Asset Management

Overview

U.S. Department of Transportation
Federal Highway Administration

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Note From the Director

The Federal Highway Administration's (FHWA's) Office of Asset Management is pleased to present this *Asset Management Overview*. When the Office was created during the 1999 FHWA reorganization effort, one of the most frequently asked questions from individuals within FHWA and outside the agency was "What is asset management?" Consequently, the Office published the *Asset Management Primer* to advance the understanding of this important concept within the transportation community. Since the Primer was published, a significant amount of activity has taken place as organizations have begun implementing the concepts of asset management. This Overview identifies next steps, challenges, and strategies in implementing a Transportation Asset Management program.

Asset management, as described later in this document, is a business process and a decisionmaking framework that covers an extended time horizon, draws from economics and engineering theory and practice, and considers a broad range of assets. The approach incorporates the economic assessment of tradeoffs between alternative investment options at both the project level and the network or system level, and uses this information to help agencies make cost-effective investment decisions.

Transportation Asset Management has come of age because of (1) changes in the transportation environment, (2) changes in public expectations, and (3) the demonstrated success of asset management principles in enhancing the effectiveness of decisionmaking. Increasing congestion, limited resources, and an aging infrastructure impact today's transportation environment. The focus has shifted from capital construction to one of optimizing the balance of preserving, upgrading, and replacing our highway assets through cost-effective management, programming, and informed decisionmaking.

Over the past decades, the public has invested $1.75 trillion through the Federal, State, and local governments in the construction, maintenance, and operation of the Nation's transportation system. The public's expectation is that governments at all levels will be responsible stewards of this investment. Federal, State, and local transportation agency officials wholeheartedly concur with this expectation and are committed to continue making wise investment decisions that the public can understand and support. The agencies recognize that the public holds them accountable.

Clearly, the combination of changes in the transportation environment and heightened public expectations has created a strong motivation for aligning transportation agency business practices with asset management principles. A key feature of asset management is that it requires a statement of explicit, clearly defined goals. In transportation, these goals reflect customer expectations, as well as considerations unique to each State or local department of transportation, and the goals are used to guide, monitor, and evaluate the entire planning and implementation process.

The asset management approach allows transportation agency officials to communicate with decisionmakers through "what if" analyses. For example, the impact of higher or lower budget levels on a system's future condition and performance—and the resulting impact on the system's users—may be demonstrated readily, and the resources needed to provide the specified level of system performance at the defined future period can be ascertained.

To assist State and local transportation agencies as they work to implement Transportation Asset Management programs, FHWA is working closely with the American Association of State Highway and Transportation Officials and the Transportation Research Board to identify research that is needed and to provide technical assistance, education, and training programs to these agencies. We believe that these essential efforts will pay tremendous dividends to the public by ensuring high-quality, cost-effective investments in our Nation's infrastructure.

Francine Shaw-Whitson
Acting Director, Office of Asset Management

What Is Transportation Asset Management?

Asset management in the transportation industry is a relatively new concept. It means many things to many organizations, but its practices provide a solid foundation for programs that optimize the performance and cost-effectiveness of transportation facilities. At its core, asset management is a business process. The application of asset management principles often means a change in thinking at every level in an organization: to base decisions on information and on getting results.

The roots of today's asset management programs originated in private industry, integrating many of the ideas of W. Edwards Demming, Malcolm Baldridge, and others. Because of its focus, asset management has been highly successful in companies that require a substantial asset base for their operations, such as electrical power companies, telephone companies, large trucking companies, and railroads. In these companies, the goal was clear—maintain a prescribed level of service at the lowest cost possible. Assets that did not meet these criteria were taken out of service and sold. This focus on guaranteeing an acceptable level of service to the customer has had positive results and has made substantial profits for these companies.

Elected officials and public agency managers noted these advancements in the private sector and began to identify ways that government could be run as a business. Although profit is not a motive in the public sector, the basic concepts of performance and cost-effectiveness apply to virtually all government activities. In addition, the sheer investment in transportation assets owned and operated by public agencies is enormous—over $1.75 trillion. In 1993, the U.S. Congress passed the Government Performance and Results Act,[1] legislation that identified accountability at all levels in the Federal Government as a priority. Many States have enacted similar legislation, typically calling for State agencies to report what is bought with public funds, how spending decisions are made, and what is accomplished. For transportation agencies, this means a full and updated accounting of the public assets—roads, bridges, and other facilities—that form the basis of Transportation Asset Management.

Defining Transportation Asset Management

Although defining asset management in the private sector was a straightforward process, for the transportation community, it has been somewhat of a struggle. Early definitions identified strategic management as the goal and were often all-inclusive in their descriptions, but they were not always sufficiently focused to be useful working definitions.

An asset management decisionmaking framework needs to be guided by performance goals, cover an extended time horizon, draw from economics as well as engineering, and consider a broad range of assets. At its most basic level, Transportation Asset Management links user expectations for system condition, performance, and availability with system management and investment strategies. Regardless of the definition, the focus is on performance of assets. The underlying goal of asset management is to take a broad approach to resource allocation and programming decisions that will provide greater value to the system and overall satisfaction for end users through improvements in program effectiveness and system performance. The core principles of asset management are listed in the box that follows.

Transportation Asset Management provides for a fact-based dialogue among system users and other stakeholders,

THE CORE PRINCIPLES OF ASSET MANAGEMENT

- **Policy-driven**—Resource allocation decisions are based on a well-defined set of policy goals and objectives.
- **Performance-based**—Policy objectives are translated into system performance measures that are used for both day-to-day and strategic management.
- **Analysis of Options and Tradeoffs**—Decisions on how to allocate funds within and across different types of investments (e.g., preventive maintenance versus rehabilitation, pavements versus bridges) are based on an analysis of how different allocations will impact achievement of relevant policy objectives.
- **Decisions Based on Quality Information**—The merits of different options with respect to an agency's policy goals are evaluated using credible and current data.
- **Monitoring Provides Clear Accountability and Feedback**—Performance results are monitored and reported for both impacts and effectiveness.

Adapted from NCHRP Report 551, *Performance Measures and Targets for Transportation Asset Management, Vol. I, Research Report,* 2006, p. ii.

State government officials, and managers concerned with day-to-day operations. This dialogue results when relevant, objective, and credible information is made accessible to all participants in the decisionmaking process. As such, decisions can be based on detailed input regarding available resources, current system condition and performance, and estimates of future performance. The information underlying asset management—sometimes raw data and at other times data generated from the analytical process—is fundamental to an improved understanding of the economic tradeoffs, return on investment, and potential value of the end product.

The Federal Highway Association (FHWA), with leadership from the Office of Asset Management, partners with the American Association of State Highway and Transportation Officials (AASHTO), State and local departments of transportation (DOTs) along with FHWA field offices, the Transportation Research Board, and industry in encouraging the application of asset management. As defined by the AASHTO Standing Committee on Highways, Planning Subcommittee on Asset Management,

> Transportation Asset Management is a strategic and systematic process of operating, maintaining, upgrading, and expanding physical assets effectively throughout their lifecycle. It focuses on business and engineering practices for resource allocation and utilization, with the objective of better decision making based upon quality information and well defined objectives.[2]

Over the years, a number of management systems derived from the private sector have been adopted by transportation agencies with varying degrees of success. Some of these include management by objectives, goal-oriented management, risk-based management, and, more recently, enterprise resource planning (ERP). Asset management has many similarities to these methods and incorporates some of the same concepts. The distinguishing feature of asset management, however, is its central focus on assets, their condition, and their performance. Systems such as ERP are based on costs and, in particular, on manpower costs versus manpower performance and progress toward selected goals. Asset management optimizes, rather, on asset performance versus cost and is more suited to transportation organizations with substantial investments in physical assets.

There has been some confusion about the relationship between management systems and asset management. Management systems provide key information and analysis capabilities to agencies implementing asset management principles, but they do not constitute the whole of asset management. Decisions rendered in an asset management environment are much broader in scope, require substantially more economic analysis, and normally involve more than one kind of asset. Transportation Asset Management focuses on the whole transportation infrastructure, and makes possible decisions that reflect the optimal performance of that infrastructure compared to the resources required to operate and maintain it. Additionally, asset management examines investment timing, tools, and economic analyses to assure the effective use of available funds. For example, if borrowing rates are high, an economic analysis might look at tradeoffs between increased costs of repairs

due to delaying the work and additional costs incurred by borrowing funds at the current, higher interest rate. Another example is evaluating the overall benefit–cost advantages of conducting regular pavement preservation efforts as compared to resurfacing and replacement. Yet another example is examining tradeoffs between construction costs and maintenance costs over the life of the asset (such as cost savings from installing median guardrail over turf versus maintenance costs for the turf over many years).

What Transportation Asset Management Means to the Public Agency

Those who work in transportation have in common three primary goals:

1. Keeping the infrastructure in as good or better condition than it is now.
2. Developing and implementing a logical capital improvement plan.
3. Containing the costs of planning, building, operating, and maintaining the facilities.

Transportation Asset Management is focused on the transportation infrastructure, and its use directly impacts these three goals. The emphasis on "more information on which to base decisions" leads to higher accountability for officials charged with making those decisions and, to some extent, a new way of looking at managing transportation infrastructure. Programs have to be directed toward defined performance goals and either show solid return on investment or face changes—similar to the way in which private industry focuses on market share and rate of return.

Transportation systems continue to grow rapidly and become increasingly complex. Asset management provides new insights and tools to help transportation professionals make wise investments that result in improved service and greater cost-effectiveness. Because information is central to effective implementation of asset management, each agency has to determine how much information is enough, and that will depend on its goals and its willingness to take risks. It is not cost-effective—or even possible—to have 100 percent assurance for every decision; determining the balance between assurance and cost is one of the key considerations for any asset management program.

Why Use Transportation Asset Management?

Historically, the Nation's transportation agencies have been focused on major building and expansion of roads, bridges, and other transportation infrastructure. In recent years, the costs of preserving and operating this $1.75 trillion investment have increased dramatically. At the same time, the public has undergone a change in its view of effective governance, based on the expectation that government should be more accountable and be managed more like a business operation.

If current trends continue into the future, State DOTs and other public-sector owners of highway infrastructure will be facing increased system and budget needs with limited resources. At the same time, these infrastructure owners will be required to deal with increased system complexity, renewed public demands for accountability, and higher user expectations regarding levels of service. The future focus for States and other governmental units will be on justifying their actions and taking responsibility for their results.

In responding to these challenges, many State and local government agencies are partnering with industry to advance the concepts and practices of asset management. Their efforts are making performance and return-on-investment considerations an integral and routine part of program evaluation and project selection. This systematic approach is seen as a way to improve efficiency and productivity and to increase the value of services and products to transportation users.

Historical Issues

Construction and expansion of transportation systems in the United States have been a central part of the culture and economy since colonial times. This infrastructure development peaked with the completion of the Interstate Highway System in the 1980s. Along with this milestone came a realization of the need to shift emphasis and resources from new construction to meet the demands of maintenance, preservation, and reconstruction of the existing infrastructure. Today, significant portions of our highway assets are deteriorating because of increasing usage, environmental impacts, and sheer aging. Simply put, the Nation's physical assets will not last forever.

The implications of an aging system are multidimensional. There are increased requirements for maintenance and reconstruction, particularly on older systems. There is a need to maximize the performance of the existing system. At the same time, demands for system expansion from individual and business users of transportation facilities compete for resources. These system users have high expectations regarding safety, comfort, convenience, and security. Commercial users cite system reliability as a critical part of their operations, particularly in the context of just-in-time delivery and other productivity-enhancing patterns of operation.

Transportation needs are not always obvious. More often than not, solutions to transportation problems require long-term planning and commitment of future funds. Agencies can no longer manage transportation assets based solely on historical trends. Transportation is inextricably linked to virtually every aspect of our culture, and the performance of its infrastructure needs to be at the center of our political and economic thinking.

