCP (Life Cycle Planning) Process to Support Transportation Asset Management: A Handbook on Putting the Federal Guidance into Practice

FHWA | January 3, 2019 | https://rosap.ntl.bts.gov/view/dot/43564
Since LCP is a relatively new process for State DOTs, the Federal Highway Administration (FHWA) launched a project to develop guidance documents on LCP, risk management, and financial planning to help State DOTs implement these activities. This particular initiative expands on the LCP guidance by offering more detailed information on implementing an LCP process for both pavements and bridges.

Addressing Resilience to Climate Change & Extreme Weather in Transportation Asset Management
FHWA | April 1, 2023 | https://www.fhwa.dot.gov/asset/pubs/hif23010.pdf
This handbook aims to assist transportation practitioners in integrating natural hazard resilience into asset management. It outlines who should be involved in the planning process and how various groups can collaborate.

Geotechnical Asset Management for Transportation Agencies, Volume 2: Implementation Manual
Transportation Research Board | September 26, 2019 |
https://www.trb.org/Publications/Blurbs/178602.aspx
This document critiques the traditional understanding of geotechnical assets as unpredictable hazard sites with significant potential liability. Rather, the report characterizes geotechnical assets as vital to the successful operation of transportation systems and claims they present an opportunity for system owners and operators to realize new economic benefits through risk-based asset management.

Lessons Learned and Impacts to Date of State DOT Implementation of New Federal Transit Asset Management and Public Transportation Agency Safety Requirements
Transportation Research Board | December 31, 2019 |
https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4332
This resource details how recent FTA rulings on asset management have influenced state DOTs internally and impacted asset condition. It provides states with information to assess the effectiveness of their efforts and refine their implementation strategies.

Return on Investment in Transportation Asset Management Systems and Practices
Transportation Research Board | January 30, 2018 |
https://www.trb.org/NCHRP/Blurbs/177179.aspx#:~:text=TRB's%20National%20Cooperative%20Highway%20Research,investment%20for%20adopting%20or%20expanding
This report examines how transportation agencies manage their assets and offers guidance on evaluating the return on investment for adopting or expanding transportation asset management systems within an agency.

Bridge Element Data Collection and Use
Transportation Research Board | January 1, 2022 |
https://nap.nationalacademies.org/catalog/26724/bridge-element-data-collection-and-use
The TRB National Cooperative Highway Research Program's NCHRP Synthesis 585: Bridge Element Data Collection and Use documents the practices and experiences of state DOTs in collecting element-level data and ensuring its accuracy. The synthesis also explores how state DOTs utilize data from inspection reports.

Highway Infrastructure Inspection Practices for the Digital Age

Transportation Research Board | January 1, 2022 | https://nap.nationalacademies.org/catalog/26592/highway-infrastructure-inspection-practices-for-the-digital-age
The TRB National Cooperative Highway Research Program's NCHRP Synthesis 582: Highway Infrastructure Inspection Practices for the Digital Age details the technologies employed by DOTs for inspecting highway infrastructure during construction and maintenance. These technologies include unmanned aircraft systems (UASs), embedded and remote sensors, intelligent machines, mobile devices, and new software applications.

Transportation System Resilience: Research Roadmap and White Papers
Transportation Research Board | January 1, 2021 | https://nap.nationalacademies.org/catalog/26160/transportation-system-resilience-research-roadmap-and-white-papers
Transportation System Resilience: Research Roadmap and White Papers identifies key knowledge gaps within AASHTO and state departments of transportation, proposes a 5-year research plan to bridge these gaps, and explores critical resilience-related challenges facing senior transportation leaders today.

Resilience Primer for Transportation Executives
Transportation Research Board | January 1, 2021 | https://nap.nationalacademies.org/catalog/26195/resilience-primer-for-transportation-executives
Resilience Primer for Transportation Executives offers a concise overview of resilience benefits, the CEO's role in enhancing resilience, and the strategies adopted by various states to strengthen their transportation systems. It also provides concepts and tools to guide agencies toward greater resilience.

Mainstreaming System Resilience Concepts into Transportation Agencies: A Guide
Transportation Research Board | January 1, 2021 | https://nap.nationalacademies.org/catalog/26125/mainstreaming-system-resilience-concepts-into-transportation-agencies-a-guide
Mainstreaming System Resilience Concepts into Transportation Agencies: A Guide equips transportation officials with a self-assessment tool to evaluate the current status of their agency's efforts to enhance transportation system resilience by integrating resilience concepts into decision-making and procedures. This tool can be used to address a wide range of natural and human-caused threats to transportation systems and services.

Disparate Approaches to Maintaining Roads and Sidewalks: An Interview Study of 16 U.S. Cities
Transportation Research Board | May 3, 2022 | https://trid.trb.org/view/1945979
While America's "crumbling roads" dominate the infrastructure narrative, deteriorating sidewalks are also in urgent need of attention. This research aims to explore the similarities and differences in how American cities manage their road versus sidewalk networks by examining whether these two essential urban public assets are repaired, maintained, and funded differently.

Technical Asset Management for Railway Transport: Using the URRAN Approach
Springer Cham | January 4, 2022 | https://link.springer.com/book/10.1007/978-3-030-90029-8
This book familiarizes readers with the fundamental elements of the URRAN-based technical asset management system, a methodology devised for managing resources and risks by assessing and ensuring the necessary levels of reliability and safety within Russia's railway transport infrastructure. It outlines the structure of the URRAN information system's unified corporate

platform (UCP URRAN) and its subsystems dedicated to infrastructure facilities and rolling stock complexes.

Best Practices in Bridge Management Decision-Making
Transportation Research Board | November 1, 2009 |
http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-68A_07-05.pdf
This resource is a domestic review centered on practices adopted by state DOTs for identifying, prioritizing, and implementing programs aimed at managing highway bridges. The review encompasses evaluations of DOT manuals, guidelines, and policy statements, along with compiling responses to detailed inquiries from DOTs and conducting visits to seven sites for discussions with DOT staff.

Incorporating Maintenance Costs into a Transportation Asset Management Plan
FHWA | October 1, 2022 | https://nap.nationalacademies.org/catalog/27290/incorporating-maintenance-costs-into-a-transportation-asset-management-plan
"Incorporating Maintenance Costs into a Transportation Asset Management Plan," part of TRB's National Cooperative Highway Research Program, presents research aimed at constructing a framework for state DOTs and other transportation agencies to integrate maintenance costs into their TAMPs.

Handbook for Including Ancillary Asses in Transportation Asset Management Programs
FHWA | September 1, 2019 |
https://www.fhwa.dot.gov/publications/research/infrastructure/19068/index.cfm
This handbook introduces a methodology designed to assist highway asset owners and maintenance personnel in identifying the assets crucial for supporting their agencies' missions and objectives, extending beyond pavements and bridges. The methodology prioritizes asset classes and identifies relevant data that best support a performance-based approach to managing the condition and utilization of these assets.

A Guide to the Reliability-Centered Maintenance (RCM) Standard
SAE International | August 1, 2011 |
https://www.sae.org/standards/content/ja1012_201108/?utm_source=google&utm_medium=ppc&utm_campaign=iso_campaign&utm_content=pd_pmax_iso_refresh032023&utm_term=b2c&gclid=CjwKCAjwp8OpBhAFEiwAG7NaEhmWwRJVHSLpTJbYILosMFpm-tfah9hgD7sCmFWyJUZ7rpjHbxD4TxoCIjAQAvD_BwE
The Guide to Reliability-Centered Maintenance (RCM) elaborates on and provides clearer explanations for each of the key criteria outlined in SAE JA1011 "Evaluation Criteria for RCM Processes." Additionally, it summarizes other essential considerations necessary for the successful application of RCM.

Evaluation Criteria for Reliability-Centered Maintenance (RCM) Processes
SAE International | August 1, 2009 | https://studylib.net/doc/25686202/23.-sae-ja1011---2009---evaluation-criteria-for-reliabili...
This document outlines the essential criteria that any process must meet to be considered compliant with RCM standards. Its purpose is to offer a framework for assessing whether a particular process adheres faithfully to the foundational principles of RCM as initially conceived.

Vulnerability Assessment and Adaptation Framework
FHWA | December 1, 2017 |
https://www.fhwa.dot.gov/environment/sustainability/resilience/adaptation_framework/

The Vulnerability Assessment and Adaptation Framework by the Federal Highway Administration is a guidebook designed to assist transportation agencies and their collaborators in evaluating the susceptibility of transportation infrastructure and systems to the impacts of extreme weather and climate conditions. It also aids agencies in incorporating climate adaptation considerations into their transportation decision-making processes.

Climate Change Adaptation Case Studies
FHWA | December 6, 2022 |
https://www.fhwa.dot.gov/environment/sustainability/resilience/case_studies/
This tool provides a series of climate change adaptation case studies. Use this search tool to narrow down the list of studies, or select "All Records" to see all of the case studies on file.

Chapter 5 References

A Guide to Computation and Use of System-Level Valuation of Transportation Assets
Transportation Research Board | July 27, 2022 |
https://nap.nationalacademies.org/catalog/26667/a-guide-to-computation-and-use-of-system-level-valuation-of-transportation-assets
Establishing the worth of a transportation organization's physical assets holds significance for both financial reporting and transportation asset management (TAM). The Guide to Computing and Utilizing System-Level Valuation of Transportation Assets provides instructions on computing asset value and leveraging it to enhance its application in TAM.

Prioritization of Public Transportation Investments: A Guide for Decision-Makers
Transportation Research Board | January 1, 2021 |
https://nap.nationalacademies.org/catalog/26224/prioritization-of-public-transportation-investments-a-guide-for-decision-makers
"Prioritizing Public Transportation Investments: A Guide for Decision-Makers" offers practical guidance to transportation agencies seeking to enhance their prioritization processes for public transportation projects.

Measuring the Effectiveness of Public Involvement in Transportation Planning and Project Development
Transportation Research Board | January 1, 2019 |
https://nap.nationalacademies.org/catalog/25447/measuring-the-effectiveness-of-public-involvement-in-transportation-planning-and-project-development
“Measuring the Effectiveness of Public Involvement in Transportation Planning and Project Development” offers a field-validated and practitioner-ready toolkit to measure the impact of a transportation agency’s public involvement activities. The toolkit is designed to collect feedback from the public on several indicators of effectiveness and to compare that feedback with the agency’s internal perspective.

A Multi-asset Transportation Infrastructure Asset Management Framework and Modeling for Local Governments
CTEDD | June 7, 2019 | https://rosap.ntl.bts.gov/view/dot/65589
This resource suggests that to uphold aging infrastructure in a state of good repair amid shrinking budgets, local governments should embrace a systematic approach to carry out cost-effective maintenance, rehabilitation, and reconstruction (MR&R), rather than depending solely on subjective individual knowledge and experience.

Case Study 5 – Financial Planning and Investment Strategies
FHWA | May 1, 2020 | https://rosap.ntl.bts.gov/view/dot/54333
This case study examines the financial planning and investment strategies observed in state DOTs in 2019. These strategies demonstrate how DOTs formulated long-term funding allocations for pavements and bridges, relying on projected revenue forecasts and estimates of funding requirements for each asset category, using the LCP processes to enhance, maintain, and preserve their transportation assets in a state of good repair.

Investment Prioritization Methods for Low-Volume Roads
Transportation Research Board | January 1, 2018 |
https://nap.nationalacademies.org/catalog/25142/investment-prioritization-methods-for-low-volume-roads
"Investment Prioritization Methods for Low-Volume Roads" outlines current practices and strategies used by transportation agencies to make investment decisions about low-volume roads.

Fix It, Sign It, or Close It: State of Good Repair in an Era of Budget Constraints
Transportation Research Board | July 1, 2021 |
https://nap.nationalacademies.org/catalog/26266/fix-it-sign-it-or-close-it-state-of-good-repair-in-an-era-of-budget-constraints
"Fix It, Sign It or Close It: State of Good Repair in an Era of Budget Constraints" examines the legal implications for transportation agencies facing decisions on whether to repair, enhance, or reconstruct assets in deteriorating condition.

Geotechnical Asset Management for Transportation Agencies, Volume 2: Implementation Manual
Transportation Research Board | January 1, 2019 |
https://nap.nationalacademies.org/catalog/25364/geotechnical-asset-management-for-transportation-agencies-volume-2-implementation-manual
"Geotechnical Asset Management for Transportation Agencies, Volume 2: Implementation Manual" offers a guidebook designed for implementing Geotechnical Asset Management (GAM) planning.

Guide to Asset Management – Processes Part 8: Financial Management
Transportation Research Board | July 26, 2018 | https://trid.trb.org/view/1527948
Chapter 8 of the GAM is designed to aid professionals in financial management, particularly in asset valuation and auditing. It emphasizes regular reporting and accounting for assets, alongside guidance on ensuring financial sustainability. This includes compiling a financial strategy, developing a long-term financial plan, and utilizing financial sustainability indicators to ensure the affordability and longevity of the asset management plan.

Asset Management Manual: Organization
PIARC | October 16, 2023 | https://road-asset.piarc.org/en/management/organization
This chapter delves into various aspects of restructuring a road organization to unlock the benefits of asset management and assist the organization in meeting its goals. These include leadership and cultural considerations, self-assessment of current asset management practices, the pivotal role of asset management champions in driving necessary changes, and establishing an organizational structure conducive to implementing asset management strategies.

Asset Valuation Practices and Functionality
FHWA | January 1, 2020 | https://rosap.ntl.bts.gov/view/dot/57420

This report improves asset management planning endeavors to align more effectively with Federal requirements by offering diverse approaches to valuing transportation assets. The project encompassed a review of current practices, an assessment of relevant literature, and an overview of workshops and training sessions demonstrating the application of various approaches.

A Guide to Incorporating Maintenance Costs into a Transportation Asset Management Plan
Transportation Research Board | January 1, 2023 | https://nap.nationalacademies.org/catalog/27291/a-guide-to-incorporating-maintenance-costs-into-a-transportation-asset-management-plan
"A Guide to Incorporating Maintenance Costs into a Transportation Asset Management Plan," part of TRB's National Cooperative Highway Research Program, guides practitioners through a six-part framework intended to address the major hurdles agencies encounter when projecting future maintenance costs in TAMP activities.

The Balanced Scorecard – Measures that Drive Performance
Harvard Business Review | February 1, 1992 | https://hbr.org/1992/01/the-balanced-scorecard-measures-that-drive-performance-2
This resource provides a framework for performance management, challenging conventional strategies developed for assessing performance measurements. The "Balance Scorecard" method includes both financial and operational measures, creating a more accurate and holistic evaluation of efficiency.

A Guide to Developing Financial Plans and Performance Measures for Transportation Asset Management
Transportation Research Board | January 1, 2019 | https://nap.nationalacademies.org/catalog/25285/a-guide-to-developing-financial-plans-and-performance-measures-for-transportation-asset-management
"A Guide to Developing Financial Plans and Performance Measures for Transportation Asset Management" offers advice for state departments of transportation (DOTs) and other agencies conducting financial analyses and crafting financial plans to bolster the efficient and effective management of the agency's transportation assets.

Chapter 6 References

Continual Improvement Processes for Asset Management: Guidelines
Austroads | May 28, 2018 | https://austroads.com.au/publications/asset-management/ap-r571-18
The guideline seeks to equip asset management practitioners with insights into the factors facilitating and maintaining ongoing enhancement. It addresses existing industry challenges concerning continual improvement and offers a framework for successful implementation.

