Asset Management Primer

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Asset Management Primer

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NOTE FROM THE DIRECTOR

Office of Asset Management, Infrastructure Core Business Unit, Federal Highway Administration

The Federal Highway Administration's Office of Asset Management is pleased to present this *Asset Management Primer*. The idea for the Primer arose during the 1998 FHWA reorganization effort, when the Office of Asset Management was created. Upon establishment of the Office, one of the most frequently asked questions both from individuals within FHWA and from people outside the agency was, "What is Asset Management?"

The origins of this inquiry are easy to understand. Most professionals within the transportation community know that State and local transportation agencies have an outstanding historical record of effective asset management. It was difficult to understand what Asset Management, with a capital "A" and capital "M," was or why it was needed. I determined that a primer on Asset Management would be useful in helping those interested gain an understanding and appreciation of this expanded and important concept.

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

Asset Management has come of age because of (1) changes in the transportation environment, (2) changes in public expectations, and (3) extraordinary advances in technology. Today's transportation environment is characterized by high user demand, budgets stretched by significant and growing requirements, past and projected declines in staff resources, and a mature system that is experiencing ongoing deterioration.

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Over the past decades, the public has invested, through Federal, State, and local government, in the construction, maintenance, and operation of the Nation's highway system. The expectation is that governments will be responsible stewards of this investment. Federal, State, and local transportation agencies wholeheartedly concur with this expectation and are committed to making investment and maintenance decisions that are understandable to the public. The agencies recognize that the public will hold them accountable.

Clearly, the combination of changes in the transportation environment and 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. These goals reflect customer expectations, as well as considerations unique to each State department of transportation (DOT), and are used to guide, monitor, and evaluate the entire process.

Asset Management was made possible with the advent of increasingly powerful computer systems. With those systems came the possibility of more sophisticated analytical tools and techniques, as well as information technology that would support a comprehensive, fully integrated Asset Management system. This new technology also allows DOT officials to effectively dialogue with decisionmakers through "what if" analyses. For example, the impact of higher or lower budget levels on system condition and performance and users may be readily demonstrated.

FHWA is working closely with the American Association of State Highway and Transportation Officials to, at their request, provide technical assistance and training to assist individual State transportation agencies as they work to implement Asset Management systems. We believe that this essential effort will pay tremendous dividends to the public by ensuring high-quality, cost-effective service.

Madeleine Bloom

Madeleine Bloom
Director, Office of Asset Management

WHAT IS ASSET MANAGEMENT?

Asset Management is a still-emerging concept in the highway industry. But at its heart, it provides a solid foundation from which to monitor the transportation system and optimize the preservation, upgrading, and timely replacement of highway assets through cost-effective management, programming, and resource allocation decisions.

Although the transportation community continues to refine the definition of Asset Management as it gains more experience with it, the following "working definition" may be offered:

> Asset management is a systematic process of maintaining, upgrading, and operating physical assets cost-effectively. It combines engineering principles with sound business practices and economic theory, and it provides tools to facilitate a more organized, logical approach to decision-making. Thus, asset management provides a framework for handling both short- and long-range planning.[1]

For a sample of other definitions, see the sidebar on the next page.

An Asset Management decision-making framework is guided by performance goals, covers an extended time horizon, draws from economics as well as engineering, and considers a broad range of assets that include physical as well as human resources. Asset Management provides for the economic assessment of trade-offs between alternative improvements and investment strategies from the network- or system-level perspective—that is, between modes and/or asset classes within modes. At the same time, it allows for the more complete comparative analysis of options for individual projects.

Asset Management links user expectations for system condition, performance, and availability with system man-

[1] *Asset Management: Advancing the State of the Art Into the 21st Century Through Public-Private Dialogue.* Federal Highway Administration and the American Association of State Highway and Transportation Officials, 1996, page 3.

ASSET MANAGEMENT GUIDING PRINCIPLES

An Asset Management system should be:

- Customer focused
- Mission driven
- System oriented
- Long-term in outlook
- Accessible and user friendly
- Flexible

An Asset Management system should include:

- 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
- Usage information
- 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 DEFINITIONS

The term *Asset Management* may be used in the context of strategic management or tactical (day-to-day) management. Because this Primer maintains a strategic orientation, the following selected definitions are provided, which describe a comprehensive, strategic, and integrated system of Asset Management.

"...a methodology needed by those who are responsible for efficiently allocating generally insufficient funds amongst valid and competing needs."

— The American Public Works Association Asset Management Task Force

"...a comprehensive and structured approach to the long-term management of assets as tools for the efficient and effective delivery of community benefits."

— Strategy for Improving Asset Management Practice, AUSTROADS, 1997

"Asset Management...goes beyond the traditional management practice of examining singular systems within the road networks, i.e., pavements, bridges, etc., and looks at the universal system of a network of roads and all of its components to allow comprehensive management of limited resources. Through proper asset management, governments can improve program and infrastructure quality, increase information accessibility and use, enhance and sharpen decision-making, make more effective investments and decrease overall costs, including the social and economic impacts of road crashes."

— Organization for European Cooperation and Development Working Group, Asset Management Systems, Project Description, 1999

"In the transportation world, asset management is defined as a systematic process of operating, maintaining, and upgrading transportation assets cost-effectively. It combines engineering and mathematical analyses with sound business practice and economic theory. The total asset management concept expands the scope of conventional infrastructure management systems by addressing the human element and other support assets as well as the physical plant (e.g., highway, transit systems, airports, etc.). Asset management systems are goal-driven and, like the traditional planning process, include components for data collection, strategy evaluation, program development, and feedback. The asset management model explicitly addresses integration of decisions made across all program areas. Its purpose is simple—to maximize benefits of a transportation program to its customers and users, based on well-defined goals and with available resources."