Compelling Reasons

Different aspects of the transportation system compete daily for resources and struggle to meet user expectations. Designs are increasingly complex, and facilities often require expensive specialized attention to operate and repair. Even small errors in, for example, planning or constructing a road or neglecting maintenance of a bridge can result in multimillion-dollar costs over the life of the asset. Transportation investments are so large that it is unthinkable to ignore maintenance and preservation needs.

Asset management focuses on the facts about the infrastructure assets, their performance, their preservation, and their anticipated longevity. Most State highway agencies have in place some of the more common elements of the asset management process (see the box "Elements of an Asset Management Program"). These systematic processes typically are used to measure real-life performance, predict future trends, and optimize the use of limited resources.

State DOTs are increasingly measuring and reporting on their performance in terms of outcomes, outputs, and economic value added. Many States have enacted legislation modeled on the Government Performance and Results Act of 1993. Such legislation typically calls for States to report what is bought with public funds, how spending decisions are made, and what is accomplished. The Governmental Accounting Standards Board (GASB) Statement 34 (www.gasb.org)[3] furthered this trend. It recommends a more asset-based approach to State financial reporting, an approach that focuses on facility condition and asset valuation over time.

For a long time, private industry has based business plans on the concept of results-oriented management. The more recent adoption of these principles by public agencies has translated into a strong need for cost-effective programs and for full accountability for decisions made at all levels. Transportation managers today have to know the facts and be ready to act upon them. Asset management helps transportation agencies to identify program needs and provides the tools to reach defensible decisions that maximize transportation investments.

ELEMENTS OF AN ASSET MANAGEMENT PROGRAM

- Strategic goals.
- Inventory of assets (physical and human resources).
- Valuation of assets.
- Quantitative condition and performance measures.
- Measures of how well strategic goals are being met.
- Performance-prediction capabilities.
- Relational databases to integrate individual management systems.
- Consideration of qualitative issues.
- Links to the budget process.
- Engineering and economic analysis tools.
- Useful outputs, effectively presented.
- Continuous feedback procedures.

Asset Management Primer, 1999, p. 7

Challenges to Implementation

Transportation systems are in a time of great change—in technology, demographics, public expectations. These changes have had a corresponding impact on how we manage the Nation's transportation assets. This section explores the strategic, institutional, measurement, integration, and analytic challenges that organizations might face and must overcome to be successful in the Transportation Asset Management environment.

Strategic Challenges

An asset management decisionmaking framework is guided by the setting of strategic objectives. Government agencies must serve a variety of stakeholders, many of whom hold strong opinions based on their own understanding of asset management, coupled with their beliefs and expectations. For example, individuals, divisions, and agencies have different missions, agendas, and values, which are expressed through their practices. These differences lead to a range of differing objectives, which are often in competition. For example, the pavement division's focus is on preservation, while the operations division may be focusing on construction. But, is this the right mix? Competing ideas have to be resolved through alignment with policy goals, an understanding of the tradeoffs, and consensus-building. Furthermore, a consistent focus on short-term budgets makes it difficult to meet the long-term capital investment planning needs of asset management. Lastly, with the ever-increasing need to do more with less, there will be fewer technological, financial, and staff resources available.

Institutional Challenges

Probably the most important and challenging aspect of a Transportation Asset Management program is addressing the needs of people within the organization. Because asset management is holistic, it depends upon comprehensive coordination and communication. Most agencies are functionally segregated. The challenge is to help the people in the organization understand and appreciate the benefits of the Transportation Asset Management process from the perspective of the entire agency rather than the viewpoint of their individual units. Another challenge is building organization-wide commitment to change. Creating buy-in at both the executive and operations levels of the organization is critical to success.

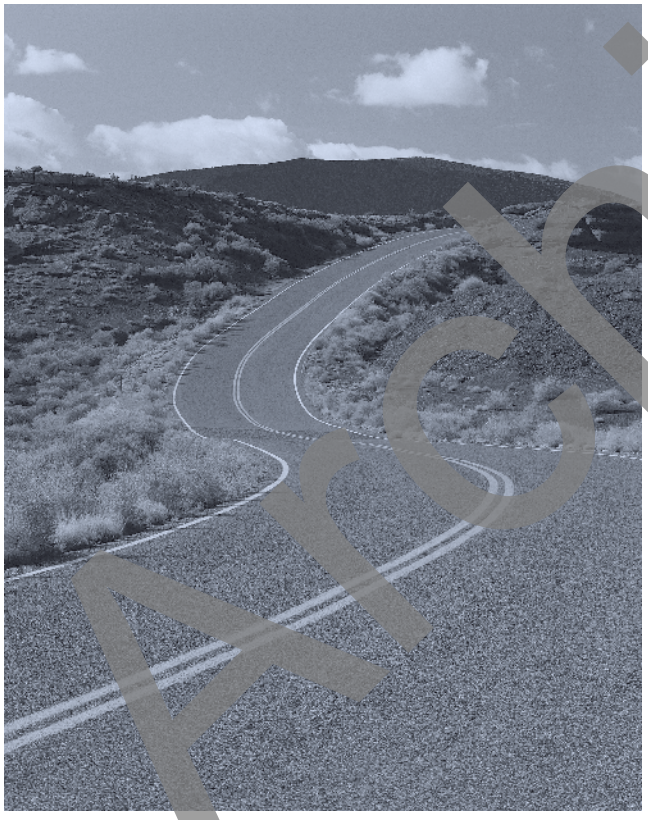
Measurement Challenges

The key to assessing program effectiveness is measuring the right things. Many of the performance measurement issues facing agencies today are extremely difficult. The problem lies in identifying appropriate and meaningful performance indicators. With respect to data collection and management, most agencies find that they are data rich but information poor. Many agencies collect data that ultimately are not used for decisionmaking and analysis. In addition, they are discovering that they still do not have information they need to make decisions. A reevaluation and inventory of the data collected is often needed to solve this problem. Also, since data are often scattered across a variety of disconnected systems, including databases, Web sites, and file systems, employees struggle to find ways

to access and process data in an orderly fashion. These problems prevent agencies from producing timely, fact-based information that is needed to make sound business decisions.

Integration Challenges

Data integration and sharing for asset management involve bringing in data from various sources. Most transportation agencies have large quantities of variable, heterogeneous data. Data heterogeneity usually results from the presence of internal legacy systems that have diverse structures and formats. The challenge is to create a framework that incorporates all of the data items needed to perform the desired asset management business functions, addresses disparities in data sources and formats, and responds flexibly to changing data requirements when new business functions are introduced or when existing processes are modified. Some agencies are using a unified enterprise architecture approach to remedy this challenge.



Analytic Challenges

The emphasis upon economic cost analysis principles is recent, so models, methods, and tools to construct and analyze economic tradeoffs are still being developed. Common, consistent definitions and formats of data across systems in a linked or shared database environment are also still under development. A challenge for most agencies in developing and implementing data standards and in converting existing data to these standards is coming up with suitable data formats, models, and protocols when existing databases are extremely diverse.

Indeed, significant challenges confront agencies that are implementing Transportation Asset Management. Each of the challenges is unique, yet they are independent and interrelated. For an asset management program to be successful, an agency must overcome these most common technical and organizational challenges.

Strategies for Implementation

AASHTO and FHWA have made Transportation Asset Management a national priority. They are providing national leadership and guidance to States as they work to incorporate asset management principles and practices into their business processes. The goal of AASHTO and FHWA is to supply generic asset management approaches to organizational integration, performance measure development, application of analytical tools, and information management. These generic processes and tools may then be utilized "as is," or they may be applied after in-house or other customized revisions.

Although the fundamental tenets of asset management are visible in each State practicing the discipline, the assumptions made, tools employed, and information used vary from State to State. Each State brings its unique organizational strengths and perspective to implementation. In addition, each State's Transportation Asset Management program reflects the State's unique decisionmaking process and individual goals. One size will never "fit all" in State asset management.

While there is no standard approach or strategy to implementing asset management, a variety of models, methodologies, tools, and techniques are available to assist in the efficient use of existing resources.[4] Agencies must examine exactly where they are, what information they have available, and where they want to go before determining (or continuing) an approach to implementing asset management. Moreover, an agency should remember these important facts:

- **Asset management implementation can be accomplished in stages.**
  1. Tasks can be identified as short-term, mid-term, or long-term, and the appropriate sequence and priority of tasks can be defined broadly in the implementation strategy.
  2. Work can begin in one program area or type of investment (e.g., preservation or maintenance) to demonstrate principles and techniques and to establish the organizational linkages and business process interactions needed to make the approach work. This demonstration can serve as a model for subsequent implementation in other program areas.

- **Asset management implies change, and change in an organization can be difficult to deal with.**
  1. Be aware that organizational and institutional changes in asset management will likely present greater challenges than changes in technical or analytic capabilities.
  2. Discuss strategies that can be put in place to bring about change more effectively, establishing support and confidence among managers and staff.
  3. Provide for open communication among all personnel involved in implementing the asset management program. An asset management program—
     a. Can improve understanding by taking some of the mystery out of how and why decisions are made.
     b. Can improve confidence in agency performance by clearly reporting achievements—and failures—and progress toward established goals.
     c. Clearly defines, communicates, and links performance measures to the agency's vision and mission so that they have meaning to its customers.
     d. Requires a culture change. Senior leadership and management of an agency must be committed to the principles of asset management and to providing the resources to implement it.

Approaches to Implementing an Asset Management Program

Generally, two different approaches are accepted in the industry for the implementation of an asset management program: policy-based or performance-based.

Policy-based asset management programs tend to support a long-term, life-cycle approach to evaluating investment benefits and costs. Policy-based decisions on programs for different assets, modes, or types of investments may be based on historical funding baselines, formula-based splits, or deal-making rather than on current performance objectives or targets. Policy-based asset management programs should define the directions and overall priorities for an agency's infrastructure management. It should relate objectives, performance measures, and performance targets. The asset management framework does not prescribe what priorities should come first—only that individual agencies and their policy-making bodies discuss and analyze policy options and adopt the ones that are thought to be warranted.

On the other hand, *performance-based asset management* programs support the preservation of existing highway assets through the use of identified measures and targets. They enable decisionmakers to identify the optimum balance between availability and utilization for any asset at any given time, based on the real-time performance measures prioritized to current business strategy. The lack of effective performance measures for maintenance, operation, and engineering, however, has resulted in performance approaches based more on budget cost management than on asset performance management.

Performance-based asset management is a process of managing an infrastructure system in order to optimize its behavior when evaluated against specified objectives. It enables prioritization of investment in highway infrastructure construction, inspection, and maintenance. It is risk based, in that the costs of alternative investments are weighed against their benefits. It also has to take account of the multiple objectives for highway assets, including economic efficiency, the environment, and safety.

The Generic Asset Management System (see Figure 1), which serves as a framework and guide to the asset management process, shows the importance of defining Goals and Policies at the start and using Performance Monitoring as a check. A system can be either policy-driven or performance-driven as long as one is used as a balance for the other. For example, an agency may adjust its policies higher or lower based on the feedback gathered by performance monitoring that is used to check conformance to the policy. When the data come back, an agency may find that it is already doing better than its stated policy objectives or it may find that the policy objectives are not realistic or need to be placed on a longer time track.