Case Study 4 – Managing Risks to Assets
FHWA | February 1, 2021 | https://rosap.ntl.bts.gov/view/dot/55725
This case study showcases the methods employed by State Departments of Transportation (DOTs) to mitigate risks to their transportation assets.

Identifying and Managing Financial Risks in a Transportation Asset Management Plan (TAMP)
FHWA | August 1, 2023 | https://www.fhwa.dot.gov/asset/pubs/hif23049.pdf

This report expands upon insights obtained from case studies conducted with State Departments of Transportation on the identification and management of financial risks. It outlines the typical financial risks addressed in State DOT TAMPs and examines how these elements shape the formulation of TAMP investment strategies.

Next-Generation Pavement Performance Measures
FHWA | September 20, 2023 | https://trid.trb.org/View/2259800
This resource summarizes the Federal Highway Administration (FHWA) report Development of Next Generation Pavement Performance Measures and connects the effort to a broader project to develop Performance Management Objectives. Furthermore, the resource describes key findings from the research and explores how they can be used to support agency decision-making strategies.

Next-Generation Transportation Asset Management Methodology
FHWA | September 20, 2023 | https://trid.trb.org/View/2259801
This TechBrief serves as a follow up to Next-Generation Pavement Performance Measures (FHWA-HRT-23-102). It outlines the Federal Highway Administration (FHWA) report Development of Next Generation Pavement Performance Measures and Asset Management in an ongoing effort to develop and refine Performance Management Objectives.

R&T Portfolio: Transportation Performance Management
FHWA | June 9, 2022 | https://highways.dot.gov/research/rtportfolio/infrastructure-performance-management
The project aims to identify, analyze, communicate, and implement a set of leading indicators for transportation performance. It will generate a report detailing how transportation agencies can use these leading indicators to monitor and adjust performance measure targets for national performance-measurement areas, including infrastructure condition. The report also outlines a method that agencies can employ to identify, analyze, and select their own leading or lagging indicators to guide investment decision-making.

Implementation of the AASHTO Guide for Enterprise Risk Management
Transportation Research Board | June 9, 2022 | https://nap.nationalacademies.org/catalog/26516/implementation-of-the-aashto-guide-for-enterprise-risk-management
"Implementation of the AASHTO Guide for Enterprise Risk Management" details how various state departments of transportation are incorporating risk management principles and practices.

Effective Methods for Setting Transportation Performance Targets
Transportation Research Board | December 30, 2022 | https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4788
This research aims to assist state DOTs and Metropolitan Planning Organizations (MPOs) in identifying effective methods for setting transportation performance targets based on established national measures.

Asset Sustainability Index: A Proposed Measure for Long-Term Performance
FHWA | June 28, 2017 | https://www.fhwa.dot.gov/planning/processes/statewide/practices/asset_sustainability_index/page01.cfm

This resource defines and positions terminology used when discussing the concept of asset sustainability.

Transportation Performance Management
FHWA | December 31, 2020 | https://www.fhwa.dot.gov/tpm/plan/
This resource outlines all the implementation plan activities scheduled for completion between 2018 and 2020. The plan includes 38 activities, 37 of which have been completed.

National Performance Measures for Congestion, Reliability, and Freight, and CMAQ Traffic Congestion
FHWA | June 1, 2018 | https://www.fhwa.dot.gov/tpm/guidance/hif18040.pdf
"National Performance Measures for Congestion, Reliability, and Freight, and CMAQ Traffic Congestion: General Guidance and Step-by-Step Metric Calculation Procedures" provides recommended procedures for calculating the National Highway System performance metrics, the Truck Travel Time Reliability metrics, and the Peak Hour Excessive Delay metric.

Linking Performance and Asset Management
FHWA | July 1, 2019 | https://www.fhwa.dot.gov/asset/etg/pubs/whitepaper2.pdf
This paper explores how the transportation asset management processes outlined in 23 CFR 515, the transportation performance management processes in 23 CFR 490, and the planning requirements in 23 CFR 450 enhance the connection between asset management and performance management.

Guide to Effective Methods for Setting Transportation Performance Targets
Transportation Research Board | January 1, 2023 | https://nap.nationalacademies.org/catalog/26326/integrating-effective-transportation-performance-risk-and-asset-management-practices
"Guide to Effective Methods for Setting Transportation Performance Targets," from TRB's National Cooperative Highway Research Program, is intended to assist state DOTs and metropolitan planning organizations in identifying effective methods for setting transportation performance targets in line with established national measures.

Remaining Service Interval: A White Paper
Transportation Research Board | March 1, 2021 | https://trid.trb.org/view/1833123
This white paper outlines, in simple terms, the fundamental concepts associated with the RSI framework. The document leads the reader through the basic process of RSI application and uses simple examples to illustrate how the RSI framework can be used to support investment decisions.

Managing Performance to Enhance Decision-Making: Making Targets Matter
Transportation Research Board | January 1, 2022 | https://nap.nationalacademies.org/catalog/26600/managing-performance-to-enhance-decision-making-making-targets-matter
"Managing Performance to Enhance Decision-Making: Making Targets Matter" presents a collection of feedback enrichment strategies demonstrated through case studies. These examples show how agencies effectively integrate people- and data-based feedback into decision-making processes for transportation issues, spanning from long-term strategy development to medium-term program planning and daily operations.

Developing a Guide to Effective Methods for Setting Transportation Performance Targets
Transportation Research Board | January 1, 2023 |
https://nap.nationalacademies.org/catalog/26764/guide-to-effective-methods-for-setting-transportation-performance-targets
"Developing a Guide to Effective Methods for Setting Transportation Performance Targets," from TRB's National Cooperative Highway Research Program, aims to assist state DOTs and metropolitan planning organizations in identifying effective methods for establishing transportation performance targets aligned with national measures.

Strategic Performance Measures for State Departments of Transportation: A Handbook for CEOs and Executives
AASHTO | March 19, 2004 | https://trid.trb.org/View/696635
This guide connects strategic planning and performance measurement through strategic performance measures, translating organizational vision into a focused set of measurable, meaningful, and accurate indicators.

Construction Economics
Engineering News-Record | October 19, 2013 | https://www.enr.com/economics
This website provides an explanation of the index's methodology and a comprehensive history of the 20-city national average for both the CCI and BCI. Each index includes a materials and labor component. In the second issue of each month, ENR publishes the CCI, BCI, materials index, skilled labor index, and common labor index for 20 cities and the national average.

Beyond the Short Term: Transportation Asset Management for Long-Term Sustainability, Accountability, and Performance
FHWA | September 10, 2010 | https://www.fhwa.dot.gov/asset/10009/tam_topr806.pdf
This report re-evaluates TAM as a method for achieving sustainability and as a system for enhancing accountability and performance. It also offers guidance on Change Management practices to elevate and expand TAM practices within a department of transportation.

Bridge Inspector's Reference Manual (BIRM)
Transportation Research Board | March 1, 2023 | https://trid.trb.org/view/2219426
This document, the Bridge Inspector's Reference Manual (BIRM), serves as an extensive reference guide on the programs, procedures, and techniques for inspecting and evaluating various in-service highway bridges. It is designed to replace the Bridge Inspector's Reference Training Manual (BITM) 90, originally published in 1991, which was developed to train highway personnel in the emerging field of bridge safety inspection.

Transportation Management System Performance Monitoring, Evaluation, and Reporting
FHWA | January 1, 2018 |
https://tmcpfs.ops.fhwa.dot.gov/cfprojects/uploaded_files/tms_pmer_brochure.pdf
Performance measures are employed to prioritize projects, assess the effectiveness of long-term strategies, refine goals and objectives, and enhance the processes for delivering transportation services.

Measuring Transportation Network Performance

Transportation Research Board | September 1, 2010 | https://nap.nationalacademies.org/catalog/14425/measuring-transportation-network-performance
Measuring Transportation Network Performance examines methods to monitor transportation network performance by creating new performance measures or integrating existing ones from various transportation modes and multiple jurisdictions.

Estimating Life Expectancies of Highway Assets
Transportation Research Board | January 1, 2012 | https://nap.nationalacademies.org/catalog/22782/estimating-life-expectancies-of-highway-assets-volume-1-guidebook
"Estimating Life Expectancies of Highway Assets, Volume 1: Guidebook" discusses the application of a methodology for estimating the life expectancies of various types of highway system assets. This methodology is tailored for use in lifecycle cost analyses to aid management decision-making.

Benchmarking and Comparative Measurement for Effective Performance Management
Transportation Research Board | January 1, 2019 | https://www.nap.edu/catalog/25365/benchmarking-and-comparative-measurement-for-effective-performance-managementcoll-by-transportation-agencies
"Benchmarking and Comparative Measurement for Effective Performance Management" by Transportation Agencies offers advice and illustrations on choosing peer groups to ensure the effective application of benchmarking for improving transportation system performance.

Maintenance Quality Assurance Field Inspection Practices
Transportation Research Board | September 1, 2015 | https://nap.nationalacademies.org/catalog/22201/maintenance-quality-assurance-field-inspection-practices
"Maintenance Quality Assurance Field Inspection Practices" provides an overview of the methods employed by state transportation agencies to uphold maintenance investments.

Life-Cycle Cost Analysis for Management of Highway Assets
Transportation Research Board | September 1, 2016 | https://www.nap.edu/catalog/23515/life-cycle-cost-analysis-for-management-of-highway-assets
Life-Cycle Cost Analysis for Management of Highway Assets illustrates the current practices of life-cycle cost analysis (LCCA) and risk-based analysis incorporated into state highway agencies' asset management plans for pavements and bridges on the National Highway System. The project aimed to compile a list of quantitative processes and models, at the asset, project, or corridor levels, for predicting life-cycle costs related to the preservation and replacement of highway assets.

A Methodology for Performance Measurement and Peer Comparison in the Public Transportation Industry
Transportation Research Board | January 1, 2010 | https://www.nap.edu/catalog/14402/a-methodology-for-performance-measurement-and-peer-comparison-in-the-public-transportation-industry
A Methodology for Performance Measurement and Peer Comparison in the Public Transportation Industry investigates the application of performance measurement and benchmarking as

instruments to assess the strengths and weaknesses of a transit organization, establish performance goals or targets, and identify best practices for enhancing performance.

Transportation Economic Trends 2017
U.S. Department of Transportation: Bureau of Transportation Statistics | January 1, 2018 | https://www.bts.gov/sites/bts.dot.gov/files/docs/browse-statistical-products-and-data/bts-publications/215901/transportation-economic-trends-2017.pdf
This resource provides a snapshot of the United States Economy as it relates to the transportation industry. Chapter 1 presents the Transportation Services Index, offering a monthly overview of both freight and passenger movement. Chapter 2 delves into the economic contributions of transportation in America. Chapter 3 scrutinizes the costs incurred by households and businesses for transportation. Chapter 4 assesses transportation-related employment. Chapter 5 explores trends in transportation productivity. Chapter 6 analyzes household expenditure on transportation goods and services. Chapter 7 scrutinizes government spending and revenue in transportation. Finally, Chapter 8 discusses transportation assets and infrastructure.

Asset Management
FHWA | May 25, 2023 | https://www.fhwa.dot.gov/asset/10009/tam_topr806.pdf
This resource serves as a database for all case studies, reports, and other publications from the FHWA that pertain to the topic: Asset Management.

The RACI Matrix: Your Blueprint for Project Success
IDG Communication's, Inc. | September 14, 2022 | https://www.cio.com/article/2395825/project-management-how-to-design-a-successful-raci-project-plan.html
A RACI matrix offers a straightforward and efficient method for delineating project roles and responsibilities. It furnishes a comprehensive chart detailing who is responsible, accountable, consulted, and informed throughout each phase of the project.

Chapter 7 References

AASHTO TAM Data Guide
AASHTO | May 1, 2020 | https://www.tamdataguide.com/
This guidebook provides a structured approach to assess current practices and improve use of data and information for TAM. Explore and apply this guidance through this website and the companion TAM Data Assistant digital application.

Building Capacity for Self-Assessment of Data Effectiveness for Agency Business Needs
Transportation Research Board | May 9, 2022 | https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4669
This research and its final report provide guidance to assist state departments of transportation (DOTs), metropolitan planning organizations (MPOs), and other transportation agencies in evaluating and improving the value of their data and their data management practices.

Data to Support Transportation Agency Business Needs: A Self-Assessment Guide
Transportation Research Board | January 1, 2015 | https://nap.nationalacademies.org/catalog/23463/data-to-support-transportation-agency-business-needs-a-self-assessment-guide

Data to Support Transportation Agency Business Needs: A Self-Assessment Guide offers techniques to assess and enhance the usefulness of data for decision-making purposes, along with their data management practices.

Lifecycle BIM for Infrastructure: A Business Case for Project Delivery and Asset Management
Transportation Research Board | January 1, 2023 | https://nap.nationalacademies.org/catalog/23463/data-to-support-transportation-agency-business-needs-a-self-assessment-guide
"Lifecycle BIM for Infrastructure: A Business Case for Project Delivery and Asset Management" centers on creating resources to facilitate the integration of Building Information Modeling by highway agencies.

Building Information Modeling (BIM) for Bridges and Structures
FHWA | August 8, 2023 | https://www.pooledfund.org/Details/Study/624
This resource outlines the adoption of building information modeling (BIM) in transportation structures through an ongoing study conducted by AASHTO.

A New Perspective in the Road Asset Management with the use of Advanced Monitoring System & BIM
EDP Sciences | November 16, 2018 | https://www.researchgate.net/publication/328992872_A_new_perspective_in_the_road_asset_management_with_the_use_of_advanced_monitoring_system_BIM
This paper discusses various applications that share a common data source: the Automatic Road Analyzer (ARAN) from the Transport Infrastructure Laboratory at the University of Catania. Data collected with ARAN were utilized to create performance indicators for road assets and to construct a BIM model.

Integrating Computer-Aided Dispatch Data with Traffic Management Centers
FHWA | February 1, 2021 | https://ops.fhwa.dot.gov/publications/fhwahop20064/index.htm
This publication outlines the benefits of integrating data from law enforcement and public safety computer-aided dispatch systems with transportation operating systems. This integration enhances incident response, contributes to saving responder lives, and enhances safety for network travelers. The document showcases multiple successful case studies of data-sharing partnerships that have led to enhanced operational information and improved decision-making data for travelers.

Establishing Multisource Data-Integration Framework for Transportation Data Analytics
Journal of Transportation Engineering | February 19, 2020 | https://trid.trb.org/view/1693703
This study presents a transportation data-integration framework centered on a standardized geospatial roadway referencing layer. Within this framework, transportation data are categorized into four groups based on the locations and coverage areas of traffic sensors: on-road segment-based data, off-road segment-based data, on-road point-based data, and off-road point-based data.

Transit Asset Management Systems Handbook
FHWA | October 15, 2020 | https://www.transit.dot.gov/regulations-and-programs/asset-management/transit-asset-management-systems-handbook

This handbook aims to enhance and offer comprehensive information and advice on managing systems and their associated assets within the transit operating environment to comply with the FTA Transit Asset Management (TAM) rule.