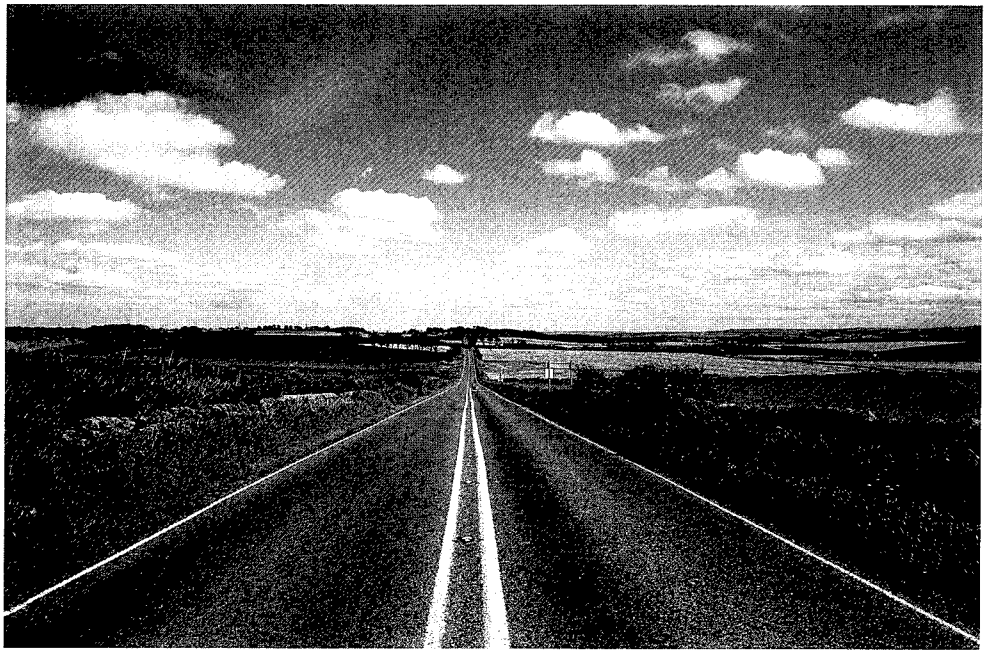
— Blueprint for Developing and Implementing an Asset Management System, Asset Management Task Force, New York State Department of Transportation, April 22, 1998

agement and investment strategies. An Asset Management system will report on progress made in achieving goals and will also evaluate the process relative to the goals. Furthermore, the impact of alternative management and investment strategies on realizing the expressed goals may be readily determined and communicated.

The focus is on assets (dollars, people, and physical resources) and system performance and includes return on investment, maximizing economic efficiency, accountability, opportunity costs, and future requirements. This broad approach to resource allocation and programming decisions can provide greater value to the system and overall satisfaction for end users. Program quality and system performance will improve.

Asset Management not only aids in the decision-making process, but also provides for a fact-based dialogue between system users and other stakeholders, State government officials, and managers concerned with day-to-day operations. This results from relevant, objective, and credible information being accessible to all participants in the decision-making 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 other times data generated from the analytical process—results in an improved understanding of the economic trade-offs, return on investment, and potential value of the end product.

Asset Management provides ready access to quantitative and qualitative data and allows decisionmakers to more readily identify and focus on key issues. Furthermore, the ability to weigh and articulate the impact of choosing one alternative over another through "what if" analyses is enhanced. And, importantly, the documentation explaining the selection of a particular strategy is improved. A fact-based, reproducible, systematic approach can enhance the dialogue among decision-making bodies regarding capital investment levels.



WHY ASSET MANAGEMENT?

In the 1960s, 1970s, and early 1980s, the Nation's transportation agencies were focused on major building and expansion of the Interstate Highway System. Since the mid 1980s and 1990s there has been a shift to preserving and operating the $1 trillion investment in highways and bridges. At the same time, the public underwent a change in its view of effective governance, resulting in the increased expectation that government will be more accountable and will be managed more like a business operation.

If current trends continue into the future, State departments of transportation (DOTs) and other public-sector owners of highway infrastructure will be facing increased system and budget needs with limited staff resources. At the same time, States will be required to deal with increased system complexity and public demands for accountability and expectations regarding levels of service. The bottom line is that States and other governmental units will need to focus on the critical, be able to justify what they are doing, and be responsible for the results.

In responding to these challenges, State DOTs are partnering with industry to advance the concepts and practices of Asset Management, a new way of doing business. The private and government sectors are, or will be, making performance and return-on-investment considerations an integral part of program evaluation and project selection. This approach is seen as a way to improve efficiency and productivity and to increase the value of services and products to transportation users. Asset Management offers a systematic approach to achieving these objectives.

The following sections outline the more important trends affecting State DOTs.

SYSTEM DEMANDS

The Interstate Highway System was completed early in the 1990s, after an almost 40-year effort. With this milestone came a shift from new construction to an emphasis on maintenance, management, and reconstruction of the existing infrastructure. Now, portions of our highway assets are deteriorating because of increasing usage of the system, environmental impacts on the system, and sheer aging of the system. Simply put, our physical assets will not last forever.

The implications are two-dimensional. The first dimension pertains to increased requirements for maintenance and reconstruction, particularly on older systems. The second dimension speaks to system performance. For example, on the personal travel side, system users have high expectations regarding safety, comfort, convenience, and security. On the commercial side, in addition to the previously indicated expectations, system reliability is critical, particularly in the context of just-in-time delivery and other productivity-enhancing patterns of operation.

PERSONNEL CONSTRAINTS

States are facing a number of personnel-related issues. First, some States have lost significant numbers of staff in recent years as a result of government reinvention and accompanying downsizing. This trend is likely to continue. Second, States are finding it difficult to attract and retain capable professional staff to manage a varied and complex array of program areas, primarily because of the competitive nature of today's economic environment and employment market. As a result, DOTs are forced to prioritize their work functions—i.e., to determine which among many valid needs will be addressed. Highway agency staffs are likely to concentrate more on management functions and less on day-to-day technical functions, which are increasingly being outsourced.