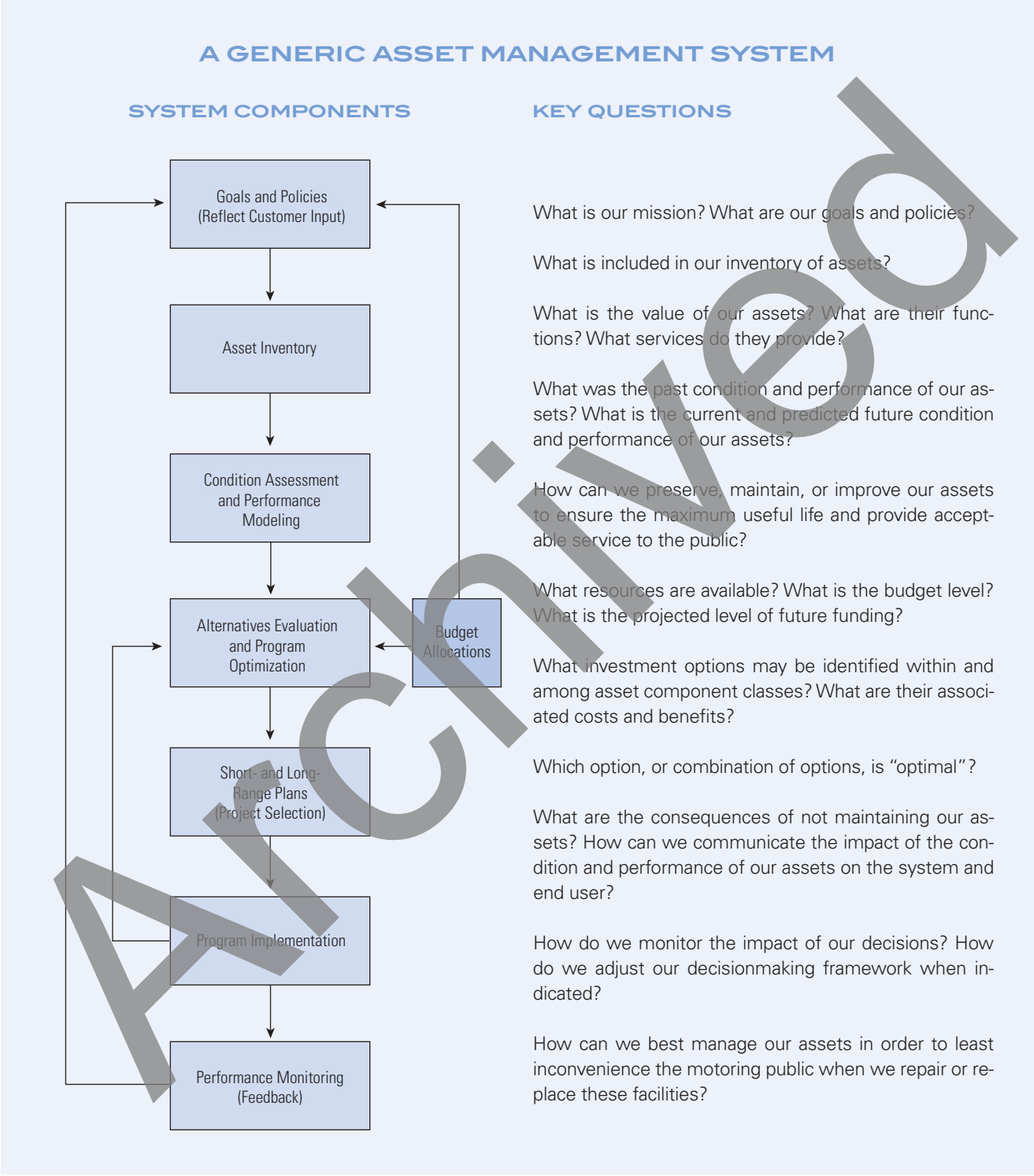


FIGURE 1. The components of a generic asset management system, the relationships among them, and key questions that inform the system's analytical process. (from *Asset Management Primer,* 1999, p. 19)

Steps to Implementing an Asset Management Program

The steps involved in implementing transportation asset management can be summarized as follows and are discussed below:

1. Review the organization's structure.
2. Conduct an asset management self-assessment.
3. Identify the asset management policies and goals to be achieved.
4. Prepare and implement an asset management action plan.
5. Review and monitor progress.
6. Solicit feedback from stakeholders.

Review the Organization's Structure

A transportation agency can begin to implement asset management principles and practices right away. Most organizations already have resources devoted to asset management but have not taken the opportunity to fully develop these resources into an organized program. It is important to identify how investment decisions are currently being made in the agency and how this method differs from an asset management approach to decisionmaking. The primary needs in getting started are a sincere desire to improve the ways in which the transportation agency conducts its business and a commitment from top management to focus on the implementation goals. Asset management is not a fix for overcoming major problems within the organization, but it can help identify methods and resources to solve some of the problems.

Conduct an Asset Management Self-Assessment

A self-assessment will help to identify specific opportunities for improvement within the transportation organization. It will help to organize thinking, identify an organization's strengths and weaknesses, and lay out an action plan for implementing an asset management program. In addition, a self-assessment will build consensus among top managers regarding the status of asset management within the organization.

The *Transportation Asset Management Guide*, published by AASHTO,[5] contains a recommended self-assessment with step-by-step instructions. This tool will quickly provide an overall picture of where a transportation agency is regarding asset management practice. The self-assessment results will reflect the agency's individual institutional, organizational, financial, and information technology environments.

Identify Asset Management Policies and Goals To Be Achieved

An agency's policies and goals will define its most important priorities (see Figure 2). Asset management is a customer-focused, goal-driven management and decisionmaking process. Organizational goals, policies, and budgets establish a consistent evaluative philosophy. Goals and performance indicators are literally the levers that drive the asset management decision framework, establishing investment levels that reflect service levels, and making resource commitments consistent with the perceived needs of the public. Analysis procedures regarding alternative options are used within this framework.

Decisions regarding program investments are optimized according to goals established by elected officials and policymakers. Performance goals provide a way to convey to the public how transportation agency officials are managing the public's assets. Asset management provides a logical, fact-based approach to dealing with and explaining the impact of the practical realities facing transportation system owners today.

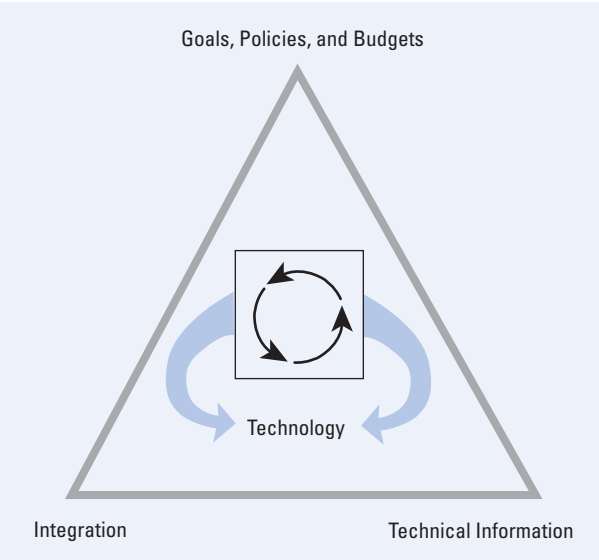


FIGURE 2. Strategic asset management framework requirements.
(from *Asset Management Primer,* 1999, p. 20)

The success of program strategies and practices is measured by changes in performance and remaining service life. Performance criteria and measures also help decisionmakers identify and target critical system requirements.

Organizational policies may be thought of as a broad overlay to the process. Nonengineering, noneconomic factors that reflect an agency's values, perceptions, and predispositions may modify performance-based decisions. For example, established policies, or "rules of thumb," may direct an agency to select an investment alternative based on historic practice or other reasons. Also, management may assign noneconomic resource constraints to some asset components.

The key to establishing performance goals is determining user priorities, values, and standards related to areas such as ride smoothness and overall level of service; travel time; overall system mobility; accessibility to the system; and availability of facilities. Goals may be defined in terms of the percentage of assets that meet specified performance levels, as one example.

Prepare and Implement an Asset Management Action Plan

The next step is to define objectives and formulate tasks to achieve each one. Formulating tasks in an action plan will require a look at the overall agency to understand the connections that may exist among issues raised in each area. This requirement does not imply that the agency should try to address every item at once. Rather, a broad perspective will help in identifying priority actions for improving asset management.

Preparing the plan involves examining the elements in the transportation program and, based on established policies and objectives, deciding which elements should be included in the plan—which assets, types of investments, business functions, and techniques (see the box "Choosing What to Include" for examples).

An important aspect of developing an asset management implementation plan is to define a timeframe for each of the improvement activities or tasks, taking into account several factors:

- The overall priority of each task.
- The logical sequence of the tasks required to achieve an objective.
- An agency's annual cycles for policy and process updates, data collection and analysis, budget and program development, or delivery of projects and services. Asset management initiatives should be scheduled to complement current business cycles.
- The resources available to implement the plan. A mixture of short-, mid-, and long-term initiatives will insure that funds and staff availability are not barriers to successful implementation.

Review and Monitor Progress

Asset management plans provide for periodic review of the agency's progress in meeting the performance values it has targeted for preservation, capital improvement, and maintenance and operations. An asset management system is built upon information, which must be continually renewed. To determine whether the system is performing as projected, data on the condition and performance of assets are captured and analyzed regularly. This information on system performance allows for analysis of investment decisions made and provides a basis for future decisions. Decisions are based on information; consequently the quality of the data that are available affects the entire asset management system.

In addition to informing the next asset management planning cycle, monitoring and periodic reviews can help to identify specific areas that require more immediate adjustment, and to serve the public's accountability requirements. In addition to reporting progress internally, many States report at least annually on their progress to their governors, high-level executives, legislatures, and oversight bodies, as well as the general public. These reports serve to educate the officials and policymakers who establish funding priorities about DOT stewardship. The use of plain language in communications with customers is vital to success. The presentation of information should be tailored to the needs of specific groups.

Solicit Feedback From Stakeholders

System users and other stakeholders should be kept abreast of the performance targets, measures, and results that pertain to their satisfaction with the transportation system and services. Typically, on a highway system, users will be concerned about availability and accessibility, congestion and travel time, safety, ride smoothness, and noise. Only by regularly collecting customer perceptions of asset condition and performance, as well as their expectations, can agencies maintain or increase customer satisfaction. Infor-

mation may be collected through formal and informal customer surveys, focus groups and panels, and on Web sites.

Communication in Asset Management

Not only is communication essential to successful asset management—asset management processes are themselves important communication tools. Communication is of singular importance in developing and implementing an asset management program, particularly because of the involvement of different disciplines and levels within an organization that typically have different perspectives and ways of talking about the transportation system. For the parties to cooperate with changes, it is vital that they understand them. In its communications and reporting plan, an agency must pay particular attention to—

- Linking performance measures in a clear and direct way to the agency's vision and mission.
- Defining clear and precise performance measures and strategies.
- Clarifying goals and related accomplishments in a concise way.
- Reporting progress made in each of the performance areas.
- Illustrating what has been done to meet goals and what still needs to be done.

An asset management program can improve understanding by taking some of the mystery out of how and why decisions are made—"by making a glass box out of the black box. It does this by clearly articulating goals in terms that are meaningful to stakeholders, by documenting current conditions, and by estimating future conditions based on alternative policy strategies and investment levels."[6] Because asset management is a fact-based system, it allows for an objective dialogue among all parties. As a system of communication, the practice of asset management can help agencies to—

- Improve confidence in agency performance by clearly reporting achievements—and failures—and progress toward established goals.
- Provide a first step in helping elected policymakers understand the extent of the responsibilities vested in the transportation agency.
- Tip the political scales in favor of greater transportation investments by communicating a common message regularly, flexibly, and by a range of transportation professionals.
- Express goals and performance in terms that relate to customers' desires and in language that customers understand.
- Help government officials at all levels to understand the condition and needs of the transportation system and the practices used to manage it.