National Transit Database
FTA | October 17, 2023 | https://www.transit.dot.gov/ntd/ntd-data
This online database contains extensive information on national transit records.

Collaborative Practices for Performance-Based Asset Management Between State DOTs and MPOs
Transportation Research Board | January 1, 2021 | https://nap.nationalacademies.org/catalog/26337/collaborative-practices-for-performance-based-asset-management-between-state-dots-and-mpos
"Collaborative Strategies for Performance-Based Asset Management Between State DOTs and MPOs" details the collaborative approaches adopted by DOTs to work with MPOs concerning target establishment, investment determinations, and performance tracking of pavement and bridge assets.

Guidebook for Data and Information Systems for Transportation Asset Management
Transportation Research Board | December 31, 2022 | https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4362
The NCHRP project aimed to develop a guidebook and related guidance materials to enhance asset management processes. It focused on principles, organizational strategies, and practical examples to improve data collection, information development, and decision-making. The goal was to ensure usability, awareness, and application of these guidelines in managing transportation system assets effectively.

AASHTO TAM Data Guide: Data and Information Systems for Transportation Asset Management
AASHTO | May 1, 2020 | https://www.tamdataguide.com/
The NCHRP 08-115 Guidebook offers a systematic method for evaluating existing TAM procedures and enhancing the utilization of data and information in TAM endeavors.

AASHTO TAM Data Assistant
AASHTO | October 18, 2023 | https://dataassessment.tam-portal.com/
The AASHTO TAM Data Assistant offers a framework to evaluate current TAM methodologies and enhance the utilization of data and information in TAM processes.

Building Capacity for Self-Assessment of Data Effectiveness for Agency Business Needs
Transportation Research Board | May 9, 2022 | https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4669
This implementation project aims to assist decision-makers and data practitioners in assessing and enhancing their data quality and management practices. The goal of this initiative is to promote the adoption and implementation of the principles and methodologies outlined in NCHRP Report 814: Data to Enhance Transportation Agency Business Needs: A Self-Assessment Guide.

Lifecycle BIM for Infrastructure: A Business Case for Project Delivery and Asset Management

Transportation Research Board | December 31, 2021 |
https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4874
The aim of this research was to assess the business rationale for BIM adoption within the United States, analyzing how implementing enterprise-wide BIM systems can enhance agency efficiencies and facilitate comprehensive lifecycle management of enterprise assets.

Life-Cycle Approach to Collecting, Managing, and Sharing Transportation Infrastructure Asset Data
ASCE Library | January 30, 2017 | https://ascelibrary.org/doi/10.1061/%28ASCE%29CO.1943-7862.0001288
This paper proposes collecting asset inventory data as an integrated part of the construction process, providing an example of such a practice in the construction of a transportation project in Indiana. It asserts that collecting inventory during project construction significantly cuts costs by eliminating duplicative data documentation.

Practical Guide for Quality Management of Pavement Condition Data Quality
FHWA | January 1, 2013 |
https://www.fhwa.dot.gov/pavement/management/qm/data_qm_guide.pdf
The Practical Guide offers insights into establishing and executing a Quality Management (QM) program, integrating established QM methods, and presenting examples or case studies utilizing pavement condition data from diverse state DOTs.

Quality Management of Pavement Condition Data Collection
Transportation Research Board | January 1, 2009 | https://www.nap.edu/catalog/14325/quality-management-of-pavement-condition-data-collection
Quality Management for Pavement Condition Data Collection investigates the quality assurance methods utilized by public highway agencies for automated, semi-automated, and manual pavement data collection and distribution.

A Remote Sensing and GIS-enabled Highway Asset Management System Phase 2
Transportation Research Board | February 2, 2018 |
https://trid.trb.org/Results?txtKeywords=%22asset+data+collection%22#/View/1505178
The aim of this project is to confirm the effectiveness of utilizing commercial remote sensing and spatial information (CRS&SI) technologies, including emerging 3D line laser imaging technology, mobile light detection and ranging (LiDAR), image processing algorithms, and Global Positioning System (GPS)/Geographic Information System (GIS) technologies, for enhancing transportation asset data collection, condition assessment, and management.

A Synthesis Study on Collecting, Managing, and Sharing Road Construction Asset Data
Purdue University: Joint Transportation Research Program | September 1, 2015 |
https://docs.lib.purdue.edu/jtrp/1588/
This project aimed to conduct a synthesis study with two objectives: 1) evaluate the existing practices at INDOT concerning asset data collection during construction and its utilization in the operation and maintenance (O&M) phase, and 2) devise a framework for INDOT to utilize the construction inspection and documentation process for asset data collection.

Best Practices in Geographical Information Systems-Based Transportation Asset Management

U.S. DOT Volpe Center | January 31, 2012 |
https://www.gis.fhwa.dot.gov/documents/GIS_AssetMgmt.pdf
This report offers an overview of Geographic Information Systems (GIS) integration with asset management. It examines the adoption of the technology by public agencies, and explores associated benefits and obstacles.

Communicating Performance Management: State DOTs Continuing to "Tell their Story"
Transportation Research Board | September 30, 2015 |
http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-24(93)B02_FR.pdf
The aim of "Communicating Performance Management—State DOTs Continuing to 'Tell Their Story'" is to build a collection of resources to aid communication and performance management (PM) professionals within state departments of transportation (DOTs).

Data on the Web Best Practices
W3C | January 31, 2017 | https://www.w3.org/TR/2017/REC-dwbp-20170131/
This document outlines best practices for publishing and utilizing data on the web, aimed at fostering a self-sustaining digital environment.

Data Visualization Methods for Transportation Agencies
Cambridge Systematics, Inc. | July 1, 2017 | http://vizguide.camsys.com/index.htm#home
This website serves as a tool for transportation professionals aiming to employ illustrations and visual aids to effectively convey their concepts to an audience.

A Practical Guide to GIS in Asset Management
ESRI | May 1, 2017 | https://www.esri.com/content/dam/esrisites/sitecore-archive/Files/Pdfs/library/whitepapers/pdfs/a-practical-guide-to-gis-in-asset-management.pdf
This white paper examines the role of GIS, drawing on the author's experiences at his own utility and insights from customer implementations of the ESRI ecosystem.

Vital Signs Tools
Metropolitan Transportation Commission | August 22, 2023 | https://mtc.ca.gov/tools-resources/vital-signs
Vital Signs is an interactive website by MTC and the Association of Bay Area Governments (ABAG) that offers data, visual representations of that data and written explanations about important trends in the Bay Area.

Successful Practices in GIS-Based Asset Management
Transportation Research Board | September 1, 2015 |
https://nap.nationalacademies.org/catalog/22194/successful-practices-in-gis-based-asset-management
Successful Practices in GIS-Based Asset Management offers guidance for state transportation agencies on utilizing geographic information system (GIS) technologies for transportation asset management (TAM).

Asset Management Data Collection Guide
AASHTO | January 1, 2006 | https://store.transportation.org/Item/PublicationDetail?ID=390

This Asset Management Data Collection Guide provides detailed information on various highway right-of-way assets. It outlines the functional characteristics of each asset type, typical data collected about the asset, general data collection methods, equipment and technology used for data acquisition, formats and standards for data transfer and storage, usage of the information for condition assessment, and proposes performance and condition standards.

The Visual Display of Quantitative Information
Graphics Press, LLC | September 1, 2001 |
http://faculty.salisbury.edu/~jtanderson/teaching/cosc311/fa21/files/tufte.pdf
Guide to statistical graphics, with emphasis on its use as a statistical method and applications in data analysis and mapping – includes chapters on aesthetics and the methodology of preparing graphs and visual aids.

Road Asset Management Manual
PIARC | October 24, 2017 | https://www.piarc.org/en/PIARC-knowledge-base-Roads-and-Road-Transportation/Road-Safety-Sustainability/Road-Assets-Management/Road-Asset-Management-Manual
The new manual by the World Road Association (PIARC) is designed to assist countries at any development stage in maintaining their infrastructure and implementing strategies for road asset management.

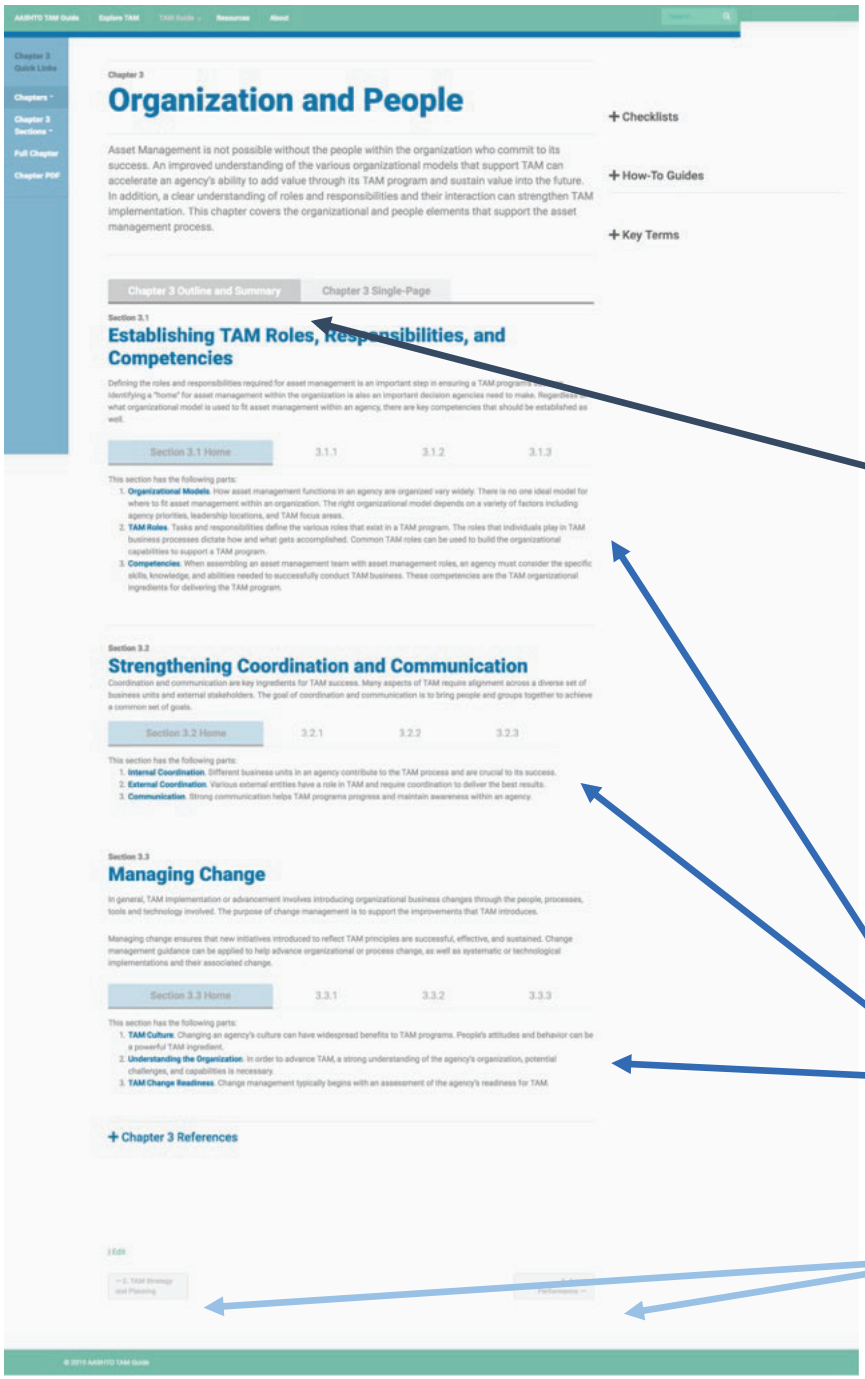
Appendix B: User and Technical Manuals

This appendix provides a combined user and technical manual on how to use the enhanced Digital TAM Guide. It includes instructions and a brief explanation of the example digital content for the Guide, as well as an overview of the additional and updated material that was created as part of the NCHRP Project 08-137 project.

Example Content – Elements

Chapter 3 Homepage

Main Elements



Main Elements of the Chapter 3 Homepage

Chapter-specific color theme. Sidebar navigation, page headers, and other elements are displayed in a chapter-specific color theme.

Outline or Single-Page Mode. Flipping the modes on this panel will change the layout of the Chapter 3 homepage.

Outline Mode Layout. Each chapter features a heading with a title and short summary. Underneath the chapter, each section has its own panel.

Section Panels. Each section has a title, short summary, and a navigable panel.

Chapter Navigation. Clicking the bottom grey buttons will move you between consecutive

Figure B.1. Chapter 3 Landing Page—Main Elements

Additional Elements

Additional Elements of the Chapter 3 Homepage

Expandable and Collapsible Sidebar. Sidebar navigation, page headers, and other elements are displayed in a chapter-specific color theme.

Checklist, How-To Guides, and Key Terms Tabs. This functionality is described in more detail on page B-5.

Chapter References Tab. Click this tab a full look at all the sources used for the chapter, and click their links to find out more about them.

Figure B.2. Chapter 3 Landing Page—Additional Elements

Chapter Sidebar

The sidebar has four buttons: Chapters, Chapter 3 Sections, Full Chapter, and Chapter PDF. The Chapters and Chapter 3 Sections buttons are expandable. This action can be seen in Figure B.3 and Figure B.4 below. The Full Chapter button takes you back to the Chapter 3 Homepage, so it is always easy to find your way back as you navigate through the various elements of the chapter. The Chapter PDF button takes you to a PDF version of the chapter, which users can also download.

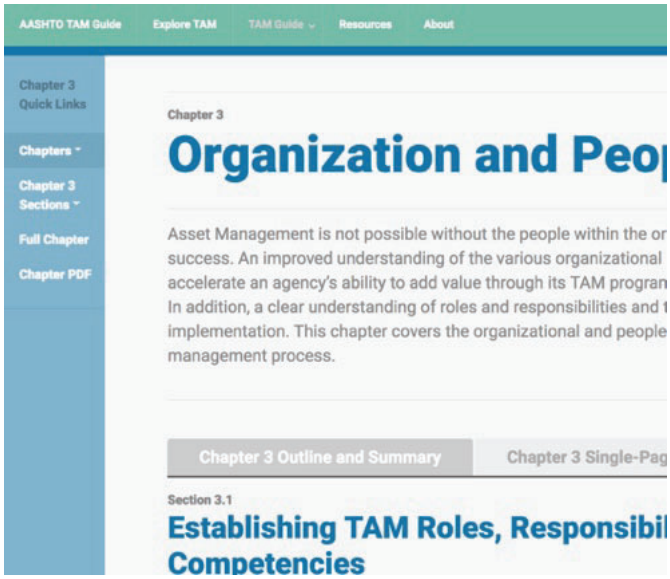


Figure B.3. Chapter 3 Sidebar—a Closer Look, Part 1

Figure B.4. Chapter 3 Sidebar—a Closer Look, Part 2

The Checklist, How-To Guide, and Key Term Tabs

All Checklist and How-To Guides contained in the chapter appear when the tab is expanded. Each is accompanied by a short summary and each heading links to the corresponding Checklist or How-To Guide. The Checklist and How-To Guides page templates are shown later in this guide—seen in Figures B.14 and B.15.

The Key Term Tab contains any Key Terms relevant to the chapter. Any term itself can be clicked and the definition will expand out. This action can be seen in Figure B.6 for the key term “business model.”