INCREASED BUDGET DEMANDS

Budget pressures arise from constraints on the availability of funds, as well as from the demand for funds. On the supply side, transportation officials may need to compete for funding with other publicly supported programs, such as education. Also, a number of legislatures have enacted provisions that direct transportation funds to be spent in areas outside traditional highway projects. On the demand side, increased usage, costs, and needed upgrade requirements strain limited budgets.

ACCOUNTABILITY TO THE PUBLIC

Public skepticism of government, combined with an increasing preference in recent years for using private-sector management approaches in the public sector, has led to demands that government be more accountable and operate more like a private business. 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 Federal Government's Government Performance and Results Act. Such legislation typically calls for States to report what is bought with public funds, how spending decisions are made, and what is accomplished. A new initiative by the Governmental Accounting Standards Board (see sidebar, page 12) furthers this trend. It recommends a more asset-based approach to State financial reporting, which would focus on facility condition and asset valuation over time.

GOVERNMENTAL ACCOUNTING STANDARDS BOARD

A major initiative undertaken by the Governmental Accounting Standards Board (GASB), which establishes requirements for the annual financial reports of State and local governments, may provide a significant impetus for State DOTs and local governments to deploy an Asset Management system.

In June 1999, GASB issued Statement No. 34, "Basic Financial Statements for State and Local Governments," which requires State and local agencies to enhance the types of information provided as part of their annual financial statements, in a manner more consistent with that used by private-sector companies and governmental utilities. Annual reports in compliance with the new rule will include financial statements prepared using full accrual-based accounting practices, which reflect all of the government's activities—not just those that cover costs by charging a fee for service. This new approach will cover all capital assets and long-term liabilities including infrastructure, as well as current assets and liabilities. Accrual accounting reports all of the costs and revenues of providing services each year.

GASB recommends that State, city, and county government agencies, in reporting capital assets as part of their modified financial statements, use a historical cost approach to establish transportation infrastructure values. If historical cost information is not available, GASB provides guidance for a proxy estimate using the current replacement cost.

Statement 34 indicates that government may use any established depreciation method and identifies both straight-line depreciation and condition-based depreciation as acceptable. However, the GASB requirements indicate that infrastructure assets that are part of a network or subsystem of a network do not have to be depreciated if two distinct criteria are met—namely, if the government manages the infrastructure assets using an asset management system, and if the government documents that the infrastructure assets are being preserved at, or above, a condition level originally established for the assets. The asset management system should:

- Have an up-to-date inventory of assets;
- Perform condition assessment of the infrastructure assets at least once every 3 years, and summarize the results using a measurement scale; and
- Estimate the annual amount required to maintain and preserve the infrastructure assets at the condition level originally established for those assets.

CURRENT PARADIGM FOR DECISION-MAKING (WHAT DO WE HAVE?)

Much of the current paradigm for State-level transportation decision-making was defined by the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, which required each State to develop a Statewide plan. Ideally, this plan presents a fiscally realistic vision, covering 20 years or more, of strategies for addressing a State's mobility and economic requirements. It reflects the full range of modal choices, covering, for example, highways, rail, and transit. The plan also covers the management of existing assets, which includes maintaining, monitoring, and improving transportation system performance.

Also required by ISTEA is a "financially constrained" Statewide Transportation Improvement Program (STIP). This is a list of projects that a State plans to advance over, at minimum, the next 3 years. The STIP must indicate the source of funding for included projects, as well as the financial plans for ensuring the continued operation and maintenance of the existing system. It is intended that the short-term capital investment and operational decisions provided in the STIP will be consistent with the policies and objectives delineated in the Statewide plan.

Most State highway agencies currently have some of the more common elements that provide information into the Asset Management process. The two most common are pavement and bridge management systems. These systems are intended to cyclically monitor the condition, measure the real-life performance, predict future trends, and recommend candidate projects and preservation treatments. In addition, many include analytical tools such as deterioration models and optimization algorithms designed to evaluate the impacts and trade-offs of current and future alternative policies, programs, and projects. All of these features are not, however, necessarily used in every State.

In summary, although each State has a unique approach to making transportation investment decisions, three primary functions are common to all highway agencies. First, each State has a long-term strategic planning element that is intended to provide guiding policies and objectives. Second, each State has a requirement to produce a short-term program of projects intended for funding. And, finally, each State has mechanisms for evaluating and selecting projects for actual implementation. Underlying this general process are data and analysis, as well as policy considerations. (See Figure 1.)