Economic Analysis in Asset Management

Economic analysis can play an important role in a comprehensive transportation asset management program. Using economic analysis, transportation agencies can identify, quantify, and value the economic benefits and costs of transportation projects and programs over a multiyear timeframe. The approach involves careful coordination with transportation planners and engineers, who provide information on the performance characteristics and costs of a proposed project. The project's performance measures are put into dollar terms and then compared to the costs of building and maintaining the project over its entire lifespan. With this "dollars and cents" information, agencies are better able to compare projects to each other (through "tradeoff" analysis), select the best mix of projects for any given budget, target scarce resources to their best uses to maximize benefits to the public, and account for their decisions. Many factors of interest to decisionmakers can be included in the economic analysis process, including the risks of changing construction costs and traffic levels on project outcomes, uncertain monetary values for certain project performance measures, and the effects of the investments on jobs, tourism, business growth, and other social goals.

A critical component of a comprehensive project or program evaluation methodology that considers all key quantitative and qualitative impacts of highway investments, economic analysis can inform many different phases of the transportation decisionmaking process. It can assist engineers in the development of more cost-effective designs once a decision has been made to go forward with a project. In planning, it can be applied to basic cost and performance data to screen a large number of potential project

alternatives, assisting in the development of program budgets and areas of program emphasis. Similarly, economic analysis can play a critical role in screening alternatives to accomplish a specific project, providing information for the environmental assessment process.

Risk Assessment and Asset Management

The principles of asset management and risk management enhance each other. It is recommended that risk management be integrated with the asset management process. The outcome of risk management is efficiently focusing resources to manage programs through improved communication. Applying risk management to look at decisions being made about delivery of the programs makes it possible to identify threats and opportunities, assess and prioritize those threats and opportunities, and determine strategies so that decisions can be made on how to deal with future issues affecting the Federal-aid highway program.

Risk is a future event that may or may not occur and would have a direct impact on the program to its benefit or detriment. Risk management is the systematic identification, assessment, planning, and management of threats and opportunities faced by our programs. Steps taken to manage risk include 1) gathering information about future events, threats, and opportunities; 2) identifying what and how those future events trigger the threats and opportunities; 3) assessing the likelihood and impact of risks; 4) prioritizing risks by their expected value and by their relative importance to a program, project, or State; 5) determining appropriate response strategies to risks; 6) carrying out response strategies, monitoring strategies, and reevaluating risks.

Role of Preservation in Asset Management

To meet the growing travel demand and the public's expectations for safety, ride quality, and traffic flow, highway agencies are redefining their objectives to focus on activities and strategies to preserve and maintain existing highway systems, instead of on the typical strategy of fixing the worst first. Focusing on preservation without exceeding budgetary limits requires a change of philosophy from reactive maintenance to preventive maintenance. Increasingly, State DOTs report that the proactive approach of preventive maintenance—known as pavement preservation—cuts the need for costly, time-consuming rehabilitation and reconstruction projects and reduces associated traffic disruptions. As a result, the public is seeing improved mobility, reduced congestion, and safer, smoother, longer lasting pavements—the goals of pavement preservation.

To advance these goals, FHWA is partnering with DOTs, industry organizations, and other stakeholders. Their objective is to spread the word that a variety of innovative techniques and strategies can preserve not only pavements, but also the Nation's investment in the highway infrastructure.

The Concept Behind Pavement Preservation

When the ride quality and structural condition of a pavement are allowed to deteriorate to fair or poor condition, as has often been the case, costly, time-consuming rehabilitation becomes necessary to repair structural damage and restore pavement conditions. This "worst first" maintenance practice came about for many reasons, including the requirements of Federal-aid funding and the need to maximize capital growth. More often now, highway agencies can extend a pavement's service life by applying a series of low-cost preventive maintenance treatments, each of which lasts a few years. This practice translates into a better investment and a better ride quality. The experience with pavement preservation in a number of States demonstrates this success: each dollar spent now on pavement preservation could save up to six dollars in the future.[7]

Pavement preservation is a concept that has long been employed by highway managers and engineers. The degree to which it is employed has varied considerably among different governmental agencies due to questions about the perceived benefits and costs of a pavement preservation program.[8]

Pavement preservation strategies are not well-suited for pavements requiring major rehabilitation or reconstruction. Furthermore, implementation varies with pavement conditions and climatic, environmental, and other regional factors, requiring each agency to adapt methods to its own conditions. No treatment can ward off pavement deterioration forever. But the strategies and techniques of pavement preservation can significantly slow the rate of deterioration.

Current Practices in Transportation Asset Management

There is no single method for implementing Transportation Asset Management. Transportation agencies differ in terms of their needs and resources and in the complexity of their systems. Typically, the first step toward implementation involves some realization that a need for change exists. However, change does not happen until people within the agency, particularly leaders at the top, find a reason for change.

Actually taking the first step is typically difficult because it involves figuring out what needs to be done. There is no prescribed series of steps for implementing agencies to follow; rather, agencies who have been successful have found the approaches and practices that are most appropriate for their unique set of circumstances. Examples are documented in the reports of recent domestic[9] and international[10] scanning programs that reviewed Transportation Asset Management practices in agencies in Canada, England, Australia, and New Zealand. For the United States, more detailed experiences of State and local highway agencies with the implementation of asset management programs appear in a series of case studies published by FHWA's Office of Asset Management.[11] Following are some real-life examples from local governments, State DOTs, and international organizations of their experiences in developing and implementing Transportation Asset Management programs.

Local Government Experience

In the United States, local governments—counties and municipalities—own more than 75 percent of the Nation's nearly 4 billion miles of roadway and over half of its nearly 600,000 bridges.[12] Because local governments typically have fewer independent systems for managing assets than State DOTs, they often have a much broader view of infrastructure assets and the goals that can be achieved through effective management of those assets. As a result, these smaller agencies may also have a greater variety of criteria and standards for judging the performance of their assets. In addition, local government agencies depend on a variety of funding sources to support the development and management of transportation assets, and typically have few resources to invest in asset management programs. Because of the large number of local government agencies in the country and the variation in the responsibilities and resources of each agency, the approaches they take to infrastructure asset management vary greatly.

Cole County, Jefferson City, Missouri

The Cole County Public Works Department has cited two reasons for moving toward asset management. The first was the agency's dependence on the experiences and memories of its workers. As workers aged and retired, the county's management information systems were literally walking out the door. Asset management provided tools that could be used to capture some of that information before the workforce retired. The second reason, which is frequently reported by agencies, was the county's need to comply with the provisions of GASB Statement 34. The new accounting rules highlighted the importance of assets and provided an opportunity to improve management procedures while meeting the reporting requirements.

With the introduction of GASB Statement 34 providing an added impetus for change in the county's asset management practices, county staff explored available "canned" software packages that could facilitate the initial invento-

rying and condition assessment of the county's transportation assets. The packages considered had broad scopes—to accommodate a range of agencies and assets—and were flexible, with all the "bells and whistles" to support various functions. Purchasing such a package would offer technical support to the county staff during management system implementation. However, the packages were costly and complicated, and would require periodic staff training to keep up with new capabilities as the software was upgraded. The county decided instead to develop its own software, with help from the University of Missouri, a local institution.

The new software, designed to be simple to use and maintain, was based on a spreadsheet model, with inventory data collected using inexpensive global positioning system (GPS) devices purchased at a local electronics store. University graduate students were employed to gather the initial data. The most complex task was designing the unique identifier "tag" to be used to designate specific assets. The county adopted a five-digit identifier.

Roadway types and other characteristics were defined using existing county procedures. Pavements were visually inspected, and condition ratings were assigned on a five-point scale from "excellent" (5) to "failed" (1). Specific pavement distress and drainage conditions were also recorded. Drainage structures, traffic signage, and guardrail were inventoried and rated for condition. Bridges were inventoried but not rated, because the State DOT rates all "off system" bridges every 2 years.

The new software is used to evaluate upcoming maintenance needs by reviewing conditions and using standard performance prediction curves. Analyses are then made of the estimated costs to maintain or improve system components with current maintenance techniques and also to extend or preserve service life with different maintenance techniques. These estimates are used to develop 3- to 5-year maintenance projections and capital improvement programming.

The county's Transportation Asset Management program provides information that increases the agency's accountability for the performance of county assets. Because infrastructure conditions have been maintained or improved, the county has found that taxpayers have grown accustomed to the new level of service and expect it to be maintained. The asset management program helps the county address this expectation by providing a basis for discussing tax rates that will assure adequate funding of maintenance and system preservation for the levels of service expected by the public.

City of Redmond, Washington

The City of Redmond developed a Transportation Asset Management strategy with particular regard for compliance with GASB Statement 34 reporting requirements. Redmond's roadway system is relatively young, and its Council was inclined to allocate adequate funds for improvements to maintain the useful life of this infrastructure.

Besides the streets themselves, the system includes signs, curbs and gutters, and right-of-way. These assets are tracked in the city's geographic information system (GIS). Streetlights and traffic signals are reported in a separate asset listing. Hiking and biking trails are also included among the transportation assets the Public Works Department manages, but they are managed in a separate module.

Redmond's asset management program currently has four principal elements: a GIS, pavement management system, park trail tracking system, and project cost system. Considerable effort was devoted to strategic planning when the system was established and, subsequently, to education and training of the GIS, engineering, and financial technicians who maintain the system. Similarly, considerable effort is dedicated to keeping the information system current and compatible with the State's financial reporting system, particularly with respect to capital projects, contributed assets (e.g., facilities or rights-of-way), and abandoned assets.

Every 2 years, the city contracts with Measurement Research Corporation to rate the entire street system. The contractor "walks the streets" of Redmond and assesses condition according to State standards that reflect the number of potholes and alligator and other cracks. Based on a rating scale where 100 represents perfect conditions, the city's roads typically average a rating of about 83. Using these ratings, an analysis is made to estimate the remaining service life of particular streets and the system in its entirety. In addition, this information is used to establish a monetary value of the street system.

When the current value of existing assets was initially established, the city put in place a process to keep this information current. The Public Works Department assigned a staff member to monitor all capital projects (in-

cluding substantial resurfacing). As projects are completed, this staff person is charged with reporting the value—based on total project cost—of new or improved infrastructures to the GIS team. The value of infrastructure contributed to the city or abandoned is estimated by the construction division and reported to this staff person, who relays the asset information to the GIS team.

By building on existing management systems and involving all staff who would be responsible for providing and maintaining data, the city was able to implement a Transportation Asset Management program without imposing much stress on the organization.

Common Issues Raised by Local Governments

Local governments across the country have raised a number of issues[13] encountered in their implementation of asset management programs:

- Getting management and staff commitment is an important requirement for successful adoption of asset management philosophy and principles.
- Building and maintaining the asset inventory is a necessary first step, and it may be accomplished by progressively drawing on available information while conducting in-field surveys.
- Asset condition assessment and valuation may be accomplished at several levels of sophistication without compromising the value of the asset management program as a decisionmaking tool.
- Asset management "programs" may be based on simple spreadsheets, as well as sophisticated database management packages, to match the needs and resources of the agency.
- Condition monitoring and maintenance of asset inventory data are essential to maintaining the validity of the asset management program, and they require a continual commitment from management.
- Intermodal comparisons—i.e., establishing priorities among different functional asset classes for resource allocation—can be supported by the asset management program.
- Standards regarding satisfactory or acceptable levels of service for infrastructure assets may vary substantially from one community to another.
- Sharing of information among departments and establishing common databases are effective ways to reduce the costs associated with the implementation of an asset management program and improve the quality of management information. Existing data, such as property assessment records, can be used as a basis for setting up the asset management program.
- Asset management tools need to be simple if they are to be used over an extended period of time; the tools need to be easily understandable, adaptable to the user's specific interests, and easy to operate without entailing lengthy, tedious activities for data entry, formatting, and other routine operations.

Payoffs have accompanied the adoption of Transportation Asset Management practices. Counties have reported, among other benefits, enhanced support by citizens and elected officials for preventive maintenance activities, a net reduction in agency costs for managing the roadway network, and improved asset conditions.