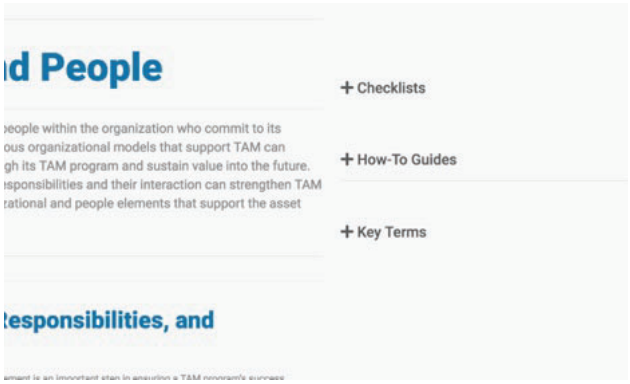


Figure B.5. Collapsed Checklist, How-To Guide, and Key Term Tabs

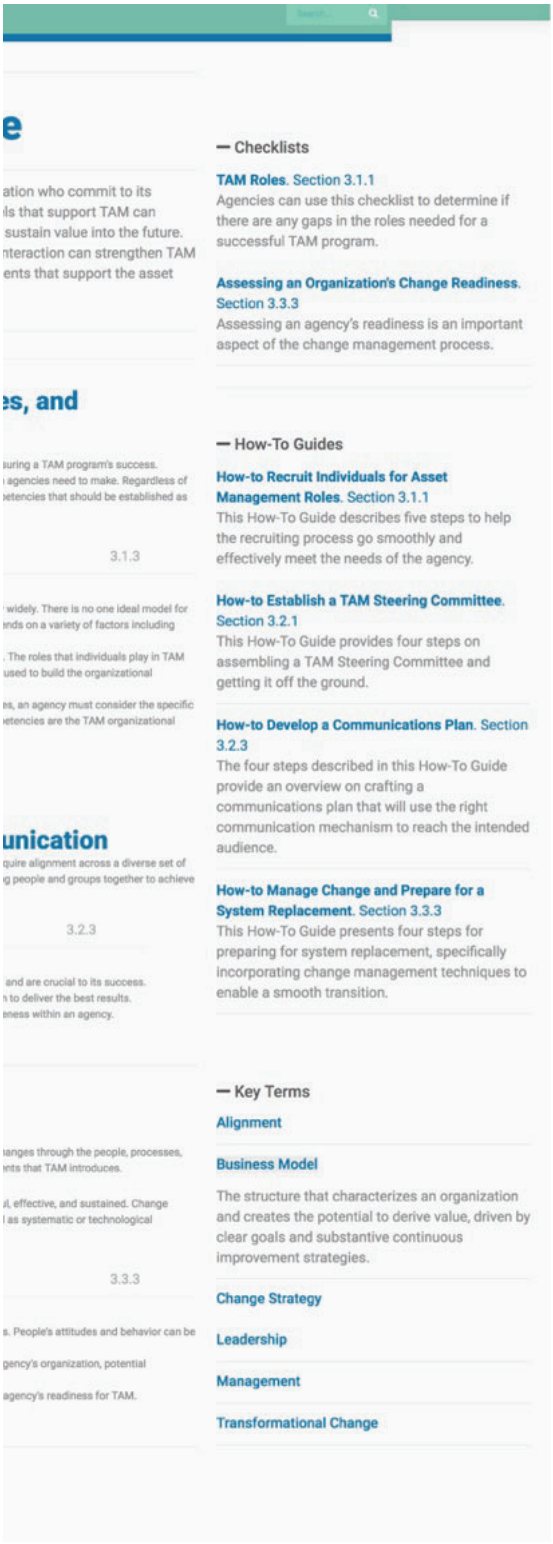
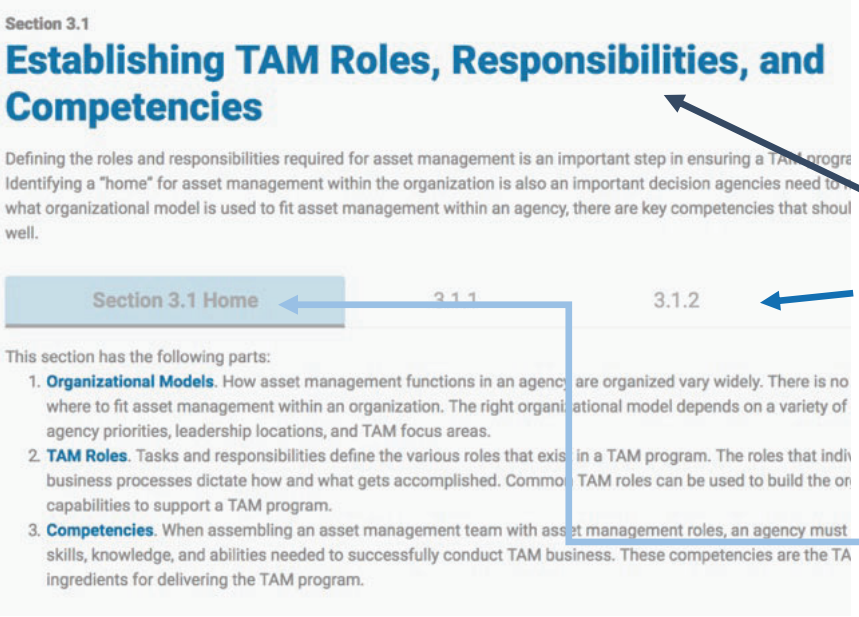


Figure B.6. Expanded Checklist, How-To Guide, and Key Term Tabs

Section Panel



Every section on the Chapter 3 Homepage has its own section panel. The panel has the following features:

Title and Summary.

Navigable Section Menu Part 1. The default position of the section menu is Section Home. The menu also contains tabs for all its subsections.

Section Home. This tab contains subsection titles and descriptions.

Figure B.7. The Section 3.1 Panel—A Closer Look, Part 1

Subsection Tabs. These tabs contain subsection topics and their descriptions.

Figure B.8. The Section 3.1 Panel—A Closer Look, Part 2

The Section Page

Ways to Get There

Click on the desired section either from the Chapter Quick Link Sidebar or click on the Section Heading directly.

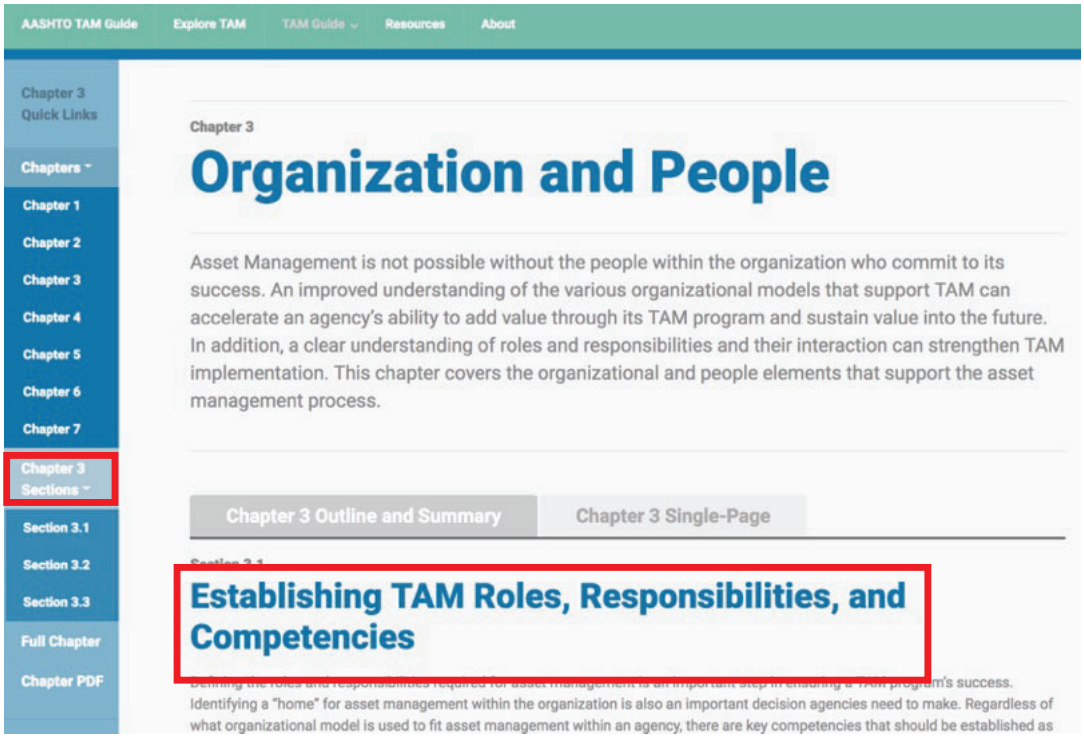
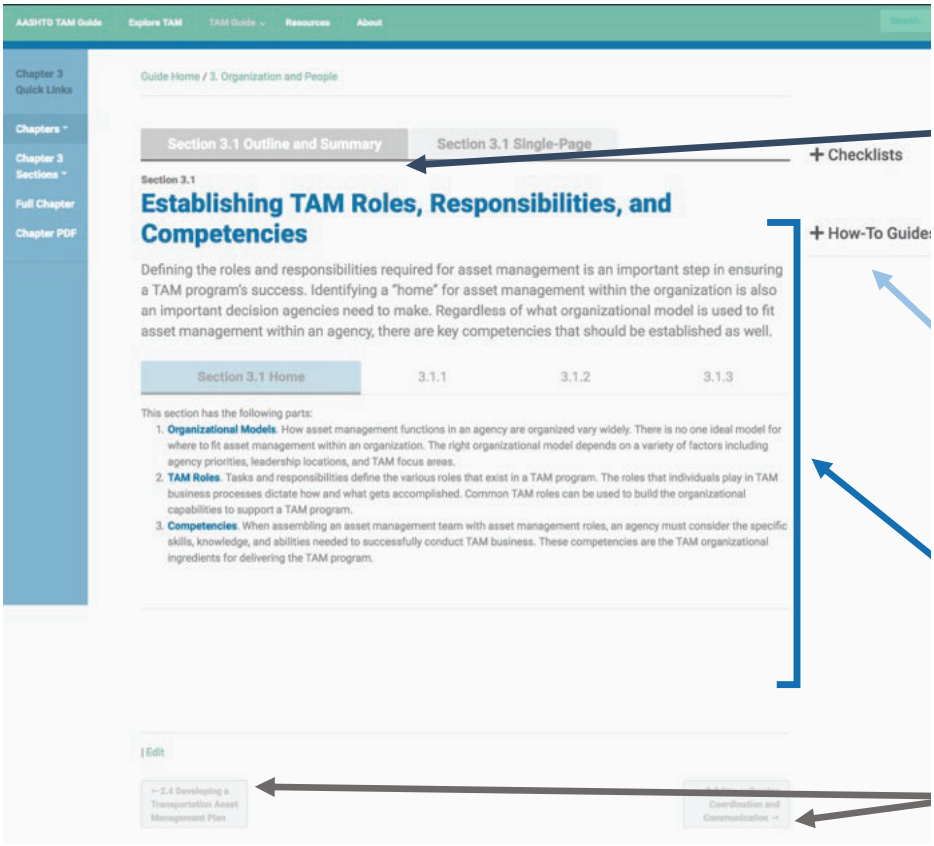


Figure B.9. Navigating to the Section 3.1 Page

Section Page Elements



Outline and Single-Page Modes. The Outline and Single-Page functionality matches the Chapter Homepage.

Checklist and How-To Guides Tabs. Checklists and How-To Guides specific to this section can be accessed here.

Section Panel. The Section Page has the same section panel as is featured on the Chapter Homepage.

Chapter Navigation. Clicking the bottom grey buttons will move you between consecutive section pages.

Figure B.10. Section 3.1 Landing Page Features

The Subsection Page

Ways to Get There

Click on the subsection tab you want. Then click on the heading.

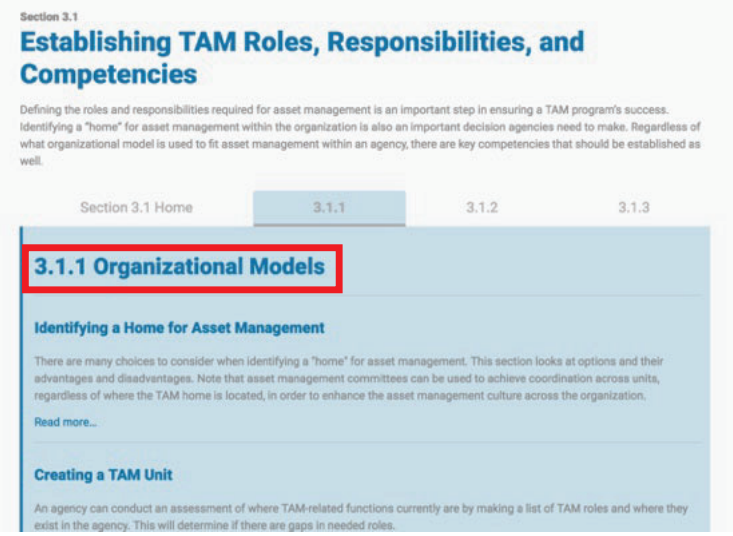


Figure B.11. Navigating to the Subsection 3.1.1 Page

Subsection Page Elements

Subsection Title and Summary.

Checklist and How-To Guides Tabs. Checklists and How-To Guides specific to this subsection can be accessed here.

Figure B.12. Subsection 3.1.1 Landing Page Features

Checklist and How-To Guide Pages

Ways to Get There

Expand the checklist/how-to guide tab and click on the desired checklist or how-to guide title.