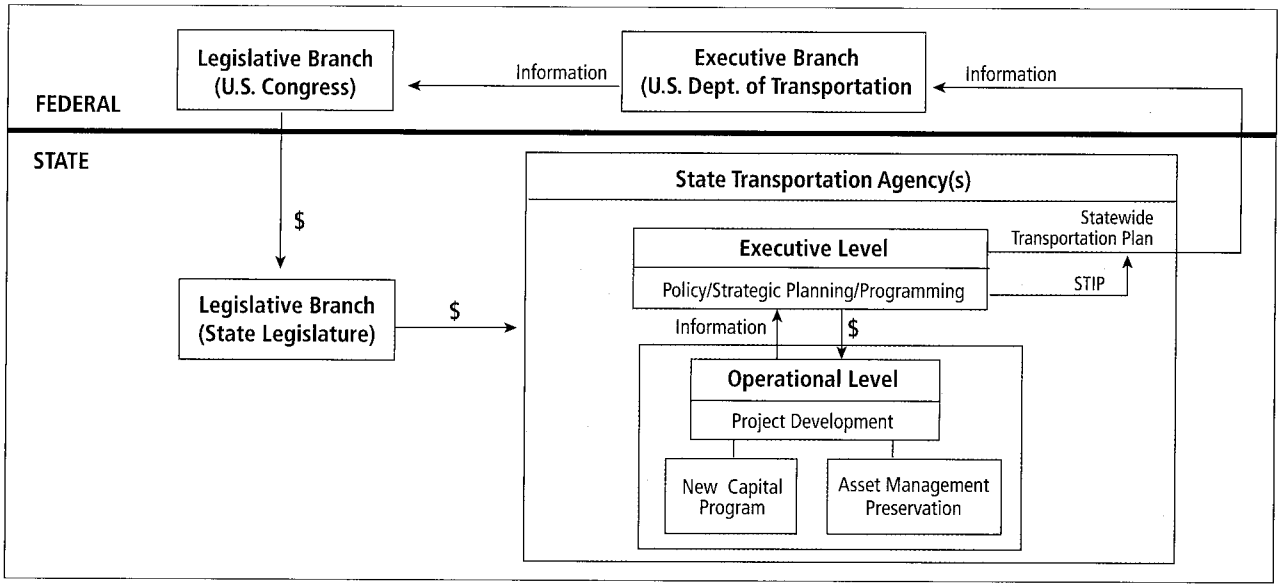


FIGURE 1. Idealized Transportation Investment Decision-Making Process (Federal and State)

PAVEMENT MANAGEMENT SYSTEMS

A Pavement Management System (PMS) has long been considered a programming tool that collects and monitors information on current pavement, forecasts future conditions, and evaluates and prioritizes alternative reconstruction, rehabilitation, and maintenance strategies to achieve a "steady state" of system preservation at a predetermined level of performance (e.g., a goal). The condition data in a PMS database can also be used as an engineering tool to evaluate the real-life performance of pavement relative to various parameters, such as thickness design, mix design, material composition, and construction specifications. Both PMS tools rely on economic as well as engineering principles.

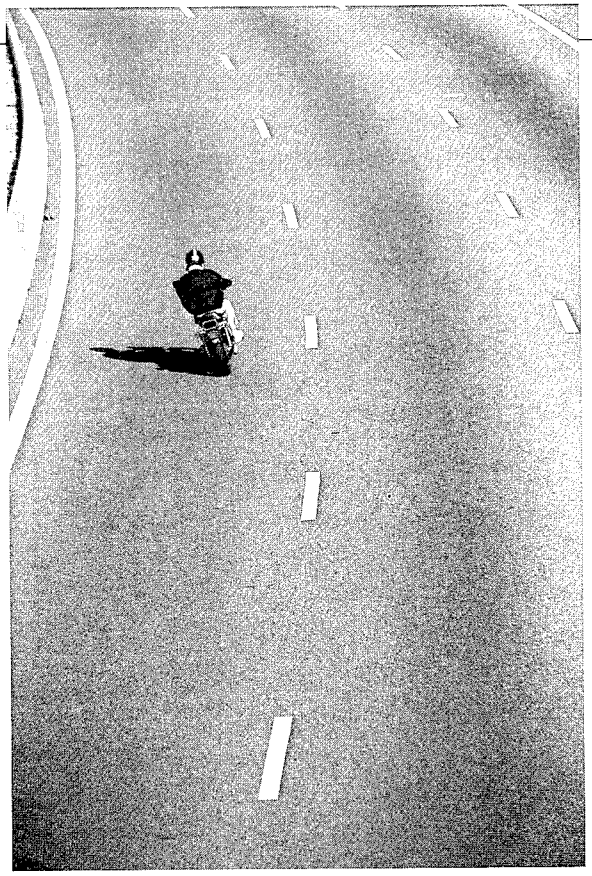
In the 1960s and 1970s, States first began to address the issue of managing pavements by devising methods to (1) show the degree of current pavement deterioration and (2) prioritize potential improvements according to a "worst first" philosophy, where the pavement in the poorest condition was addressed first. Today the PMSs used by many States include the capability to consider both the engineering aspects and the economic aspects of pavement investments and the return on investment. Use of a PMS approach has been shown to be more efficient than always focusing on the "worst first."

There are three principal components of a PMS:

- data collection and management,
- analysis, and
- feedback/updates.

The data component contains inventory information, including physical cross-section, materials, history, traffic/load data, and condition.

The second feature, the analytical component, is applicable at both the network and project levels.



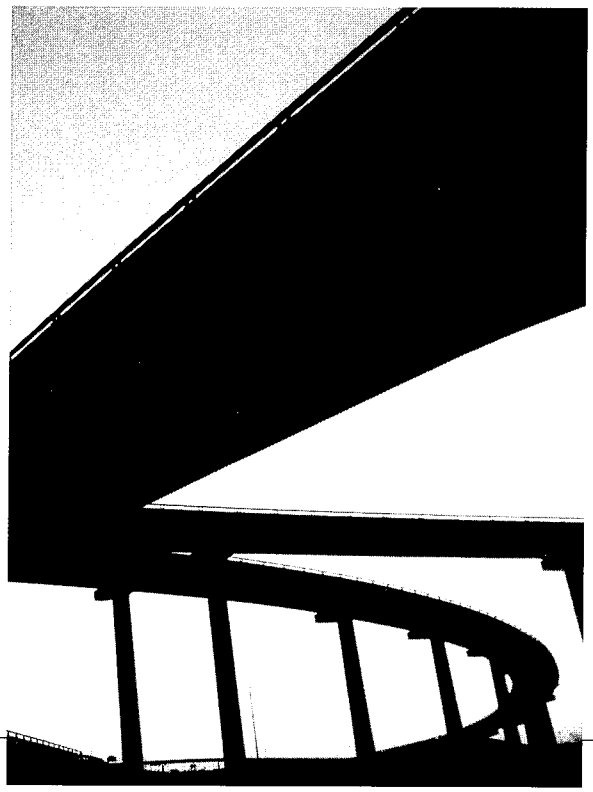
Network-level analysis looks at the entire system and prioritizes projects generally based on benefits and costs. At the project level, pavement management is the process of recommending viable repair strategies based on engineering and economic factors. The final component provides for an annual evaluation of the PMS.

Although most States have some form of PMS in place or under development, in many systems not all features are yet fully functional. The challenge facing many agencies is to complete the development and then begin to fully utilize the systems. When that is accomplished, an agency will be equipped to integrate its PMS into its Asset Management program.