State Department of Transportation Experience

Most State highway agencies have some of the systems that provide information used in the asset management process, most commonly pavement and bridge management systems that monitor conditions, measure performance, predict trends, and recommend candidate projects and preservation treatments. Many are also using analytical tools to compare the relative merits—and risks—of alternative policies, programs, and projects. Still others have linked their asset management efforts to their State's long-range transportation planning process. Florida, Maryland, Michigan, and Pennsylvania serve as examples of the widely varying ways in which State DOTs are approaching asset management.

Florida

Florida has managed its transportation assets through a strategic planning process referred to as "program and policy planning." The DOT has no asset management department, but its approach to decisionmaking, investment analysis, and management of transportation assets spans the department's agencies, from planning and financial management to maintenance, bridge, and pavement offices. A continuous process links policies with financial planning, programming, and performance monitoring.

Performance measurements lead to appropriate decisions regarding funding levels and adjustment of plans and policies to begin a new cycle of planning. The Office of Planning is responsible for evaluating and reporting the results of monitoring against goals and objectives.

Asset management comprises the entire process from programming and planning to preservation of the system and is characterized by a solid policy framework, measurable objectives, and continuous performance monitoring. This process results in sound investment decisions with a customer focus. The asset management concepts of data-supported decisionmaking, management systems, strong relationships between condition and performance, and an emphasis on tradeoff and investment analysis are integral components of daily business that support the department's mission—to provide a safe transportation system that ensures the mobility of people and goods, enhances economic prosperity, and preserves the quality of Florida's environment and communities. These concepts are part of the culture and are strongly supported by upper management.

In Florida, asset management begins with a strong statutory policy framework documented in the Florida Transportation Plan, which has a 20-year timeframe. A more detailed Program and Resource Plan sets forth specific operating polices and performance measures that guide the development of each program. The 10-year Program and Resource Plan contains program funding levels and financial and production targets that are balanced to anticipated revenues. A 5-year listing of projects (called the Work Program[14]) is developed annually, based on the Florida Transportation Plan, Program and Resource Plan, extensive district and public involvement, and, ultimately, decisionmaking by a strong executive board at the department.

The 5-year Work Program is reviewed, revised as necessary, and extended each year. Data collected by each district's performance monitoring programs and regional planning information are used to develop a list of projects and estimated funds that will be needed to maintain the State's performance standards for highways and bridges. Metropolitan planning organizations (MPOs) participate in this process. At the State level, these data and project lists are aggregated for executive board review. The executive board allocates funds to each district in proportion to the district's percentage of deficient lane–miles and bridges. Working with these allocations, the districts in turn determine how best to use the funds at their disposal. Life-cycle cost analysis at the district level helps decisionmakers to fit the right treatments to specific projects.

Florida has decided that preservation of highway investments will be "taken off the top." That is, it is critical to maintain existing assets before investing in new system capacity. From an asset management perspective, this ensures that roads and bridges are maintained at current value and provide the best product to the traveling public. Preservation is divided into three categories: pavement, bridge, and routine maintenance. Each has an extensive inventory-driven, performance-based, management system that allows investment decisions to be based on real needs and priorities. Monitoring and standards for each system are as follows:[15]

- *Pavement Management System*—An annual pavement condition survey is conducted to evaluate ride quality, crack severity, and average depth of wheelpath ruts. A rating of 6 or less on a 10-point scale in any of these areas causes a pavement segment to be declared eligible for treatment. The pavement condition objective is that at least 80 percent of the State Highway System lane–miles are of sufficient quality to meet department standards; in mid 2007, 83.5 percent met the standards. Decisions concerning whether a preservation treatment, repaving, or reconstruction is most cost effective for a pavement segment are informed by life-cycle cost

analysis. These analyses at the district level help to establish priorities for maintenance and replacement for the eligible projects within available funds.

- *Bridge Management System*—Each of the 6,409 State-owned and –maintained bridges and about 5,039 other bridges is inspected every 2 years to identify which need preventative maintenance, minor or major repair work, or replacement. A bridge that meets department standards is defined as not showing evidence of structural deterioration, not being limited by weight restrictions, and not needing preventative maintenance. The objective is that 90 percent of department-maintained bridges must be kept at a level that meets these standards; in mid 2007, 93 percent met the standards.
- *Maintenance Rating Program*—State highway maintenance condition is based on a sampling process that rates five primary categories of highway environment three times a year. The items rated are roadway (potholes, etc.), roadside (shoulders), vegetation and aesthetics (mowing, litter removal), traffic services (signs, lighting), and drainage (ditches). Each category is rated, and the overall maintenance condition is calculated. A maintenance rating of 80 is considered acceptable. The department's objective is to ensure that 100 percent of the State Highway System meets the maintenance standard; currently, this standard is being met.

Only after all preservation and public transportation dollars have been allocated are capacity dollars programmed. Another "off the top" allocation of at least 50 percent of all highway capacity dollars goes to the Florida Strategic Intermodal System. This statutory requirement ensures that the goals of mobility and economic prosperity are supported. A decision support system is used as a tool to support investment decisions, and the relative needs for improvement are based on five variables: pavement condition, congestion, safety, intermodal connectivity, and economic development. Mobility performance measures of quantity and quality of service, accessibility, and utilization of the system are also used. Included within these variables are level of service, vehicle miles traveled, and percentage of system heavily congested. In addition, Florida has developed a bottom-up process of incorporating input from many active MPOs for the purpose of decisionmaking in the areas of budgeting, performance monitoring, and project priority selection.

The characteristics that ensure success of the department's asset management process are statutory authority, management commitment, and high-quality data, and the fact that the process is needs based. The process allows for assessing tradeoffs in decisions and includes prediction measures and trend indicators. At the policy level, the executive board assesses tradeoffs that affect funding levels and determines the desired outcomes state-wide, whereas, at the district level, program and project life-cycle cost analysis help determine priorities and methods within the funding constraints and the condition objectives set at the State level. In summary, the Florida DOT's asset management process is simply good quality management. It is mission driven and customer focused with clear links between decisions, budgeting, and performance monitoring.

Maryland

The Maryland DOT has a multimodal structure, and asset management is the first goal in the State Transportation Plan—"Efficiency: maximize the effectiveness of existing systems."[16] The Maryland State Highway Administration (SHA) is the only administration within the DOT that has a formal, comprehensive, asset management program underway, although a multimodal, department-wide, asset management committee has been formed to develop guidelines and principles for asset management that cross the modes and to pursue asset management initiatives. The Maryland SHA's asset management program has historically focused on pavements and bridges, which represent the largest portion of the State's infrastructure assets. The emphasis now is on applying an asset management approach to managing assets other than pavements and bridges. The Highway Hydraulics Division, the Office of Traffic and Safety, and the Office of CHART (Coordinated Highways Action Response Team) and Intelligent Transportation Systems Development are beginning steps toward adopting asset management practices, and efforts are underway for the development of an agency-wide asset infrastructure data warehouse.

Supporting Maryland's Transportation Plan Goal 1 is the objective "Extend the useful life of existing facilities and equipment: The Department will place the highest priority on maximizing the useful life of existing assets and on keeping facilities in top condition to ensure service quality."[17]Aligned with this objective, the SHA Pavement Division's goals for its asset management program are to

determine a funding strategy; select specific projects to maximize highway network health within funding constraints; and predict future network health under a range of possible funding levels to inform policymakers of the effects of potential policy actions and funding levels.

The SHA's asset management approach to managing pavements has five steps: condition assessment, network-level planning, project selection, project advertisement, and construction. The SHA performs a condition assessment of its highway network (roughly 16,000 lane–miles) every year, rating ride quality as very good, good, fair, mediocre, or poor. The use of ARAN equipment across the State provides consistency.

Network-level planning—optimization—is done at the State level, within the Pavement Division, using a linear programming model to develop investment strategies that meet specific objectives. For a given objective (such as "maximize pavement condition under a specific funding constraint"), the model produces a list of how many lane–miles in each of the five conditions should be treated and with what type of treatment. It does not identify specific highway segments for treatment. The data necessary for this optimization process include pavement type, traffic level, road type, road class, district, last major treatment level, and condition for each pavement segment. Using these parameters, similar pavements are grouped. Treatment levels are also grouped by life expectancy: do nothing; maintenance (+4 years, +2 years); major (5, 8, 12, and 15 years). Using the pavement and treatment groupings, the models generate a variety of performance scenarios to predict future pavement performance, costs, and benefits across the network. The output identifies the percentage of each pavement group that should receive each level of treatment.

Project selection involves the SHA's Chief Engineer's office and each of the local districts through the Project Selection Tool (PST), software developed by the SHA. Using this tool, each district can access a roadway section inventory that shows roadway condition and traffic level as well as goals for the district: the number of lane–miles to treat within a budget constraint. Together, each district and the Pavement Division develop a list of potential projects. After cost estimates for the candidate projects are developed, the districts use the PST to compare the effectiveness of individual projects toward meeting the district's goals.

Each district's project selections are reviewed by the Chief Engineer's office to determine whether they will receive funding. The Pavement Division tries to design alternatives that meet a specified design life within defined costs. Project selection may be changed after advertising and project bidding take place and the costs in the PST are adjusted to reflect actual costs.

Maryland's Transportation Asset Management approach to pavements is notable for its linkage to strategic planning through a formal, annual, "Managing for Results" process as well as the use of formal performance measures; its high level of cooperation between central leadership and local districts; and its focus on long-term optimization. The Pavement Division is using asset management on a continual basis to meet the State's system preservation and customer satisfaction goals.

Michigan

The Michigan DOT has used an interagency committee to guide the implementation of asset management throughout the State. Michigan is one of the few States that have asset management mandated by law,[18] a key factor enabling implementation progress. The Michigan DOT has a lot of enthusiasm and hope for the changes and improvements that asset management will bring. Public Act 499, which established the Transportation Asset Management Council (TAMC), explicitly terms asset management a "strategic" process, in which goals and objectives are set, life-cycle costs are analyzed, and investment strategies are recommended. The TAMC is mandated to propose a strategy to the State Transportation Commission.

The TAMC produces an annual budget, and interviews suggest that asset management has changed the way that projects are planned in terms of funding. In the past, when the State had money, it would be awarded to teams based on their responsiveness, not on the basis of overall system needs or priorities. Asset management has given the State the tools needed to budget responsibly, and also to negotiate political funding.

Michigan is actively pursuing asset management, and it is transforming the way Michigan's DOT operates by decentralizing operations and pushing planners into regional offices with the engineers. It is causing officials to rethink the way the State's trunkline highways are maintained and improved. It has provided a common language that allows disagreements to be discussed rationally and resolved, not just within the department, but also between the department and city and county governments.

The State's Transportation Management System database incorporates more than 100 performance measures. Three relate directly to management of highway infrastructure: bridge condition, pavement condition, and customer satisfaction. Each bridge is evaluated every 2 years through the bridge inspection process and the National Bridge Inventory; pavement condition is evaluated on the basis of ride smoothness, cracking, and rutting; and customer satisfaction surveys provide feedback on how well the Michigan DOT is addressing customer expectations.

As Michigan continues down this path, more changes will occur. The State is in the beginning phases of developing data collection and management systems that will allow it to fully utilize the power of asset management. While asset management is referenced in the Long-Range Plan, specific linkages are under development.

The passage of Public Act 499 has caused a sea change within the DOT. The culture is changing, and the old ways of "worst first" project prioritization are being replaced by thinking in terms of system optimization. As the data collection and management processes come on line and further linkages to the strategic plan are created, Michigan will continue to reap the substantial benefits of asset management.

Pennsylvania

The Pennsylvania DOT (PennDOT) has a strong strategic planning process as well as a well-defined asset management concept plan. The strategic planning process at PennDOT started in the 1970s; however, the asset management concept plan began in March 2001.[19]

The purpose of asset management is to implement the right strategy for the right asset at the right time. PennDOT's concept plan calls for every strategic objective to have an owner or a leader who is responsible for that specific objective. In many of these objectives, the leaders may be directly involved in implementing asset management in their division or in part of a specific management system.