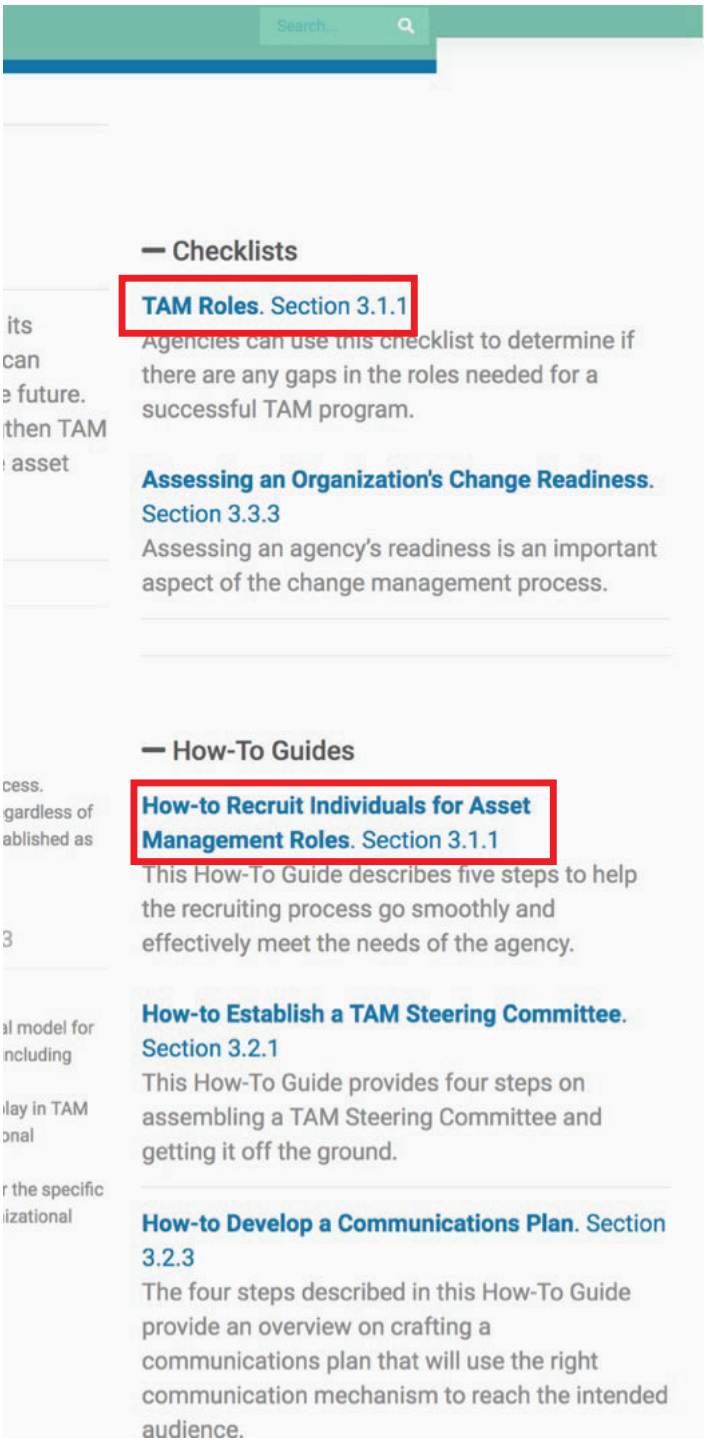
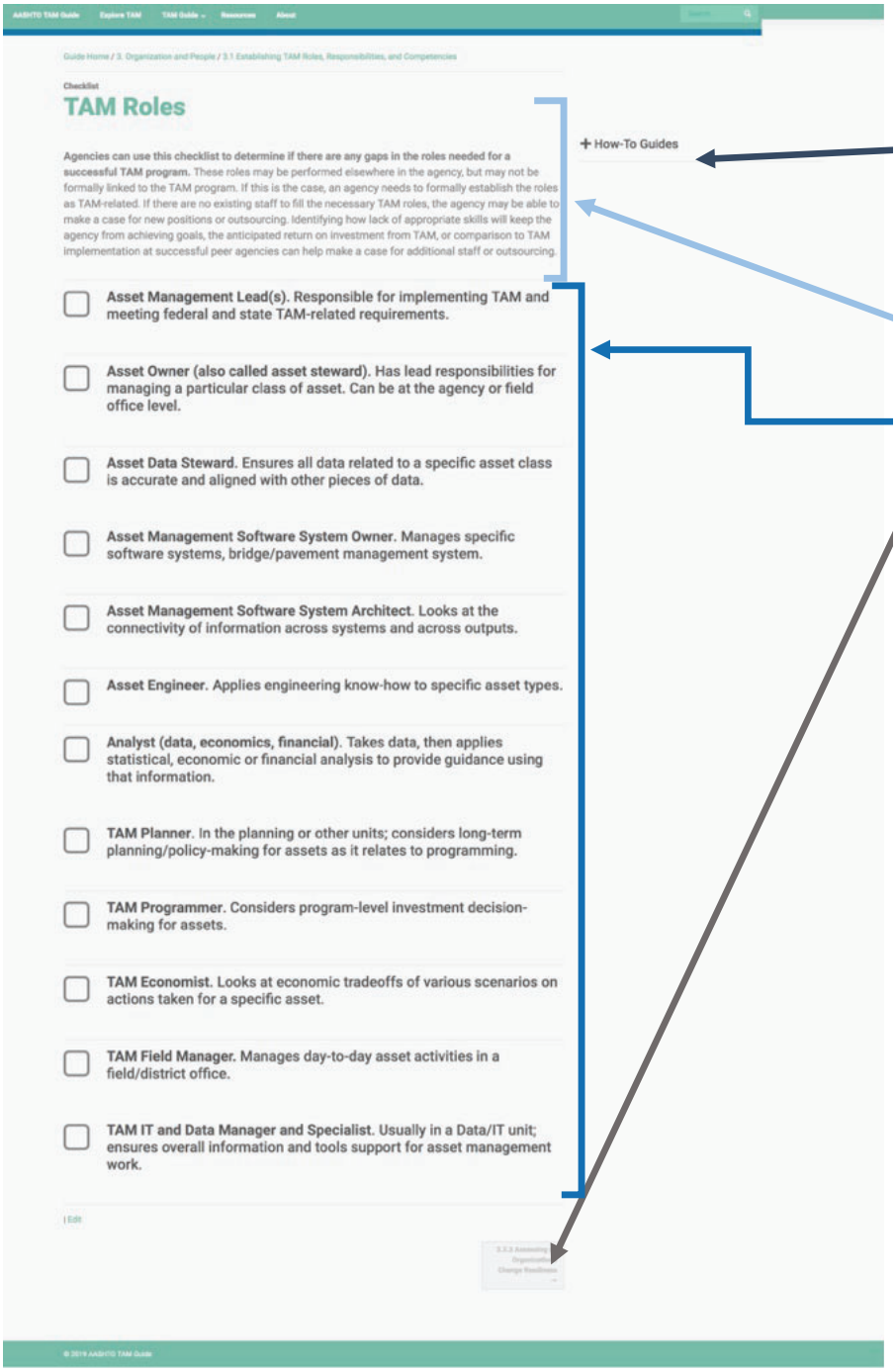


Figure B.13. Navigating to the Checklist or How-To Guide Pages

Checklist Page Elements



Checklist Page Elements

How-To Guides Tab. How-To Guides from the same section appear here.

Checklist Title and Summary.

Checklist Items.

Checklist Navigation. The Checklist navigation button(s) at the bottom will take you to the neighboring checklists in the chapter.

Figure B.14. Checklist Page Features

How-To Guide Page Elements

How-To Guide Page Elements

Checklist Tab. Checklists from the same section appear here.

Guide Title and Summary.

How-To Guide Steps.

How-To Guide Navigation. The How-To Guide navigation button(s) at the bottom will take you to the other guides in the chapter.

Figure B.15. How-To Guide Page Features

Practice Examples

When viewing the single-page chapter, single-page section, or subsection pages, users may run across Practice Example page banners. These are interactive and can be clicked on. The text for the practice example will expand out under the banner. Some practice examples also come with pictures like below.

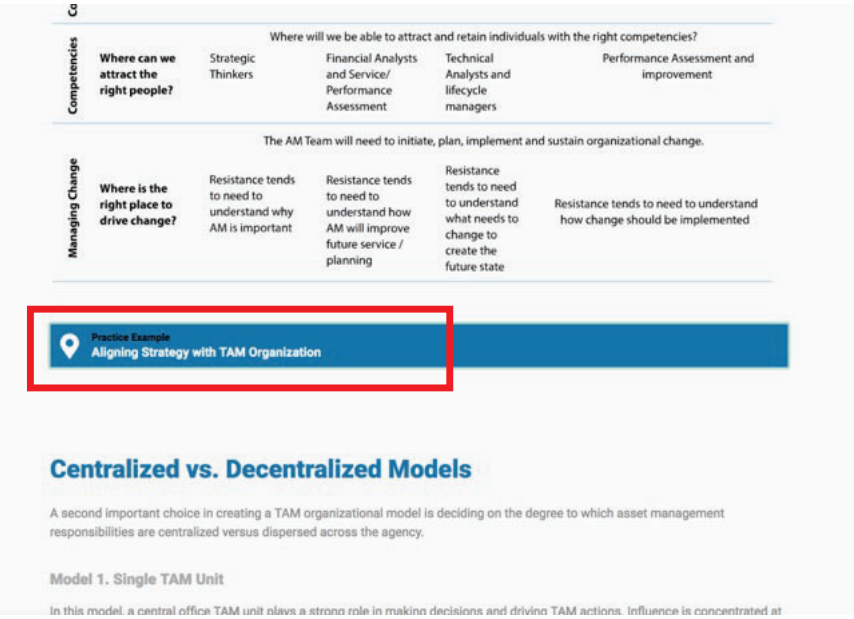


Figure B.16. Collapsed Practice Example

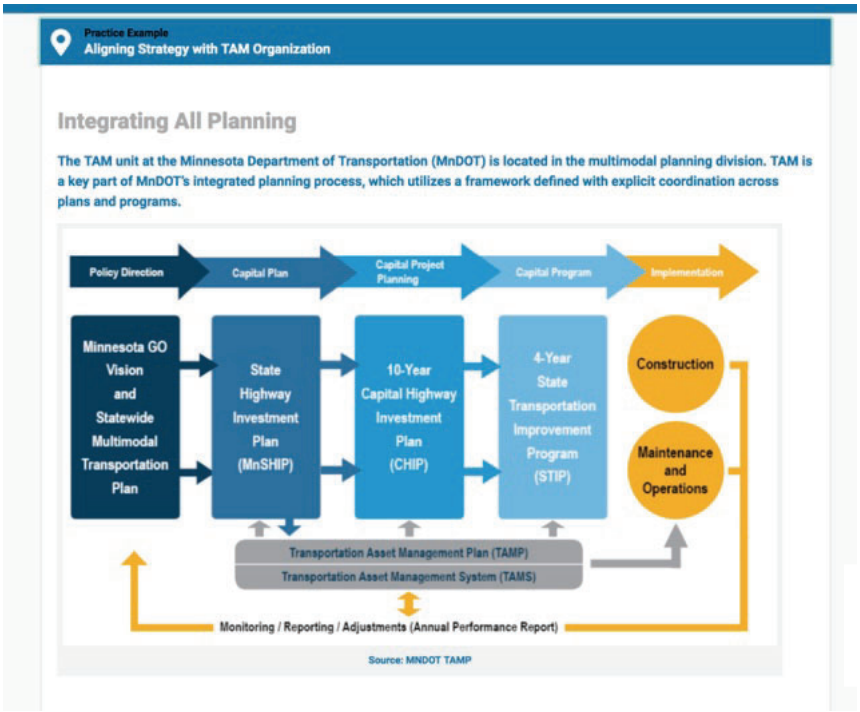


Figure B.17. Expanded Practice Example

Updates to Existing Guide Components

This section highlights the changes, improvements, and enhancements that were made to existing components of the site during the update process.

New Sections & Subsections

The majority of new information can be found in the new Chapter Sections and Subsections that have been added to the guide. This new text can be found across the 7 original chapters of the guide. Each new page is labeled with a corresponding “New Section” or “New Subsection” tag.

How to access these updates?

In the green navigation bar at the top of the site, hover over “TAM Guide” to reveal a list of the 7 main chapter sections. Hover over any of these chapters to reveal the main chapter sections, and then repeat the process to navigate directly to a chapter subsection.

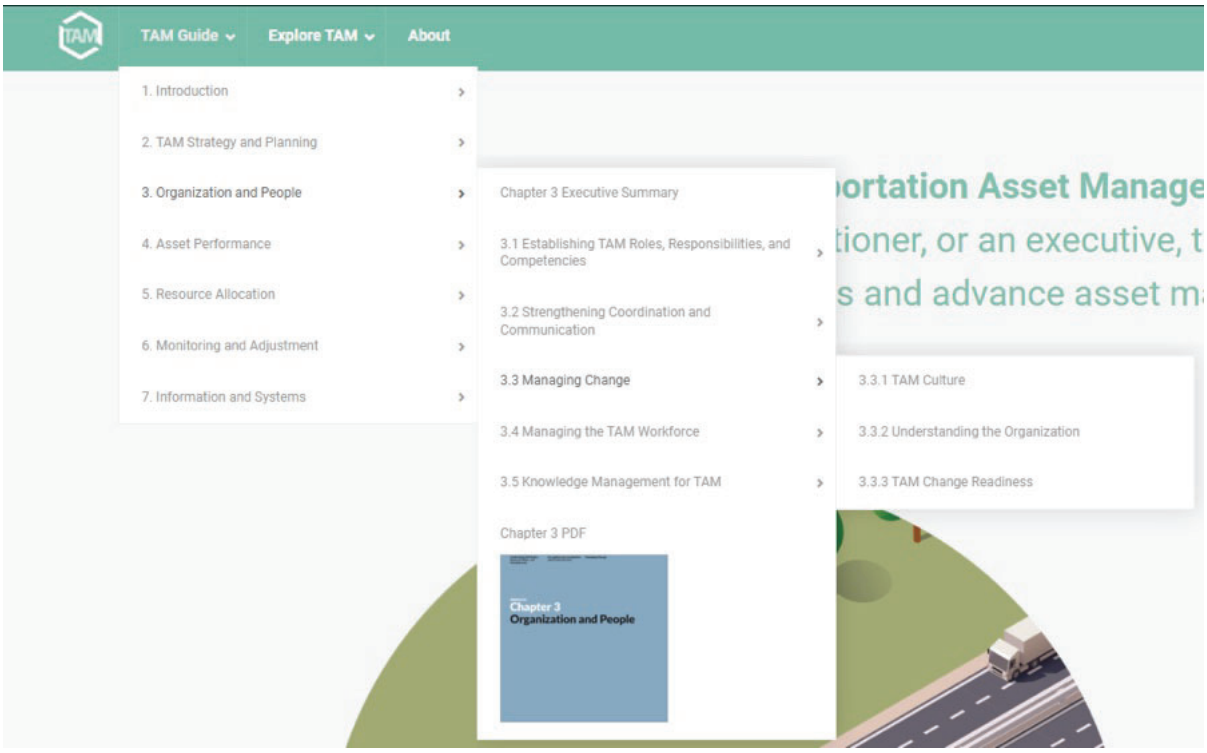


Figure B.18. Accessing New Sections & Subsections

What is new? Understanding the update tagging system.

To highlight what changes have been made to the chapter content, a new tagging system was developed. These tags are visible within the “Sections” dropdown menu within the lefthand navigation column, and can also be found within the Navigation Tables at the Chapter and Section level. These content tags include:

- **New Section** – Denotes new sections that have been added to chapters.

- **New Subsection** – Denotes new subsections that have been added to existing sections. (*Note that new subsections within new sections are not individually tagged*)
- **New Content** – Denotes existing subsections where content has been updated or added.