BRIDGE MANAGEMENT SYSTEMS

Bridge Management Systems (BMSs) are decision-support tools developed to assist States in determining how and when to make bridge investments that will improve safety and preserve existing infrastructure. Ideally, a BMS should identify current and future deficiencies, estimate the backlog of investment requirements, and project future requirements. A BMS is also intended to determine the optimal program of bridge investments over time periods, given particular funding levels.

In 1991, the Federal Highway Administration sponsored the development of the PONTIS BMS. The software was made available to the States in 1991, and in 1995 it was incorporated into the American Association of State Highway and Transportation Officials AASHTOWare product line. It has been enhanced several times since then.



Key features of PONTIS include:

- Data and analytical models: (1) an inventory of the State's bridges to include condition data, (2) engineering and economic models to include deterioration prediction models, (3) an array of improvement options, and (4) updating procedures;
- Procedures to identify optimal maintenance, repair, and rehabilitation strategies;
- Procedures to identify and rank capital improvements based on economic criteria; and
- An integration model that develops a consolidated master list of recommended maintenance and capital improvements.

To date, 37 States have procured a license to implement PONTIS. However, significantly fewer than 37 are using the model for decision-making. One issue is the requirement to populate the PONTIS database with information on bridge elements—data that are not readily available because bridge inspectors must be trained to conduct element-level inspections. Another issue is that States have found it difficult to obtain adequate data on current and historical maintenance and repair actions, which are needed to develop maintenance cost estimates.

Another BMS, developed under the National Cooperative Highway Research Program, is the BRIDGIT model. In contrast to PONTIS, which conducts network-level optimization analysis and applies it at the project level, BRIDGIT evaluates projects and aggregates the results to develop optimal network strategies. Only two States use the BRIDGIT model. In addition to PONTIS and BRIDGIT, several States have been successful in developing BMS approaches tailored to their own unique requirements.

CURRENT PRACTICE (HOW IS IT WORKING?)

During the 1960s, 1970s, and even into the 1980s, transportation preservation projects were selected and developed without the benefit of today's vast technology expansion and the information resources made possible by the technical revolution in computers, automated data collection, testing equipment, design procedures, analytical tools, and so forth. Investment decisions were project driven, and asset preservation and upgrading were frequently by-products of facility expansion and new construction. Over the past two decades, progress in the planning and programming arena of system preservation, upgrading, and operation has been considerable, with asset management becoming a more important element in the States' overarching policies and transportation plans.

Today, most State transportation plans include more explicit policies and goals relative to asset management. However, the link between the transportation plan and actual programming and resource allocation decisions may be tenuous if state-of-the-art engineering, economic, and business practices are not in place. The policies and objectives regarding Asset Management and investment are intended to guide project selection and development. In the past, transportation investment and maintenance decisions within and among asset classes tended to reflect tradition, intuition, personal experience, resource availability, and political considerations, with systematic application of objective analytical techniques applied to a lesser degree because of lack of availability. Furthermore, success was often measured in terms of controlling backlogs, not in optimizing system performance, maximizing return on investment, or minimizing user impacts. Currently, more States are developing performance measures and targets to guide the overall decision-making process.

Achieving the situation where programs and projects reflect predetermined goals and policies is difficult for a number of reasons. First, available analytical tools are subject to technical constraints related to data inputs, assumptions, and theoretical understanding. Second, practical realities related to institutional considerations, social objectives, and political goals may circumvent the process. And third, the planning, programming, and project development processes in many States must deal with antiquated data systems, disparate management systems (such as for pavement and bridges), and limited communication channels, especially along horizontal lines.

TECHNICAL CONSIDERATIONS

Although management systems, such as pavement and bridge systems, have been under development for many years and these systems have inherent investment analysis capabilities, few States use economic efficiency criteria to assess the relative merits of overarching alternative investment strategies within all asset classes, e.g., one highway facility versus another based on relative costs and benefits.

Most States limit application of their management systems to monitoring conditions and then plan and program their projects on a "worst first" basis. Existing management systems typically function at the operations level and focus on one particular asset. The current approach to asset management in general, and resource allocation and investment analysis in particular, is tactical rather than strategic.

Another technical issue facing State DOTs is the requirement for appropriately trained analysts with the ability to translate the results of complex analytical processes into relevant conclusions that can be readily understood by the layperson. Furthermore, it is important for the analysts to have a full understanding of the important concepts and techniques. States face some difficulty in finding and retaining staff with these capabilities because of the personnel situation described earlier.

PRACTICAL REALITIES

Beyond the technical hurdles, State practitioners are faced with a host of practical realities that confound objective, analytically based decisions. Institutional considerations, social objectives, and political goals have the potential to dominate the resource allocation and project selection process.

Examples of institutional considerations include the legislative earmarking of Federal and State funds. In addition, State budgets generally cover time horizons of 1 to 2 years. Therefore, committing available funds over the long term is difficult. The short budget cycle, combined with uncertain future funding levels, creates pressure to select the alternative with the lowest initial cost, regardless of total life-cycle cost and return on investment. In other words, the cost-effective solution may not be the most politically practical solution.

A further complication arises from the competition between political objectives and the technical decision-making process. For example, elected and appointed officials may find a strictly long-term perspective demanded by the analytical approach to be untenable. In addition, the public often measures the success of such officials by their ability to advance specific projects and services. As such, decisionmakers may prefer a process that will accommodate individual efforts, as opposed to a technical approach that does not specifically reflect such efforts. Long-term, cost-effective solutions therefore may not always be the most attractive because of competing policy objectives.

INTEGRATION

In many of the State DOTs, horizontal and vertical communication has historically been limited. This situation inhibits a systems approach to managing assets. States that have established management systems have done so by focusing on individual asset classes. The result has been so-called "stovepipe" operations with limited horizontal coordination. For instance, bridge management systems were developed by bridge engineers, and pavement management systems were produced by pavement engineers. Typically, there is little, if any, data exchange between systems. Furthermore, there is little consistency with respect to investment decision procedures. As a result, these systems are not able to evaluate trade-offs between various classes of assets, for example, highways versus bridges.