Today, PennDOT is working toward an asset management program for Highway and Bridges. Historically, roadway, bridge, and maintenance functions have had separate management and reporting systems that are entrenched. Today, the department is data-rich, but to move the systems to the next level will require integration. PennDOT is incrementally bringing asset management to roads and bridges, where most of the dollars are spent. Some of the first steps that PennDOT has taken in moving toward asset management are replacing its old mainframe Bridge Management System (BMS) with its new Pontis-based BMS2 and replacing its old maintenance system with SAP/Plant Maintenance. In addition, PennDOT is a partner with AASHTO and other States in utilizing AASHTO's AssetManager NT and PT tools. Through these tools, PennDOT expects asset management to give the agency a good platform for tradeoff analysis. Although asset management is not yet defined at the strategic level and does not yet drive the agenda, it is still part of the plan.

Future management system enhancements and replacements are to be made in accordance with an overall information technology strategic plan. This plan has not yet been developed, although efforts have been made to define business needs and priorities.

Issues Raised by State Departments of Transportation

In workshops and seminars, State DOTs have raised a number of issues and challenges:

- Technology can serve as an effective driver for advancing asset management in an agency.
- Organizational culture may be one of the most significant obstacles to advancing asset management in an agency.
- No one particular model can serve as the panacea in moving forward with asset management.
- Agencies that are taking substantive steps to do good asset management differ in their use of the modified approach for GASB 34 reporting.
- Agencies that have evaluated the Self-Assessment Tool[20] developed by the National Cooperative Highway Research Program have found it helpful in identifying gaps in their approaches to asset management or have endorsed it as a useful starting place for agencies interested in beginning asset management.

States have also reported that the implementation of Transportation Asset Management programs has introduced a common language that improves communication in several ways:

- Facilitates discussion and resolution of differences among different parts of the DOT.
- Establishes a basis for rational debate among cities, counties, and the State.
- Enables teamwork among disparate professions—planners, engineers, maintenance managers.

In addition, States have confirmed that asset management tools are an effective aid for negotiating political funding as well as for stabilizing the funding process over longer periods.

Many State DOTs have participated in the development and refinement of Transportation Asset Management practice through national committees and conferences. These include the Transportation Research Board's Asset Management Committee, AASHTO's Standing Committee on Maintenance, and collaborative efforts sponsored by FHWA with its partners, such as development of the *Transportation Asset Management Guide*.[21] The States recognize that ongoing research is needed to develop and improve processes, implementation tools, and staff training programs in asset management. During the 6th National Conference on Transportation Asset Management,[22] in 2005, a panel discussion focused on research needs and strategies for meeting them. Together with State DOTs, the views of academicians, university transportation centers, and systems consultants were represented. The panel identified the following research needs:

Data collection and integration

- Maintaining databases of condition data (currency)
- Metadata standards
- Improving data quality
- Automated data collection

Condition assessment

- Condition assessment processes for hidden infrastructure
- Using remote sensing capabilities
- Better warning systems
- Linking condition assessment with decisionmaking processes

Performance modeling

- Capturing the effect of routine maintenance in life–value
- Modeling preventative maintenance
- Enhanced modeling techniques
- Defining performance measures

Analysis

- Tradeoffs in the decisionmaking process
- Asset valuation methodologies
- Risk analysis–cost of failure
- Treatment selection methods

Big picture issues

- Documenting the benefits of asset management
- Infrastructure security
- Applications of emerging technologies
- Sustainable development

Teaching infrastructure management

- Clearinghouse for infrastructure management course materials
- Translating research into course materials

International Experience

International experiences with asset management are even more diverse than those in the United States because the institutional structures, funding sources, populations and areas served, and current state of the infrastructure assets vary considerably. A sampling of these experiences is documented in the 2005 report from the International Scanning Study team, which investigated advances and innovations in four countries at the national and state/provincial levels.[23] To illustrate some of these international experiences, the following section describes some implementation approaches at the national level in Canada, Australia, New Zealand, and England, including collaboration between Australia and New Zealand.

Canada

Asset management systems are one of five strategic research and development initiatives named in the Transportation Association of Canada's (TAC's) *Final Report: A National Agenda for Technological Research and Development in Road and Intermodal Transportation*,[24] which reports Canada's current progress and activities. The government's focus in the near future will be on rehabilitation and maintenance, since Canada's road system is well-developed and further expansion is unlikely for some time. Canada's assets rep-

resent billions of dollars in replacement value alone, and the ongoing costs to build, maintain, and operate the road network are considerable. Related to asset management, TAC's Final Report addresses trends, opportunities and needs, and research and development projects. Trends include the following (pp. 20–21):

- Increasing public demand for accountability—efficient utilization of public resources.
- Continuing shifting and re-balancing between funding of new facilities and preservation of existing facilities.
- Increasing movement toward privatization of financing, operating, and maintaining highway infrastructure.
- Emergence of "absentee" owners" (i.e., asset owners develop goals, plans, and budgets while actual maintenance and operation of highway infrastructure is done by agents acting on behalf of the owners).

Six specific areas of need for high-priority research and development in asset management were identified (pp. 21–24):

- Objective measurement of asset condition and value—An agreed-upon asset condition measure (objective, verifiable, and time-stable assessment of asset condition and value) is not yet available in Canada. Canadian agencies use a variety of subjective condition assessment methods.
- Tradeoffs between different programs or classes of assets—A technology is needed to determine the value users place on different programs and classes of assets and to translate these values into resource allocation decisions. Asset management should enable decisionmakers to readily evaluate tradeoffs among funding policies and should use a common yardstick for judging different programs.
- Determination of desirable asset condition—To allocate funds to transportation infrastructure and its competing parts rationally, a methodology is needed to evaluate the public's willingness to pay for transportation services. Since market forces do not apply to public highway services, the equilibrium between level of service and willingness to pay is not known.
- Response to industry demands for changes in vehicle weight and dimension regulations—A methodology is needed for assessing changes in heavy vehicle weight and dimension regulations on industry productivity and infrastructure impacts (benefits from increasing limits versus increased infrastructure costs), especially for evaluating new infrastructure-friendly truck suspension systems.
- Advances in electronic data processing—A broad range of front-line staff should have access to data-based management tools and should be involved in the decision-making process. Technological applications such as the use of GPS to highway inventory, use of pattern recognition techniques, monitoring asset condition by video-recording, and advances in data processing and storage capabilities make highly integrated asset management systems possible.
- Social and economic importance of highway infrastructure—The benefits of highway investments—economic growth, productivity gains, and employment opportunities—must be communicated effectively to the public to promote the understanding that highway infrastructure is an investment with a high rate of return that supports economic activities and increases productivity.

TAC reported that although the provinces have begun developing asset management systems, a system for assessment against a shared set of criteria is needed to set national investment priorities, and the ability to make that assessment has yet to be developed. To introduce asset management more widely at the federal, provincial, and municipal levels, TAC also has released *Highway Asset Management Systems: A Primer.*[25]

Australia and New Zealand

The principles of asset management and pavement management are widely recognized in Australia and New Zealand, and the use of integrated information and predictive and optimizing systems is increasing. The region's major road agencies began reporting the financial value of their road infrastructure assets in the late 1980s, and since 1997 all major road agencies have recognized road assets in annual financial statements. For more than a decade, the two countries have collaborated to advance their asset management programs.

A 1997 Austroads report, *Strategy for Improving Asset Management Practice*,[26] lists 38 priority research and development actions for cooperative effort in Australia and New Zealand. Current activity includes developing standard guidelines for road condition measurement, refine-

ment of models to predict road deterioration, accelerated testing, long-term monitoring to support the prediction of works effects, and correlation of road condition measures with community expectations, specifically for local roads carrying low volumes of high-mass vehicles. Work to improve understanding of the interaction between heavy vehicle loading and pavements is in the early stages. (Per capita, Australia is the world's most intensive user of road freight, and freight travel in Australia is predicted to double in the next 15 years.)

Many agencies have developed asset management manuals, detailed processes, and analytical tools that support the day-to-day management and planning of road-related assets; however, a protocol is in place to support harmonized modeling of road user costs among road agencies across Australia. The protocol recognizes harmonization[27] as dynamic in nature, and allows for continuous improvement on a coordinated basis. The concept of road hierarchies (fitness for purpose) is entrenched among the major road agencies, and is spreading among smaller road agencies.

The Austroads document *Integrated Asset Management Guidelines for Road Networks*[28] details a process for integrating all applicable asset management components—policy development, planning, plan execution, and verification—into a comprehensive planning framework. It defines Integrated Asset Management as "a process for ensuring the requirements of road agencies, road users and other stakeholders are clearly understood and integrated into an asset management framework that optimizes the outcomes achieved from policy and investment decisions" (p. 1).

In New Zealand, Transit NZ, the national highway agency, uses a National Asset Management Plan to guide planning related to transportation assets and decisions concerning resource allocation. This plan is instrumental in establishing the process and substance of asset management at the national level.

Performance measures and indicators are found at all levels of planning and decisionmaking. At the strategic management level, such measures and indicators are defined in the Statement of Intent, where targets are set at the start of each year and reconfirmed at midyear. An annual report shows progress on these indicators and presents information on the economic, environmental, and social goals that constitute the triple bottom line. It also includes a pavement condition report that includes measures relating to roughness, rutting, texture, and skid resistance. Operational performance measures cover issues such as availability of the network, level of congestion, safety, and response times. Financial information is also presented for program progress and delivery accountability. In addition, a monthly report presents progress reports against key performance measures in both absolute terms and trends.

Information on user satisfaction with the road network is also collected. The target established is 90 percent of road users rating their satisfaction with the road network as good or above. Road characteristics included in this survey are traffic flow, road safety, road surface, road marking, road signs, rest areas, and quality of the roadside environment.

Transit NZ is also incorporating asset management concepts into other activities and planning efforts. For example, it has developed a new agency environmental plan that is closely integrated with asset management.

England

England is a world leader in transportation, known for having one of the lowest road fatality rates of any country in the world as well as for applying innovative technologies and methods to the management of its infrastructure. The country's road network can be considered in two parts. The strategic or national network is managed by the Highways Agency, an executive agency in the United Kingdom's Department for Transport, and local authorities manage the nonstrategic, or local, network. One interesting aspect of the Highways Agency's road network is that, unlike in other countries, the mileage for which the Highway Agency is responsible has decreased each year over the past decade because the agency has been turning roads and bridges back to local governments (a practice referred to as "detrunking").

The impetus for asset management in England has been governmental directives on transport policy and accounting procedures, beginning in 1825, when Parliament stated that it was government's duty to maintain infrastructure built with public funds. The more recent evolution in asset management has come about in connection with governmental policies and procedures that have been established over the past 10 years.

The national government published a white paper in 1998 entitled *A New Deal for Transport: Better for Everyone*[29] and a report called *A New Deal for Trunk Roads in England.*[30] Three major investment areas were identified in these reports—maintenance, operations, and capital improve-

ment—along with investment criteria on safety, environment, economy, accessibility, and network integration. The reports also identified new directions for the Highways Agency, one of which was to "give priority to the maintenance of trunk roads and bridges with the broad objective of minimizing whole life costs."[31]

A Local Government Act of 1999 defined governmental responsibility for stewardship of public funds by government agencies. Local governments and their agencies are deemed "best value authorities" with "best value" being their "general duty." A best-value authority must "make arrangements to secure continuous improvement in the way its functions are exercised, having regard to a combination of economy, efficiency and effectiveness."[32] This act was preceded by a Compulsory Competitive Tendering policy, which required local authorities to follow certain processes when delivering services, thus leading to increased privatization of service delivery. This policy also changed the bid selection process from low bid to best value. The concept of "best value" has found its way into many technical guidelines and processes. For example, *Well-maintained Highways*, published by the Roads Liaison Group, is the U.K.'s "code of practice" for maintenance management. The code clearly places asset management at the center of guaranteeing best value in the road sector. In this document, the key principles of a Highway Asset Management Plan are defined as follows:[33]

- Set of objectives and policies linked to business objectives.
- An asset register (or inventory).
- Levels of service.
- Maintenance strategies for the long term based on sustainable use of physical resources and whole life costing.
- Identification of future funding requirements to maintain required level of service.
- Managing risk of failure or loss of use.
- Development of coordinated forward programs for highway maintenance, operation, and improvement.
- Measurement of performance and continuous improvement.