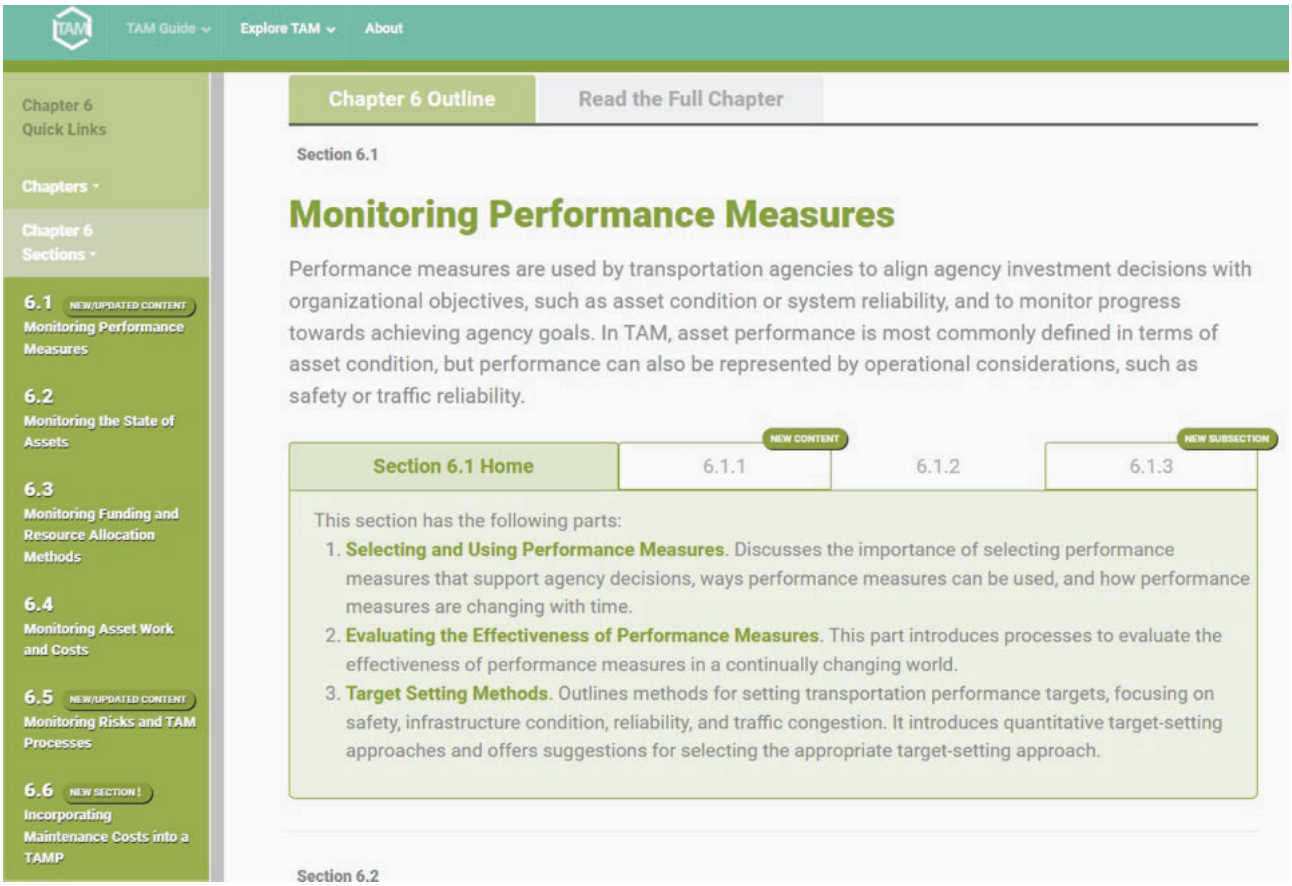


Figure B.19. Tagging Example: Chapter 6 Homepage

Tags only apply to text-based updates that have been made to the main chapter content of the guide. Other guide elements such as Videos and Practice Examples have been added to existing subsections, but these enhancements did not warrant content tagging.

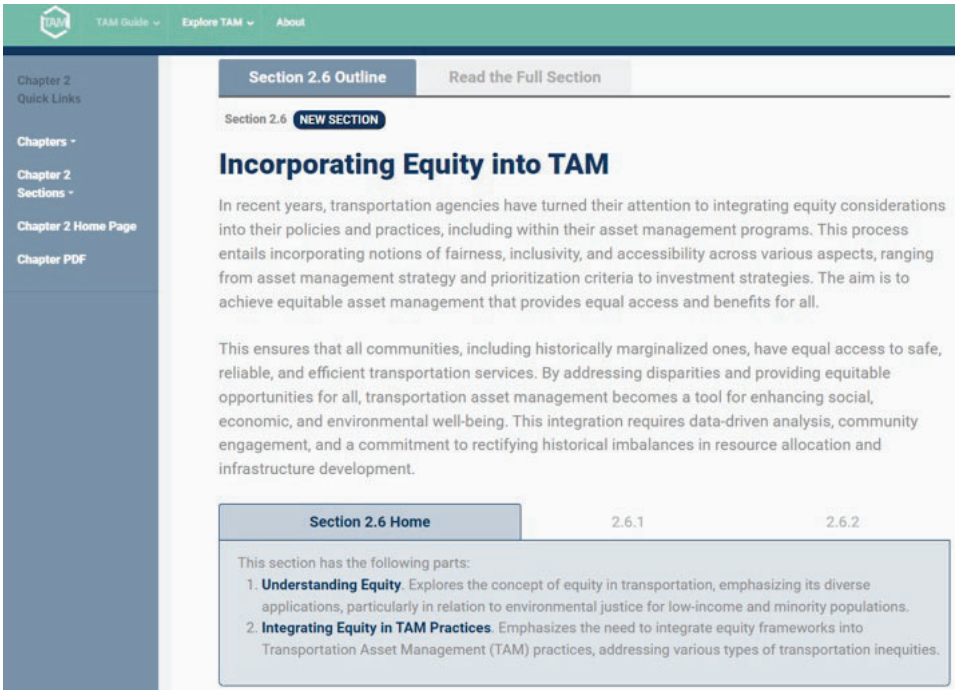


Figure B.20. New Section Example: 2.6 Incorporating Equity into TAM

The section home page provides an overview of a given topic, and includes an outline for the subsections contained within it. Readers are able to select “Read the Full Section” to see all the content laid out on one singular page, or quickly navigate to the desired material.

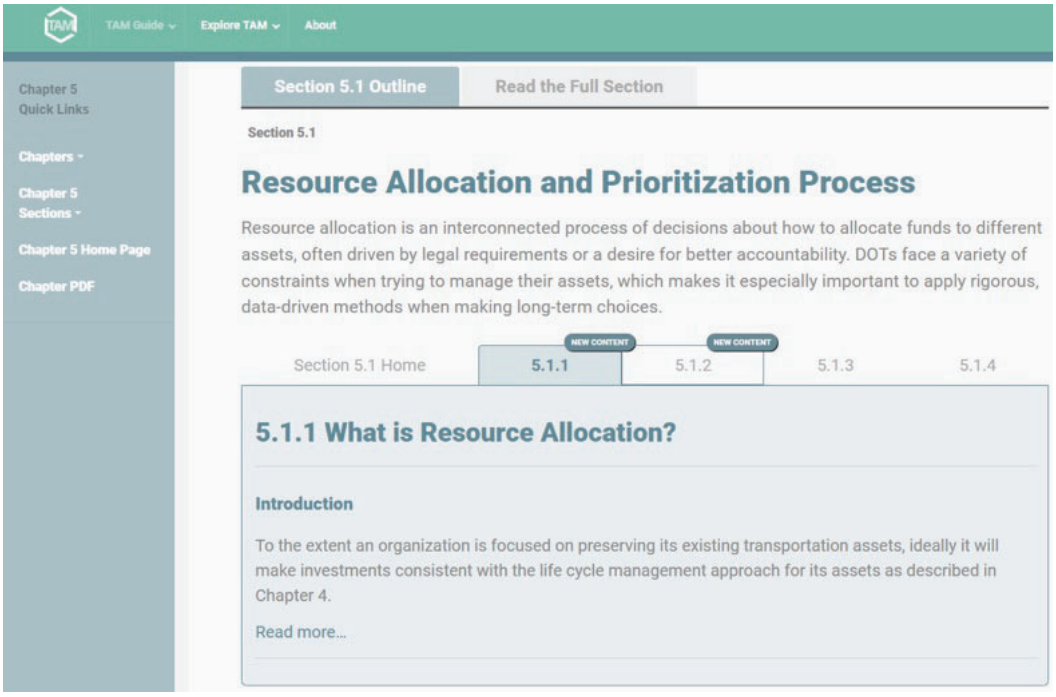


Figure B.21. New Subsection Example: Subsection 5.1.1

New Practice Examples

Over 30 additional Practice Examples have been added to the guide across the chapters and topic pages. Most of these new real-world examples of TAM practices and strategies are more contemporary, covering the four-year period since the guide was originally published in 2020.

How to access these updates?

Practice Examples can be found as integrated elements throughout most subsections of all chapters. Readers can also use the TAM Resources Page to filter for them and see a complete alphabetical list of all Practice Examples included on the site.

- TAM Resources Page > Resource Type > Practice Examples

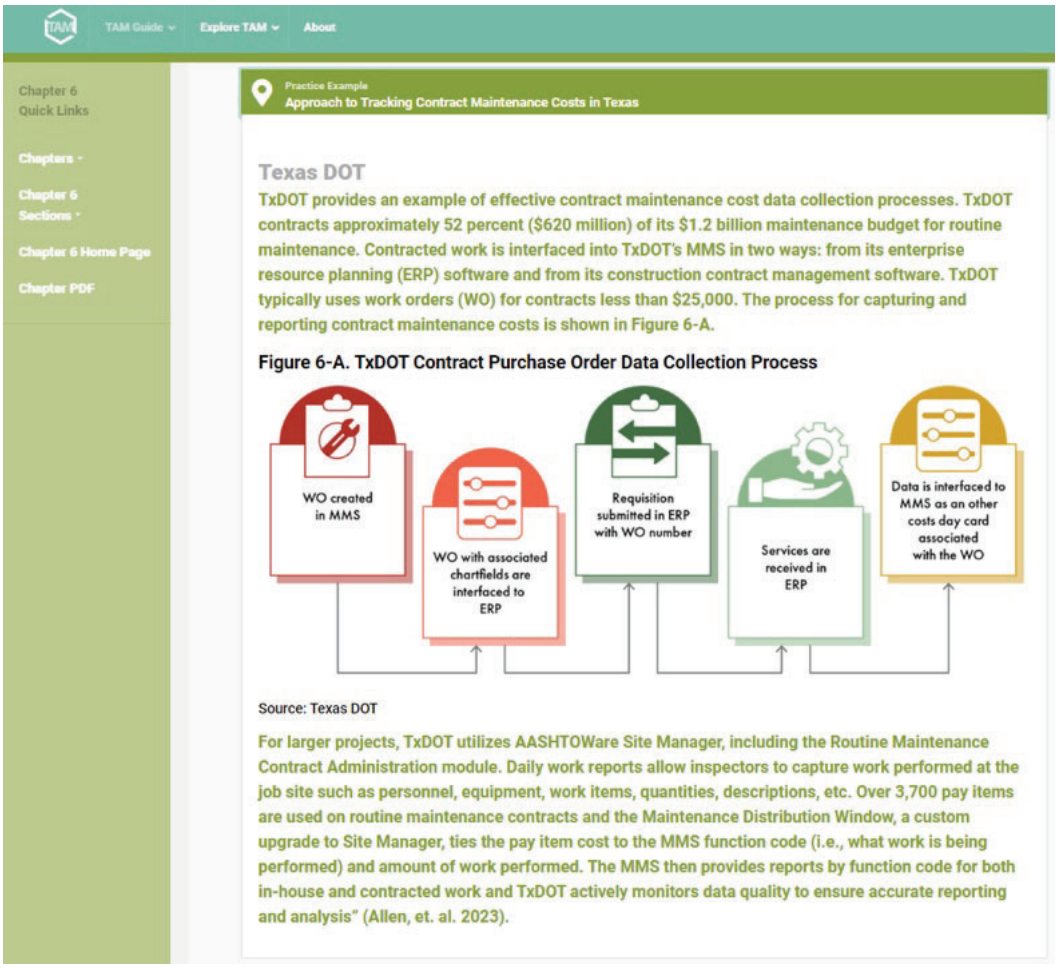


Figure B.22. Demonstration of a New Practice Example: Approach to Tracking Contract Maintenance Costs in Texas

New Checklists

More Checklists have been added to the guide. These checklists center around new topics, strategies, and concepts that were added to the site through additional sections and subsections.

How to access these updates?

Checklists can be found listed under relevant Topic Area pages. Readers can also use the TAM Resources Page to filter for them and see a complete alphabetical list of all Checklists included on the site.

- TAM Topic Area Pages > Workforce > Checklists
- TAM Resources Page > Resource Type > Practice Examples

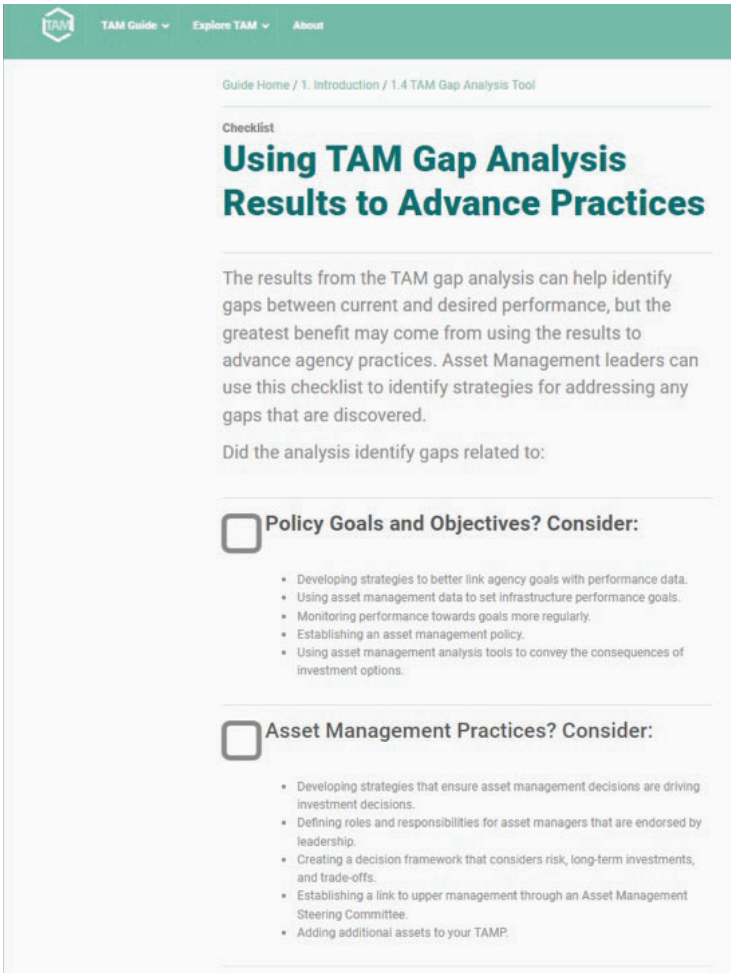


Figure B.23. New Checklist Example: Using TAM Gap Analysis Results to Advance Practices

New References

Over 150 additional References have been added to the guide across all 7 chapters. These sources cover a range of material, including new topics that have been covered in new Section and Subsection content.

How to access these updates?

A complete list of References for each chapter can be found at the bottom of the chapter home pages. To view a list of all sources from each chapter, go to the TAM Guide Resources page and use the filters to search for only References.