Complicating coordination across asset classes is the typical State DOT's organizational structure. Many State DOTs experienced most of their growth and development during the Interstate Highway construction years. As a result, most of these organizations have budgets, staffs, and other internal resources that support the requirements of a highway construction program and are not necessarily geared to highway preservation and system efficiencies.

IMPROVING THE PROCESS (WHAT DO WE NEED?)

Distilled to its essence, Asset Management is a strategic, as opposed to tactical, approach to managing assets. The process works as follows: First, performance expectations, consistent with goals, available budgets, and organizational policies, are established and used to guide the analytical process, as well as the decision-making framework. Second, inventory and performance information are collected and analyzed. This information provides input on future system requirements (also called "needs"). Third, the use of analytical tools and reproducible procedures produces viable cost-effective strategies for allocating budgets to satisfy agency needs and user requirements, using performance expectations as critical inputs. Alternative choices are then evaluated, consistent with long-range plans, policies, and goals. The entire process is reevaluated annually through performance monitoring and systematic processes.

Figure 2 illustrates a generic Asset Management system and lists key questions that inform the analytical process. The components are indicated, as are the relationships among them. Various issues, tools, and/or activities are associated with each component. For example, "trade-off analysis" would include the application of an array of engineering economic analysis (EEA) tools, including benefit/cost analysis, life-cycle cost analysis, and risk analysis.

The components indicated would typically be included in any Asset Management approach, although the specifics of any given system would differ to suit a particular highway agency. States will define the parameters of their own systems based on State decision variables, such as policies, goals, asset types and characteristics, budgets, and State operating procedures and business practices. Furthermore, any Asset Management system should be flexible enough to respond to changes in any of these variables or factors.

The assets likely to be included in a State's initial Asset Management implementation efforts will depend on the organization's existing capabilities, particularly in the area of technical, financial, and human resources. See the sidebar below for a representative overview of assets found in most States.

What is needed to support the Asset Management approach is a logical sequence of decision steps, constituting a decision framework. The framework is supported by (1) information regarding organizational goals, policies, and budgets, (2) horizontal and vertical organizational integration to implement the decision steps in practice, and (3) technical information to support the decision-making process.

TYPICAL STATE HIGHWAY ASSETS

Infrastructure Assets

Pavements

Structures

Tunnels

Hardware (guardrail, signs, lighting, barriers, impact attenuators, electronic surveillance and monitoring equipment, and operating facilities, etc.)

Other Assets

Construction and maintenance equipment

Vehicles

Real estate (buildings, property, roadside and right-of-way)

Materials

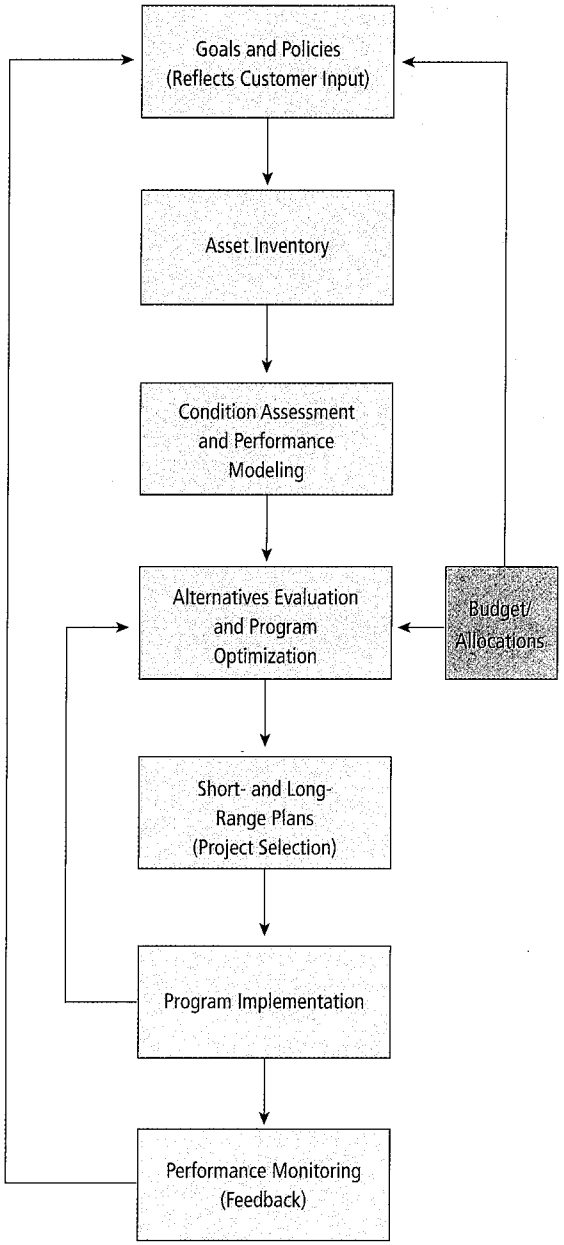
Human resources

Corporate data and information

Ground and water transportation facilities and equipment

A GENERIC ASSET MANAGEMENT SYSTEM

SYSTEM COMPONENTS



KEY QUESTIONS

- What is our mission? What are our goals and policies?
- What is included in our inventory of assets?
- What is the value of our assets? What are their functions? What services do they provide?
- What was the past condition and performance of our assets? What is the current and predicted future condition and performance of our assets?
- How can we preserve, maintain, or improve our assets to ensure the maximum useful life and provide acceptable service to the public?
- What resources are available? What is the budget level? What is the projected level of future funding?
- What investment options may be identified within and among asset component classes? What are their associated costs and benefits?
- Which option, or combination of options, is "optimal?"
- What are the consequences of not maintaining our assets? How can we communicate the impact of the condition and performance of our assets on the system and end user?
- How do we monitor the impact of our decisions? How do we adjust our decision-making framework when indicated?
- How can we best manage our assets in order to least inconvenience the motoring public when we repair or replace these facilities?