The Highways Agency has defined successful asset management as consisting of several steps: setting strategy and standards, recording the asset, identifying maintenance needs, prioritizing and managing maintenance needs, managing work programs and outcomes, influencing maintenance through design, measuring performance, and innovating and developing. At the top management level, the Highways Agency's Business Plan identifies the performance measures that reflect the different products and services to be delivered. Other more technical guidance on asset management is available for specific asset categories.

The U.K.'s Department of the Environment, Transport, and Regions has developed guidelines for the implementation of best practices in asset management, and the publication *Modernizing Local Government Capital Finance Paper, Chapter 4 – Encouraging Best Practice in Asset Management*[34] describes the government's efforts to see local government authorities make better use of their infrastructure assets.

Issues and Observations on the International Level

The 2005 International Scan of nearly a dozen sites in Australia and New Zealand, Canada, and the United Kingdom made some 31 observations on the asset management practices of the transportation agencies visited. Following is a sampling of those observations.

- Most of the highway agencies had top-level agency commitment to asset management. Since top transportation leaders are usually in place for longer than is typical in the United States, once leaders are educated on the merits of asset management programs, agencies can rely on support for an extended period. All of the agencies had established a management position or office that was the

focal point for guidance, information, and public participation related to asset management activities, as well as bringing together agency resources and capabilities for undertaking asset management and creating an asset management culture.

- Legislation has been an important catalyst in bringing about current thinking and practice of asset management. Agencies stressed the importance of educating public officials and the general public.
- Some of the technical approaches and use of data in the surveyed countries are similar to those in the United States:
  - All are using life-cycle (whole life) costing, supported by data identification and collection targeted for that purpose.
  - All are developing locational referencing systems for database support for asset management.
  - Some have adopted quality-control procedures, including periodic resampling, to assure high-quality data.
  - Data were highly accessible agency-wide.
  - All the agencies used risk assessment in some form in asset management applications, whether in asset management analysis, network development programs, or project prioritization, to a greater degree than is common in U.S. transportation agencies.
- A key challenge has been changing organizational culture to support asset management programs.
- To be effective, an asset management program must have a strong human resource element. Some positions have been established that name "asset management" in the job responsibilities; however, it has been difficult to find qualified candidates. Training, including the development of manuals and best-practice procedures, has been an important part of asset management implementation strategies. Professional associations and user groups related to asset management have also been useful recruitment and training tools.
- Since private contracts deliver much of the maintenance and minor capital construction programs, contractor ownership of asset management in delivered programs is encouraged, and strong asset management principles are incorporated in public–private partnership agreements.
- Most of the agencies must compete against other government programs for resources. Good data on infrastructure needs have provided justification for additional funding. A good asset management program also conveys to elected officials strong stewardship of transportation assets.
- In general, the principles and processes of asset management have been incorporated into agency planning and policy documents and are linked to environmental policy and community quality of life efforts.

Conclusion

Today, Transportation Asset Management is widely understood and accepted among transportation agencies. While, in the early 1990s, new legislative and reporting requirements gave impetus to the adoption of asset management practices, today the widely demonstrated benefits of asset management in transportation decisionmaking encourage its adoption.

The challenges to transportation agencies that grew during the 1990s continue to intensify: high user demand, stretched budgets, declining staff resources, increasing complexity, more stringent accountability requirements, rapid technological change, and a deteriorating transportation infrastructure. Transportation Asset Management is the key to finding the most effective and cost-efficient balance of preserving, upgrading, and replacing highway assets in this environment.

Most State highway agencies have some of the elements that provide information to the asset management process, most often pavement and bridge management systems that monitor conditions, measure performance, predict trends, and recommend candidate projects and preservation treatments. Many States now are also using analytical tools to compare the relative merits—and risks—of alternative policies, programs, and projects. Local governments too have found that using asset management helps them be better stewards of the infrastructure they own. However, there is a long way to go.

What lies ahead? As more State and local agencies adopt asset management, others are refining successful programs. For agencies with maturing systems, the next challenges are to broaden their asset management systems and increase their integration of missions, resources, and organizations:

- To integrate information and processes within and between systems—roads, bridges, tunnels, rails, and roadside features—and to integrate preservation programs with capital improvement programs through asset management.
- To structure stronger linkages to State (and local) policies and goals.
- To extend the asset management system to operational assets (equipment, fleets) and capital assets (buildings, facilities) and to apply asset management across transportation modes (transit, aviation, port).

- To increase collaboration and cooperation between State and local governments and with other infrastructure planners and owners, such as MPOs, environmental protection agencies, and private asset holders.
- To work toward intermodal asset management planning at all levels.
- To strive to communicate more clearly with policymakers and transportation users.

FHWA, with its public and private partners, will continue to promote Transportation Asset Management and to support research, the identification of best practices, and the development of analytical tools, as well as the provision of technical assistance, education programs, and peer exchanges. The agency's ultimate goal is to make the use of asset management the norm across the Nation for long-range transportation planning, capital program development, strategic business planning, and performance accountability.

Transportation Asset Management Resources

The latest information from FHWA on Transportation Asset Management is posted at http://www.fhwa.dot.gov/infrastructure/asstmgmt/. Following is a sample of resources available through FHWA and its partners.

Asset Management Publications

Analytical Tools for Asset Management, NCHRP Report 545 (Project 20-57), 2005, Transportation Research Board, Washington, DC. http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_545.pdf

Asset Management in Planning and Operations: A Peer Exchange. TRB Electronic Circular E-C076, 2005, Transportation Research Board, Washington, DC. http://onlinepubs.trb.org/onlinepubs/circulars/ec076.pdf

Asset Management Primer, 1999, Federal Highway Administration, Washington, DC. http://www.fhwa.dot.gov/infrastructure/asstmgmt/amprimer.pdf

At the Crossroads: Preserving Our Highway Investment, 2007, John O'Doherty, National Center for Pavement Preservation, Okemos, MI. http://www.pavementpreservation.org/news/crossroads.php

Data, Survey Methods, Traffic Monitoring, and Asset Management, 2007, Transportation Research Record No. 1993, Transportation Research Board, Washington, DC (Accession No. 01077529). http://www.trb.org/news/blurb_detail.asp?ID=8271

Economic Analysis Primer, 2000, Federal Highway Administration, Washington, DC. http://www.fhwa.dot.gov/infrastructure/asstmgmt/primer.htm

Federal Highway Administration Asset Management Position Paper, 2004. http://www.fhwa.dot.gov/infrastructure/asstmgmt/ampp.htm

Improving Conceptual Model of Transportation Asset Management: Lessons Learned From Local Level, 2007, Transportation Research Board Annual Meeting 2007 Paper #07-0285. Vincent Louis Bernardin, Pablo Luis Durango-Cohen. Transportation Research Board. Washington, DC. http://pubsindex.trb.org/orderform.html

Integrating Asset Management into the Metropolitan Planning Process: A Peer Exchange, 2006 (FHWA-HEP-07-013), Proceedings of a peer exchange held in Traverse City, Michigan, July 18–19, 2006. Federal Highway Administration, Washington, DC. www.fhwa.dot.gov/HEP10/state/intassetmgmt.htm

Life-Cycle Cost Analysis Primer, 2002 (FHWA-IF-02-047), Federal Highway Administration, Washington, DC. http://www.fhwa.dot.gov/infrastructure/asstmgmt/lcca.cfm

Optimal Timing of Pavement Preventive Maintenance Treatment Applications, NCHRP Report 523, 2004, Transportation Research Board, Washington, DC. http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_523.pdf

Performance Measures and Targets for Transportation Asset Management (NCHRP Report 551), Transportation Research Board, Washington, DC, 2006. http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_551.pdf

Primer: GASB 34, 2000, FHWA, Washington, DC. http://isddc.dot.gov/OLPFiles/FHWA/010019.pdf

Relationships Between Asset Management and Travel Demand: Findings and Recommendations from Four State DOT Site Visits (FHWA-IF-07-016). http://www.fhwa.dot.gov/infrastructure/asstmgmt/vmt.cfm

Roadway Safety Hardware Asset Management Systems Case Studies, 2005 (FHWA-HRT-05-073), Federal Highway Administration, Washington, DC. http://www.tfhrc.gov/safety/pubs/05073/

Transportation Asset Management in Australia, Canada, England, and New Zealand, 2005 (FHWA-PL-05-019), Federal Highway Administration, Washington, DC. http://international.fhwa.dot.gov/assetmanagement

Transportation Asset Management Case Studies (an ongoing series). Federal Highway Administration. http://www.fhwa.dot.gov/infrastructure/asstmgmt/

Bridge Management: California, Florida, South Dakota

Culvert Management Systems: Alabama, Maryland, Minnesota, Shelby County

Comprehensive Transportation Asset Management: North Carolina, Washington State

Data Integration: Arizona, Colorado, Michigan, Pennsylvania, Virginia

Economics: Florida, New York, Ohio-Kentucky-Indiana Regional Council of Governments

HERS-ST: Indiana, New Mexico, Oregon

Life-Cycle Cost Analysis: Pennsylvania

Pavement Management Systems: Kansas, Minnesota, Oklahoma, Washington State

Transportation Asset Management Guide, November 2002 (NCHRP 20-24(11)). Pub. Code: RP-TAMG-1. American Association of State Highway and Transportation Officials, Washington, DC. http://downloads.transportation.org/amguide.pdf

Transportation Asset Management for Local Government Agencies: Threshold Levels and Best Practice Guide, 2006, Midwest Regional University Transportation Center, Madison, WI. http://www.mrutc.org/research/0501/MRUTC_05-01_FR.pdf

U. S. Domestic Scan Program: Best Practices in Transportation Asset Management (NCHRP Project 20-68), 2007. http://onlinepubs.trb.org/onlinepubs/trbnet/acl/NCRHP2068_Domestic_Scan_TAM_Final_Report.pdf

Why Your Agency Should Consider Asset Management Systems for Roadway Safety, 2005 (FHWA-HRT-05-077), Federal Highway Administration, Washington, DC. http://www.tfhrc.gov/safety/pubs/05077/05077.pdf

Training and Peer Exchange Opportunities

Asset Management and GASB 34 for Transportation Agencies. Presentations from a workshop held November 2000 in Kansas City, MO (introduction, accounting fundamentals, policy issues, data needs and collection tools, decision support tools). http://www.ctre.iastate.edu/gasb34/

Asset Management I—Framework for Decision Making: Guide to Evidence Based Decisions through Asset Management (presentations from Ohio LTAP Workshop, October 2003) and Asset Management II—Inventory Collection & Evaluation (from Ohio LTAP Workshop, May 2004). http://www.dot.state.oh.us/ltap/AssetMgmnt.htm

Asset Management for Small Wastewater Utilities. Presentation prepared by the Maryland Center for Environmental Training. http://www.dot.state.oh.us/ltap/AssetMgmnt.htm

Database. Available Training Courses on Asset Management Topics. Federal Highway Administration. http://www.fhwa.dot.gov/infrastructure/asstmgmt/training.htm

Database of training resources through the Local and Tribal Technical Assistance Programs (LTAP/TTAP) at http://www.ltapt2.org/resources/. Many individual LTAP/TTAP Web sites also have searchable libraries of training publications and videos.