- TAM Guide Home Page > 5. Resource Allocation > Scroll to bottom of page to reveal accordion-style menu
- TAM Resources Page > Resource Type > References

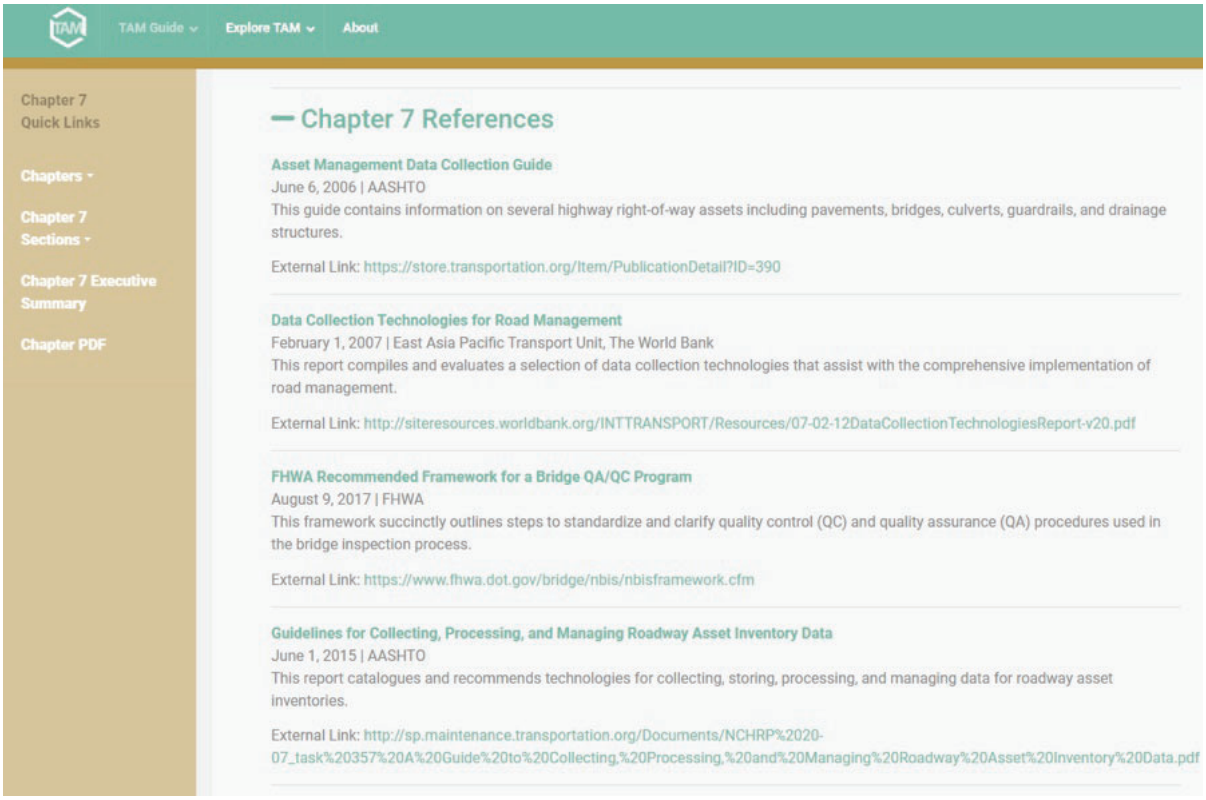


Figure B.24. Demonstration of New References: Chapter 7 References

New How Tos

The number of How To instructional resources on the guide has doubled. These additional How Tos enhance previously included topics on the guide, as well as cover a range of new topics that have been introduced through new Section and Subsection content. These topics include: equity, risk management, resiliency, & performance measures.

How to access these updates?

How Tos can be found listed under relevant Topic Area pages. Readers can also use the TAM Resources Page to filter for them and see a complete alphabetical list of all How To instructions included on the site.

- TAM Topic Area Pages > Workforce > How To Guides
- TAM Resources Page > Resource Type > How To

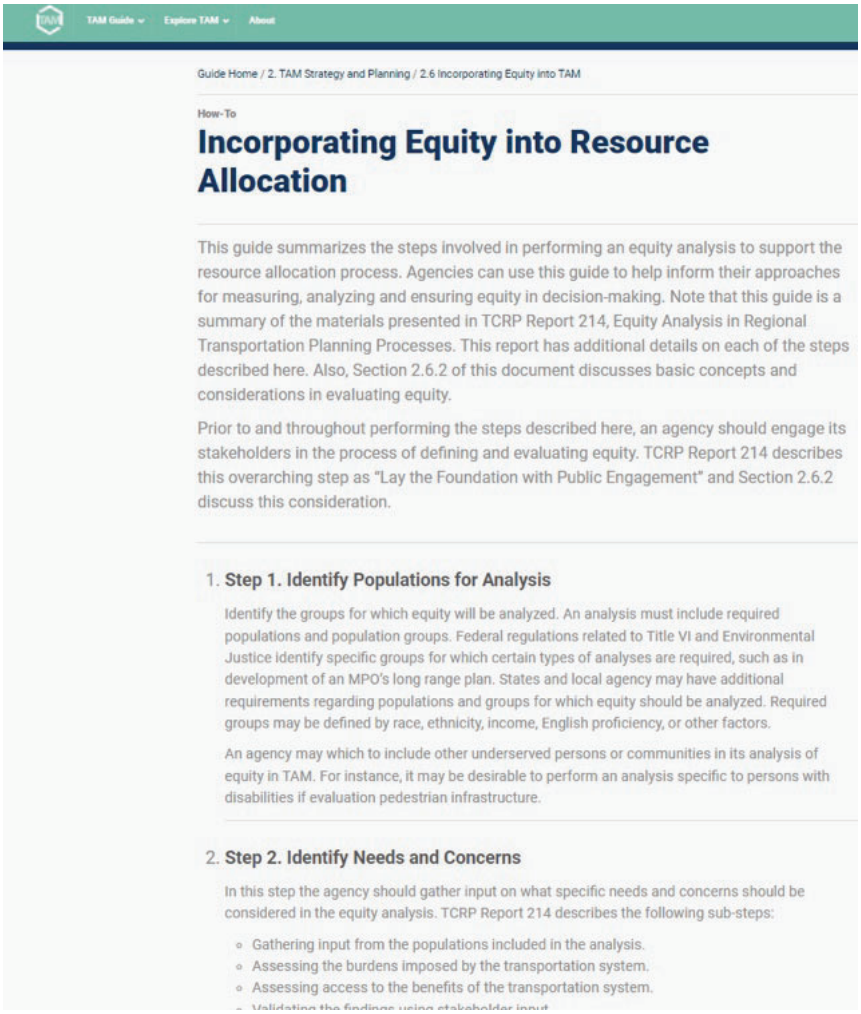


Figure B.25. New How To Example: Incorporating Equity into Resource Allocation

Additional Quality of Life Improvements

These changes to the guide center around improving the experience for readers.

Enhancing the Audio Version of the Guide:

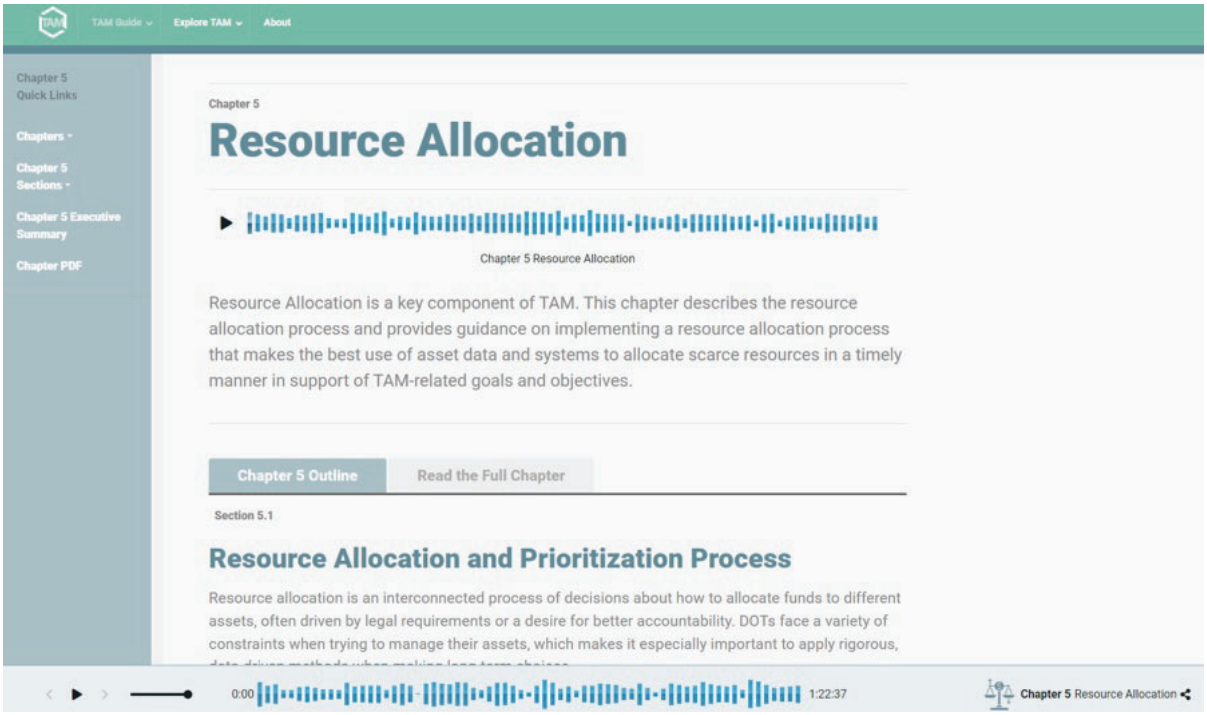


Figure B.26. Example Shown: Chapter 5: Resource Allocation Media Player

The media players have been redesigned to be listed at the top of each chapter home page and include a recording of the entire chapter's material (found in the "Read the Full Chapter" tab). This gives readers the opportunity to explore the guide content through a new medium – increasing accessibility.

Enhancements Made to Visual Elements:

Images & Figures have been added to the guide to accompany the new content within Sections, Subsections, and Practice Examples. Adjustments have also been made to existing images on the guide, improving their legibility and positioning on the page. Data tables were added and revamped. Tables are now built using a WordPress plugin that integrates the themes and visual style of each chapter, while still presenting the information in an organized manner. These tables replace screen captures and exports from spreadsheet programs.

Figure B.27. Image Example: Vegetation Control / Yukon, Canada - Department of Highways and Public Works

Asset	Inventory (unit)	Replacement Value ($M)	Current Value($M)	Condition
Pavement	573.7 lane miles	$573.7	$393.8	
Bridges	63 bridges	$95.0	$80.7	
Culverts	844 culverts	$26.9	$13.7	
Signalized Intersections	52 intersections	$20.8	$10.0	
Medians	843,591 (sf) median 120,632 (lf) curb	$6.0	$6.0	
Guardrail	31,633 linear ft	$3.0	$1.7	
Pedestrian Ramps	924 ramps	$2.7	$1.1	
Signal/Sign Supports	4,970 sign supports 120 signal supports	$2.1	$1.1	
Pavement Markings	4,335,242 linear ft of markings 59,963 sq ft of transverse markings	$1.8	$0.9	
Signs	7,811 signs	$0.5	$0.3	
Stormwater	5,592 assets	-	-	
Lighting	116 assets	-	-	
Railroad Crossings	55 crossings	-	-	

Figure B.28. Figure Example: Carver County, Minnesota / Carver County Public Works

Table 2.1 - Frameworks for Assessing Current Practice

Framework	NCHRP 08-90 Gap Analysis Tool	ISO 55001 Asset Management Gap Analysis	International Infrastructure Manual (IIMM)	IAM Self-Assessment Methodology
Background	This tool was developed based on the tool and process created through development of the 2011 AASHTO TAM Guide. Uses a point scale for evaluating current and desired capabilities. See more	This is the most widely adopted standard for asset management globally. It is generic to accommodate many contexts. Describes a management system approach to asset management. See more	Recognizing that the ISO Standards for asset management are very much the "What to do", the IIMM looks to provide the "How to do it". Identifies an Asset Maturity Index (Aware, Basis, Core, Intermediate, Advanced) to identify the current and an appropriate level of asset management for each asset. See more	As an aid to the application of ISO 55001, the IAM decided to update their methodology into one that enables organizations in all sectors to measure their capabilities against the requirements of both PAS 55 and ISO 55001. See more
Assessment or Focus Areas	• Policy goals and objectives • Asset management practices • Planning, programing, and project delivery • Data management • Information systems • Transparency and outreach • Performance Results • Workforce capacity and development	• Leadership • Planning • Support • Operation • Performance Evaluation • Improvement	• Understanding and Defining Requirements • Life cycle Planning • Asset Management Enablers	• Organizational Strategic Plan • Organization and People • Strategy and Planning • Asset Management Decision-Making • Life cycle Delivery • Risk and Review • Asset Information
Why use this framework?	This framework is best for an agency that wants to work explicitly within a US-defined context that adopt wider influences. Since this tool can be fully customized by an agency, an agency that wants to tailor the analysis to their particular needs will find this useful. Finally, the tool	This framework is ideal for agencies that want to adopt a world-recognized approach to asset management that provides a developed asset management lexicon. This is currently the most internationally-recognized standard in	This framework has been refined over time with many examples that illustrate successful application of concepts by organizations. Public agency focused, and largely written for the asset management practitioner responsible	This standard is well recognized internationally, is infrastructure agnostic, and has applicability to infrastructure owners in both the private and public sector. It has many other resources developed along with the framework including training materials,

Figure B.29. Data Table Example: Frameworks for Assessing Current Practice

New Content Additions

Section 3 highlights new features to the guide, and other elements that have been majorly redesigned during the update process.

Chapter Quizzes

A “Knowledge Check” has been added to the bottom of each chapter home page. Each assessment includes 5-10 True/False questions centering on the main concepts featured in the corresponding chapter. Apon completing the quiz, respondents are asked to input their name and email address to receive a certificate that includes their score.