FIGURE 2. Generic Asset Management System Components and Key Questions

Technology enables an Asset Management system to function. Asset Management relies on technology in two key areas. First is the collection, storage, and analysis of data. Data can be gathered more quickly with higher quality and spatial accuracy than ever before. The data can then be stored, retrieved, and analyzed with powerful data servers and software. For example, with the advances in geographical information systems (GIS) and global positioning systems (GPS), the important spatial component of analysis can be more fully explored. With the development of faster and more capable computers, the application of more robust and sophisticated modeling software is possible.

The second important aspect of technology relates to the presentation and communication of the analytical results to decisionmakers inside and outside the agency. Most DOTs have their computers on networks, which allow for greater levels of communication than ever before. Again, advances in software, including GIS, allow for the presentation of these results graphically. Through advanced multimedia capabilities, today's software can paint a picture of what the analysis predicts, markedly improving the communication of ideas.

The critical inputs to the Asset Management decision-making framework are depicted in Figure 3 and are addressed in the following sections.

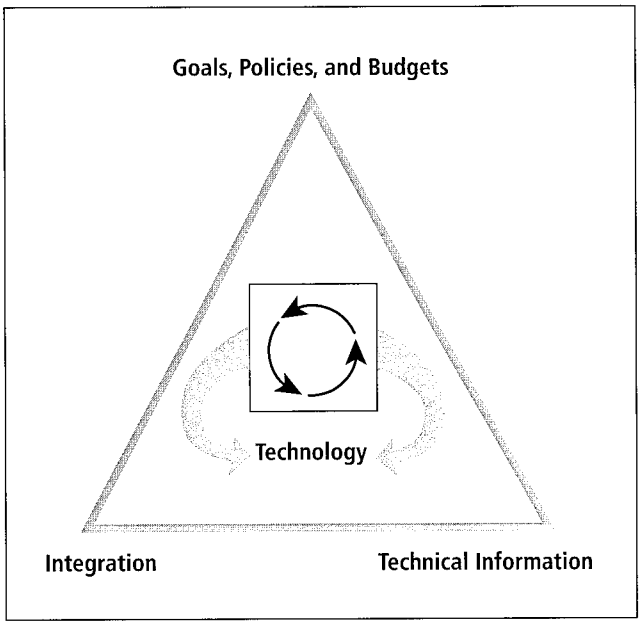


FIGURE 3. **Strategic Asset Management Framework Requirements**

ORGANIZATION GOALS, POLICIES, AND BUDGETS

Asset Management is a customer-focused, goal-driven management and decision-making 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 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 policy makers. Performance goals provide a way to convey to the public how DOT 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 discussed earlier.

The success of program strategies and practices is measured by changes in performance and remaining structural 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 agency performance levels/goals, as one example.

PRESERVATION AND PREVENTIVE MAINTENANCE

Considering the costs and benefits of preservation-oriented investment strategies in the context of other investment options is particularly important because the Nation's highway system has matured and is now deteriorating in response to usage and environmental factors. A comprehensive, fully integrated Asset Management system will fold infrastructure preservation considerations into the overall decision-making process.

"Preservation" refers to a customer-focused program of activities undertaken to provide and maintain serviceable roadways. It encompasses reconstruction, rehabilitation, and preventive maintenance, as well as minor rehabilitation activities. The goal of infrastructure preservation is to cost-effectively and efficiently improve asset performance, as measured by attributes such as ride quality, safety, and service life.

Infrastructure preservation programs represent a departure from traditional approaches to maintenance, in which deficiencies are addressed as they occur. Preservation seeks to reduce the rate of deterioration. The preventive approach is generally less costly and time-consuming than the traditional, more reactive approach. However, a strategy of prevention may be more difficult to justify because the public's expectation is that the worst roads demand immediate attention. Furthermore, the public often interprets activities related to pavement preservation as "fixing something that isn't broken."

Implementing a preservation program, be it for pavements, bridges, tunnels, or hardware, works best when elected officials, State DOT officials, and the general public fully understand the cost-effectiveness and return on investment from such a program, relative to traditional strategies. The application of tools such as life-cycle cost analysis is one way to achieve this. Findings from such analysis have the potential to demonstrate that implementation of a preservation strategy may cost less over the life of an asset than more "traditional" approaches that wait until the deficiencies are evident.

INTEGRATION

Key to an Asset Management decision-making framework (see Figure 3) is organizational integration. The strategic orientation of Asset Management demands a system that (1) includes channels of communication which will transmit the overarching information required by legislators, the public, and other stakeholders; agency executives; and front-line practitioners; and (2) will supply information and coordinating mechanisms across functions and asset classes within the organization.

The prevalent "stovepipe" approach to managing assets (discussed earlier), in which decisions are primarily driven by the objectives of individual organizational units, will be coordinated and integrated in an Asset Management approach so that communication occurs horizontally as well as vertically. A comprehensive, fully integrated Asset Management system weaves together information on all asset inventories; condition and performance databases; and alternative investment options.

Vertical communication channels start at the traditional asset management systems and continue to the highest executive-level decisionmakers. Vertical communication is essential to the success of Asset Management in two ways. First, effective communication between the various organizational levels will assist in overcoming implementation challenges by helping senior managers to understand the factors that drive decisions at the operational, or working, level. Those workers on the front line will be supplied the information necessary to appreciate the connection between the agency's strategic goals and tactical decisions resulting in particular actions. In this way, buy-in and support for incorporating Asset Management principles, concepts, and techniques into an agency's organizational culture and business practice are facilitated.

Second, vertical communication is important in facilitating the flow of information from one level of the organization to another and beyond. Effective information flow within the DOT and from the DOT to the customer—the traveling public—is critical. Performance goals and measures, discussed in the preceding section, facilitate the education and involvement of users and decisionmakers.