Documenting Training Opportunities Related to Transportation Asset Management. Midwest Regional University Transportation Center. October 2005. pp. 24–52. http://minds.wisconsin.edu/handle/1793/6987

GPS and Asset Management. Training. Utah Local Technical Assistance Program. http://www.utahltap.org/Services/Training.php

National Highway Institute. Transportation Asset Management (FHWA-NHI-131105) and nine other courses on topics such as preventive maintenance and pavement preservation are available. For course listings, see http://www.nhi.fhwa.dot.gov/training/brows_catalog.aspx.

TAMS Practices, Implementation Issues, and Case Studies. Utah Local Technical Assistance Program workshop presentation. 2005. http://www.worldbank.org/transport/learning/presentations/Transportation%20Asset%20Management/bolling_TAMS%20-%20LOCAL%20ROADS-PRES-FINAL2.pdf

Transportation Asset Management CD, 2007, Federal Highway Administration, Washington, DC.

Transportation Asset Management Today Community of Practice, an online knowledge site sponsored by the AASHTO Subcommittee on Transportation Asset Management and dedicated to the open exchange of information and knowledge about transportation asset management. Open to the public. http://assetmanagement.transportation.org/tam/aashto.nsf/home

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Terms and Acronyms

AASHTO—American Association of State Highway and Transportation Officials

Allocate—(as in "allocate resources")—To define a distribution of available resources among programs, geographic districts, or other uses of these resources

Alternatives—available choices or courses of action that can be considered at each stage of resource allocation or utilization: e.g., modal or investment choices to advance policy goals as considered in long-range planning; methods or work zone strategies to complete projects as considered in project development and construction design; potential allocations of funds among programs considered during program tradeoff analyses; methods to deliver construction or maintenance services as considered in program delivery; data collection procedures and data processing methods available to conduct system monitoring

Asset—the physical transportation infrastructure (e.g., travel way, structures, other features and appurtenances, operations systems, and major elements thereof); more generally, can include the full range of resources capable of producing value-added for an agency: e.g., human resources, financial capacity, real estate, corporate information, equipment and materials, etc.

Asset management—a strategic approach to managing transportation infrastructure. It focuses on business processes for resource allocation and utilization with the objective of better decisionmaking based upon quality information and well-defined objectives.

Benefit–cost—a comparison of the economic benefit of an investment to its cost. The computation should account for costs and benefits to both the agency and the transportation users through an appropriate life cycle. In asset management, benefit–cost can be applied to prioritization of projects; sums of benefits and costs for all projects in a program can be used in program tradeoffs.

Capital—type of investment that generally involves construction or major repair; includes the construction of new assets, reconstruction or replacement of existing assets, structural and functional improvements to existing assets, and rehabilitation of existing assets

Condition—measure of an asset's physical state as affected by deterioration and past maintenance and repair; can be expressed in terms of damage present (e.g., amount or percentage of cracking), an agency-defined or standard scale (e.g., condition states 1 through 5; or good, fair, poor); often used in conjunction with "performance" when described in the context of performance-based processes

Data—raw or partially processed observations, measurements, facts, figures, statistics, records, etc. collected by an agency

Data integration—process of sharing data from one source among multiple applications, or of merging data from multiple sources for use by a single application

Decision—determination of a course of action or selection of an option from available choices

Decision support—the use of information (e.g., from management systems, other analytic tools, or estimates and studies by staff) to help understand the consequences of decisions

Deficiency—gap between an asset's current condition/ performance and a defined target or threshold value; implies need for work

Enterprise architecture—the practice of applying a comprehensive and rigorous method for describing a current and/or future structure and behavior for an organization's processes, information systems, personnel, and organizational subunits so that they align with the organization's core goals and strategic direction. Although the term is often associated strictly with information technology, it relates more broadly to the practice of business optimization in that it addresses business architecture, performance management, organizational structure, and process architecture as well.

GASB—Governmental Accounting Standards Board—professional, nongovernmental organization that sets standards for financial statements for State and local governments

GASB Statement 34—a compilation of standards for financial reporting by State and local governments; notable for new requirement to report financial status of transportation infrastructure assets

GIS—geographic information system—a tool to organize geographically based data, create maps, and perform spatial analyses

Goals—desired outcomes, broadly defined, as expressed in policy

GPS—global positioning system

Impact—effect or result, as of a project, program, policy, level of investment, or budget

Improvement—a project or investment that enhances transportation system functionality; may include capacity additions or operations enhancements to existing facilities, or construction of new facilities

Information—processed or refined data in a form that communicates meaningful indications of current status or calculations and predictions useful for decision support

Integration—combining of data or results from multiple systems

Inventory (as in asset inventory)—a compilation of the infrastructure assets of an agency, and their relevant characteristics: e.g., count or quantity, location, size, functional classification, traffic usage, district responsibility, etc.; may include condition or performance data, depending on agency practice

Life cycle—a length of time that spans the stages of asset construction, operation, maintenance, rehabilitation, and reconstruction or disposal/abandonment; when associated with analyses, refers to a length of time sufficient to span these several stages and to capture the costs, benefits, and long-term performance impacts of different investment options

Levels of service (LOS)—measures related to the public's perception of asset condition or of agency services; used to express current and target values for maintenance and operations activities.

Maintenance—program of activities to enable a transportation system to continue to perform at its intended level; comprises a range of services in preservation, cleaning, replacing worn or failed components, periodic or unscheduled repairs and upkeep, motorist services (incident response, hazardous materials response), snow and ice control, and servicing of traffic devices and aids; does not add to structural or operational capacity of an existing facility

Management system—software application that supports a particular set of an agency's business processes, whether in managing assets or resources (e.g., pavements, bridges, human resources, equipment fleets, materials stockpiles, lands and buildings), performing prescribed functions (e.g., planning, project development, construction management, maintenance management), recording and managing transactions (e.g., financial management and accounting, payroll), or processing and communicating information (e.g., executive information, customer comments and complaints)

Monitoring—collecting and processing condition and performance data and related data (e.g., traffic usage) to understand the current status of the transportation system, identify problem areas, gauge improvements resulting from investments, and track progress toward performance targets; provides a feedback mechanism for resource allocation and utilization decisions

Need—work required to help attain a policy objective or performance target, or to address a problem or deficiency

Network—system of assets to provide transportation services to customers

Objective—translation of a policy goal into a more specific measure of attainment: e.g., a policy goal of improved pavement performance might be expressed through an objective of improved serviceability or ride quality, or reduced roughness; a policy goal of improved mobility might be expressed through an objective of reduced travel time or total trip time, percentage increase in user benefits, or improvement in congestion measures or indexes

Operations, operational improvements—investments and activities to improve the efficiency and safety of traffic movement on the existing transportation system (e.g., through improved signal timing, installation of variable message signs and other ITS devices, improved traffic monitoring and reporting of problem locations, traffic metering)

Optimal—the preferred or best option based on some criterion

Options—see alternatives

Outcome—result or consequence (especially in terms of performance), as of an investment decision, a particular allocation of resources, completion of a project, conduct of maintenance at a particular level of service, or selection of a particular alternative

Performance—characteristic of an asset that reflects its functionality or its serviceability as perceived by transportation users; often related to condition

Performance measure—an indicator, preferably quantitative, of service provided by the transportation system to users; the service may be gauged in several ways (e.g., quality of ride, efficiency and safety of traffic movements, services at rest areas, quality of system condition, etc.)

Performance target—threshold value of a performance measure that an agency will strive to achieve to satisfy a policy objective

Preservation—actions to deter or correct deterioration of an asset to extend its useful life; does not entail structural or operational improvement of an existing asset beyond its originally designed strength or capacity

Preventive maintenance—proactive maintenance approach that is applied while the asset is still in good condition; extends asset life by preventing the onset or growth (propagation) of distress

Program—A set of projects of similar type of work (e.g., pavement rehabilitation) or serving a similar objective (e.g., to improve mobility or safety)

Project—construction work to address a need or deficiency in system preservation, improvement, or operations

Project prioritization—process of comparing costs, benefits, and other performance impacts among peer projects to rank them by merit

Rehabilitation—project to perform comprehensive structural repair or capacity, operations, or safety improvements to an existing asset

Resource—an input to the construction, operation, maintenance, repair, renewal, or disposal of transportation infrastructure assets; adds value to these processes; may include labor knowledge and skills, financial capacity, real estate, corporate information, equipment and materials

Strategic—a view of assets that is policy-based, performance-driven, long-term, and comprehensive

Tradeoffs—comparisons between alternative solutions, particularly involving consequences of reallocating funds between programs

User benefits—economic gains to transportation users resulting from a project or investment strategy; may include monetary value of travel time savings, accident reductions, reduced costs of vehicle operation, and savings or advantages gained from more reliable transportation services (e.g., regarding transportation of goods)

Utilization—as in resource utilization: process of applying labor, funds, information, and other resources to implement projects and services for the transportation system

"What if" analysis—Also referred to as scenario analysis. Analytic study of the consequences of different actions or assumptions; in asset management, often refers to predictions of asset condition and performance for different budget or revenue assumptions, levels of investment, or sets of policies (the "scenarios"); a capability of modern pavement management, bridge management, and maintenance management systems

Notes

1. Government Performance and Results Act of 1993, Pub. L. No. 103-62, 107 Stat. 285 (codified as amended in scattered sections of 5 U.S.C., 31 U.S.C., and 39 U.S.C.). See http://www.whitehouse.gov/omb/mgmt-gpra/gplaw2m.html.
2. This definition was developed by the AASHTO Subcommittee on Asset Management in January 2006. http://www.transportation.org/sites/scoh/docs/Motion_Trans_Asset_Management.doc
3. Issued in June 1999. http://72.3.167.244/repmodel/index.html
4. Ernie Wittwer, Sue McNeil, Katie Zimmerman, Jason Bittner, and others, *Key Findings From the Fifth National Workshop on Transportation Asset Management*, September 29–30 and October 20–21, 2003. Midwest Regional University Transportation Center. http://www.mrutc.org/outreach/FinalReport5thNTAM.pdf
5. *Transportation Asset Management Guide*, 2002, National Cooperative Highway Research Program Report Number 20-24(11). Pub. Code: RP-TAMG-1. American Association of State Highway and Transportation Officials, Washington, DC. pp. 3-1–13.
6. Ernie Wittwer et al., *Key Findings From the Fifth National Workshop on Transportation Asset Management.* p. 20. (note 4)
7. *At the Crossroads: Preserving Our Highway Investment,* 2007, John O'Doherty, National Center for Pavement Preservation, Okemos, MI. http://www.pavementpreservation.org/news/crossroads.php
8. Proceedings—Fourth Annual Lead States Workshop. *Leading Technology into the 21st Century: Preparing for the Future.* 1999. http://leadstates.transportation.org/99proceedings.pdf
9. *U.S. Domestic Scan Program: Best Practices in Transportation Asset Management, SCAN-TOUR REPORT.* 2007. Transportation Research Board, Washington, DC. http://onlinepubs.trb.org/onlinepubs/trbnet/acl/NCRHP2068_Domestic_Scan_TAM_Final_Report.pdf
10. *Transportation Asset Management in Australia, Canada, England, and New Zealand,* (FHWA-PL-05-019), 2005, Federal Highway Administration, Washington, DC. http://international.fhwa.dot.gov/assetmanagement/2005tam.pdf
11. See http://www.fhwa.dot.gov/infrastructure/asstmgmt/casestudies.cfm

All Web URLs were accessed December 20, 2007.

12. Vincent Bernardin, Jr., and Pablo Durango-Cohen, 2006, *Transportation Asset Management for Local Government Agencies: Threshold Levels and Best Practice Guide*, Midwest Regional University Transportation Center, Madison, WI. p. 10. http://digital.library.wisc.edu/1793/6963

13. Ernie Wittwer et al., *Key Findings From the Fifth National Workshop on Transportation Asset Management* (note 4). See also Vincent Bernardin, Jr., and Pablo Durango-Cohen, 2006 (note 12).

14. See http://www2.dot.state.fl.us/programdevelopmentoffice/wp/default.asp for detail of Work Program.

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