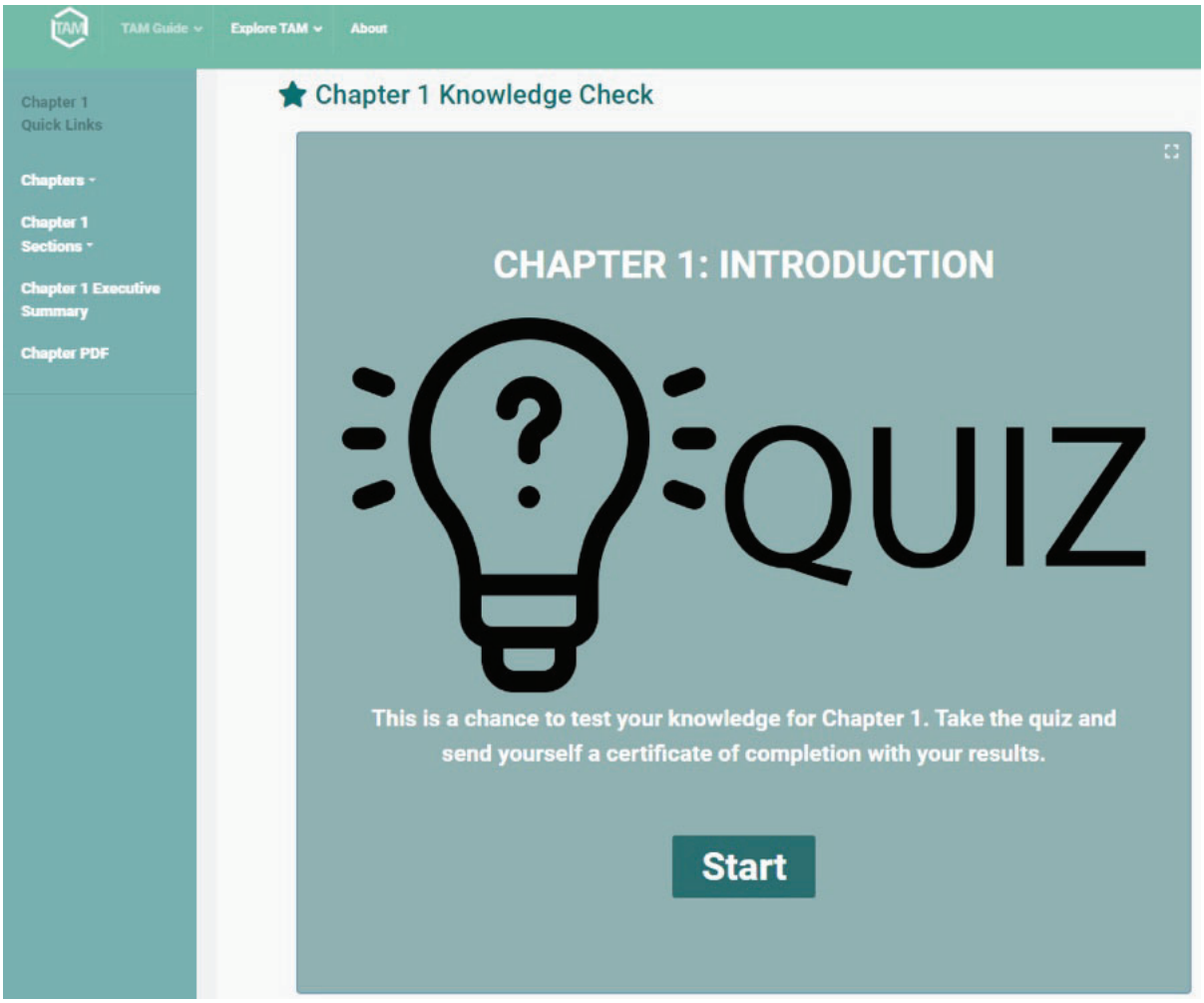


Figure B.30. Example Quiz: Chapter 1: Introduction – Start Page

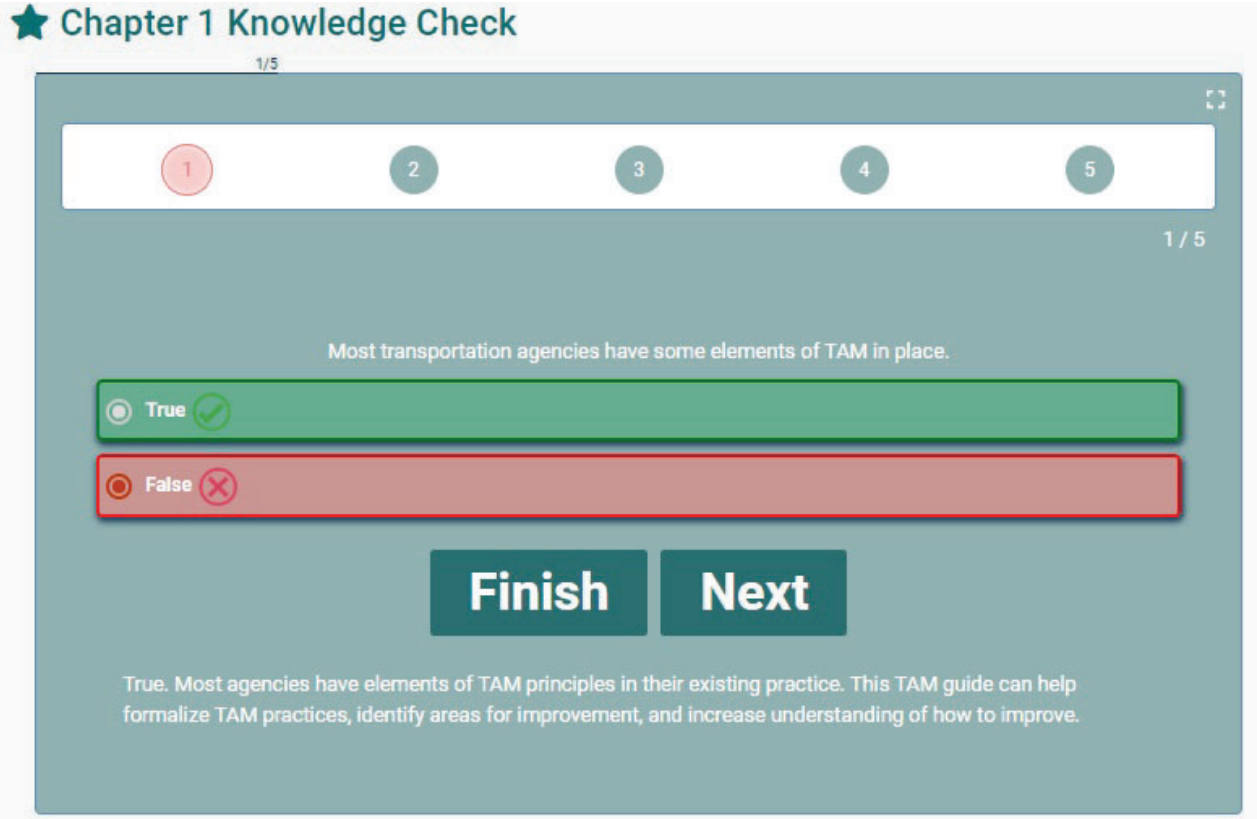


Figure B.31. Constructive Feedback Provided with Each Question

Figure B.32. Certificate Delivered Directly to Provided Email Address

Video Elements: TAM+TPM Webinars & Interviews

For the first time, videos are now included within the TAM Guide. Over 50 examples have been added across the site through Sections, Subsections, and Practice Examples. These videos enrich the guide with insights from experts in asset management.

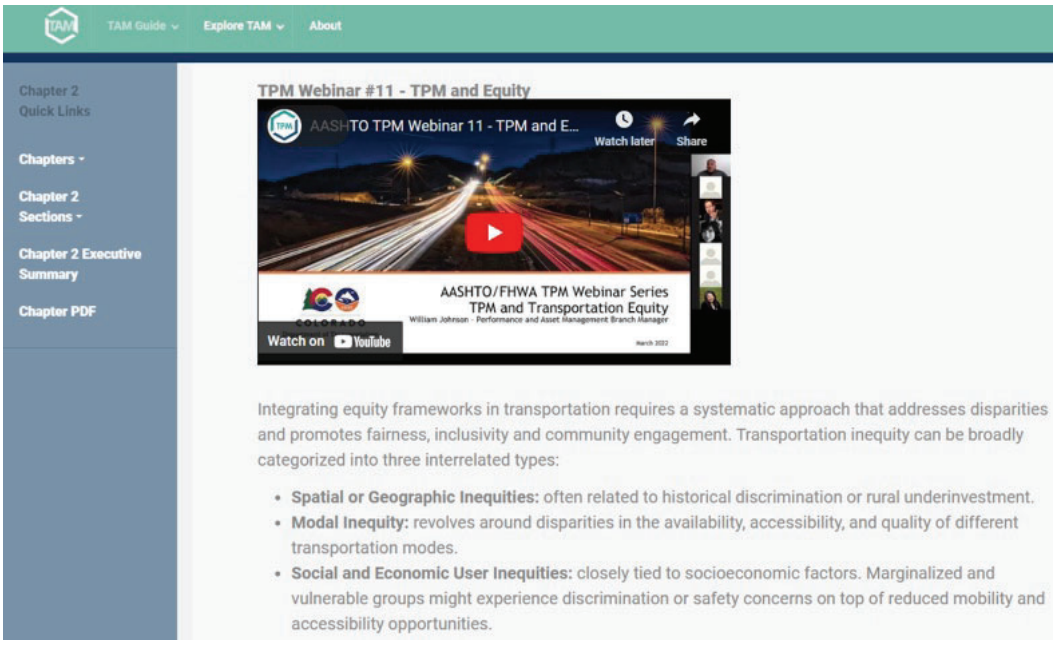


Figure B.33. Example Webinar: TPM Webinar #11 – TPM and Equity

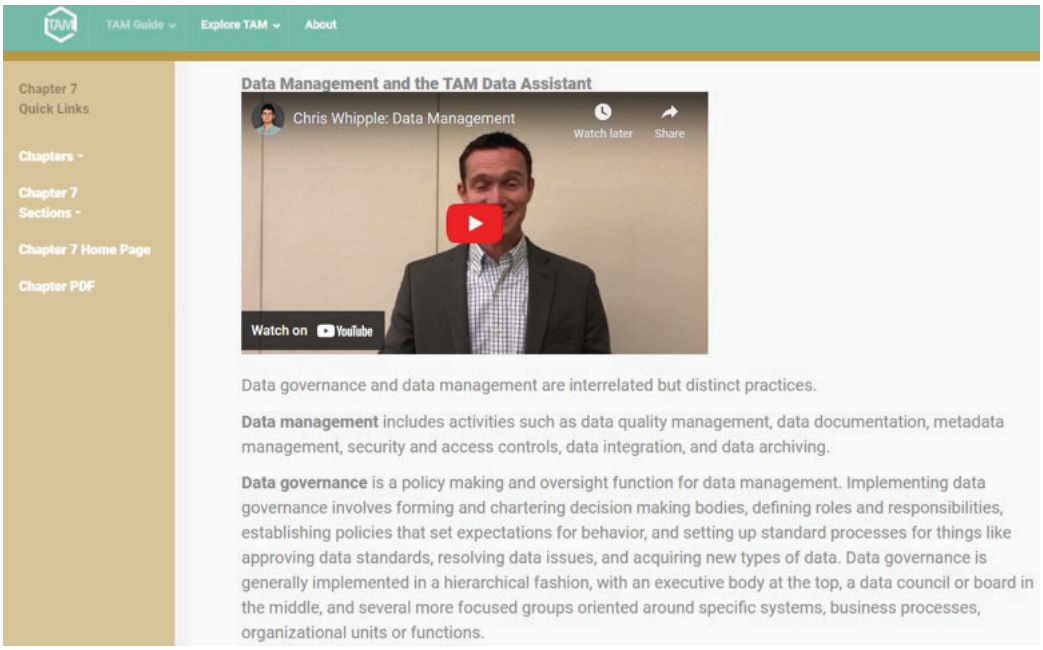


Figure B.34. Example Interview: Data Management and the TAM Data Assistant

TAM Topic Area Pages

The Topic Area Pages have been substantially expanded since the first iteration of the guide. The 12 topic areas have been enhanced to include an overview of the topic, key concepts, implementation considerations, and additional resources for further research into the topic. These new additions are presented alongside content being pulled from the 7 chapters of the guide. This content includes all relevant Subsections, Practice Examples, How To Guides, Checklists, and chapter References. By combining these elements together on Topic Area Pages, readers are able to focus in on particular topics and explore content that would normally be spread across multiple different pages.

- Hover over "Explore TAM" in the green navigation bar at the top of the guide > TAM Topics

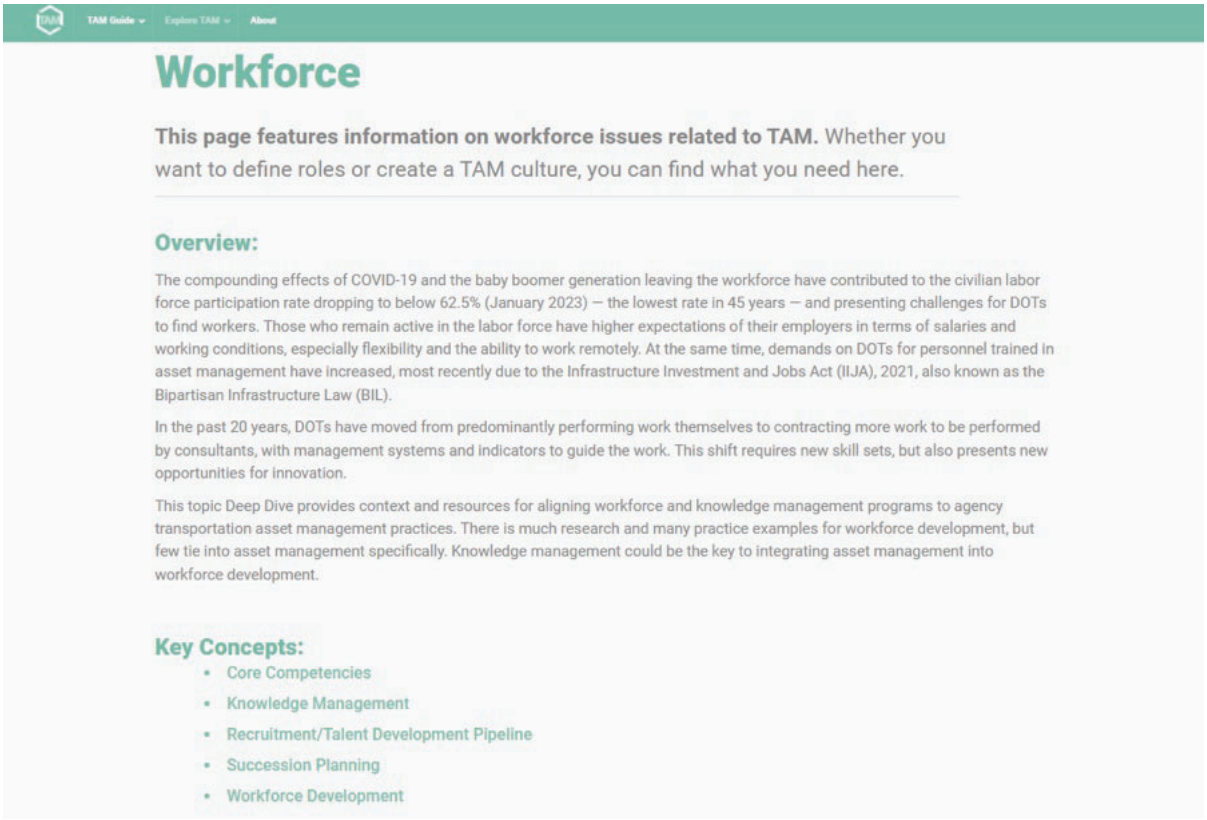


Figure B.35. Example: TAM Topic Area – Workforce

Appendix C: Research Implementation Plan

The Digital TAM Guide is actively used by the transportation community currently through the web-resources that are supported by the AASHTO Committee on Performance-Based Management (CPBM). When the NCHRP 08-137 project is complete, the enhanced Digital TAM Guide will move from the staging site that only the panel and research team has had access to, to become the live site. The access and support for the Digital TAM Guide will continue to be through the AASHTO CPBM. The following activities will be conducted to communicate and train the transportation community on the enhancements made to the Digital TAM Guide.

- Communicate the launching of the enhanced Digital TAM Guide
- Conducting a project webinar to share the enhancements to the Digital TAM Guide
    - The webinar might follow the example of the "TAM Book Club" that was used when the current Guide was launched
- Initiate an additional research project to support implementation of the research through NCHRP Project 20-44, the NCHRP Implementation Support Program. The focus of this project could be to develop case studies on how a set of agencies are using the enhanced Digital TAM Guide to advance their TAM programs.