Legislators and political appointees need information regarding the importance of long-term time horizons. An example of where this is important is in the need to communicate the merits of system preservation, needed upgrades, and continued operating reliability that customers expect of a highway agency and all the facilities and assets it manages. The relationship between preservation, upgrading, operation, and return on investment and customer satisfaction must be effectively articulated and clearly demonstrated to decisionmakers.

Horizontal communication implies organizational integration and is important to the Asset Management decision-making framework because input from functions ranging from finance to planning to information management to human resources is required. To make Asset Management a viable process, managers in the various disciplines will need to be comfortable with Asset Management analyses and will need to incorporate the findings of an Asset Management process into their own work. In addition, horizontal communication between those responsible for the various asset classes is crucial.

There are both opportunities and constraints facing organizations embarking on implementing an Asset Management system. In particular, the component "stovepipe" structure provides a foundation from which to build more sophisticated data collection procedures and advanced analytical approaches. However, the stovepipe structure also fosters a sense of private ownership and discourages communication and cooperation.

State DOTs, however, have already begun to lay the groundwork in varying degrees for new formal or informal organizational structures. Advocates of "quality" have recognized the value of communication as essential to a productive work environment. As a result, some DOTs have been engaged in reengineering their organizations consistent with quality principles.

TECHNICAL INFORMATION

Since much data is already available, the goal is to take that data and convert it to information. This requires (1) the ability to collect, process, and evaluate the data; (2) the analytical tools to evaluate and select the most cost-effective alternative investment strategies, both within and among program areas; and (3) the tools and expertise to effectively communicate this information to other groups that may not be familiar with the programs or situation. As indicated earlier, DOTs will build on current capabilities. Agencies will integrate the new with the old. They will also work to improve current approaches and tools.

Information Management

The technological strides made in information management—gathering, processing, analyzing, storing, retrieving, and communicating enormous quantities of data—have made comprehensive Asset Management a feasible goal.

Asset Management is a data-intensive process, with information management at the center. It requires, for example, inventory-based information on all the physical assets in the portfolio of interest. This includes descriptions, types and number, functional responsibilities, and past, current, and expected future condition and performance.

Many State DOTs have established databases and collection procedures that support existing component asset management systems, such as for pavements, bridges, and maintenance. States have made significant strides forward in deploying these systems, yet much remains to be done in terms of establishing mechanisms for bringing the data from these disparate systems to a common decision-making platform.

New Asset Management structures will build upon the existing systems and capabilities. The new tools will need to be compatible with the established systems. It is interesting to note that component management systems are not expected to be replaced, as they will continue to be appropriate for consideration of asset-specific issues such as those related to project design.

Asset Management requires much more than co-locating a collection of pavement, bridge, and maintenance management capabilities under one umbrella. Improved information systems (including hardware and software), analytical tools, and interfaces between functions and asset classes need to be linked so the required information is communicated to the relevant decisionmakers in a universally comprehensible form. This does not necessarily imply a single database; separate databases that include compatible referencing systems for information exchange may be appropriate. In addition to relational databases, key technologies in this area are likely to include GIS and GPS.

Questions about what data to collect, at what frequency, with what level of quality, and at what cost need to be addressed in the context of what is required for the "bottom line" decisions. Data collection is not an end in itself. As indicated earlier, data collection procedures should be consistent with an agency's goals as expressed in their performance measures.

Analytical Tools

Engineering, economic, and behavioral models are an integral part of an Asset Management–based decision-making process. Analytical tools used in the course of Asset Management relate investment to performance of the system. The fundamental objective is to maximize benefits for users while minimizing agency costs. Asset Management recognizes the impact that the condition and performance of the transportation system have on the user, as well as the more traditional perspective which focuses on the impact that the user has on the system.

LIFE-CYCLE COST ANALYSIS

The life-cycle cost analysis (LCCA) technique is widely accepted as a useful project evaluation tool. Nonetheless, it does not enjoy widespread application. It is useful to examine this disconnect as a way of understanding some of the impediments to implementing engineering economic analysis in general.

Simply stated, LCCA is an evaluation of agency and user costs incurred over the life of a project. It allows the analyst to conduct comparative analysis between or among various alternatives. By adopting a long-term view of the transportation system, LCCA promotes consideration of total cost, to include maintenance and operation expenditures. Comprehensive LCCA includes all the economic variables essential to the evaluation: user costs such as delay and safety costs associated with maintenance and rehabilitation projects, agency capital cost, and life-cycle maintenance costs.

Almost all States use LCCA in some capacity. However, State application of LCCA is highly diversified. Although LCCA procedures and methods have application for program and policy analysis, those States currently using LCCA do so primarily for pavement-type selection and design specification.

The fact that LCCA is applied narrowly (e.g., mostly for pavement design) and incompletely (e.g., not including user costs) is not surprising given the limits on the availability of critical data and limited theoretical understanding of the complex concepts and techniques. The main concerns surrounding implementation of LCCA by States focus on the following technical issues:

- Selecting an appropriate discount rate
- Quantifying nonagency costs such as user costs
- Securing credible supporting data, including traffic data
- Projecting costs and travel demand throughout the analysis period
- Estimating salvage value and useful life
- Estimating maintenance costs and effectiveness
- Modeling asset deterioration

The analytical tools facilitate the discussion underlying the decision-making process by providing the ability to articulate the impact of choosing one alternative over another through engineering and economic-based "what if" analyses. Increasingly sophisticated analytical applications, greater understanding of key relationships and concepts, and improved procedures contribute to the ability to credibly calculate and report the results of alternative investment scenario evaluations. These tools provide a means of communicating the importance of transportation investments to the public and to decisionmakers operating in the political arena.

Engineering economic analysis (EEA) provides a broad collection of tools that collectively allow competing investment options to be prioritized according to relative economic efficiency levels. These tools include lifecycle cost analysis; benefit/cost analysis; optimization and prioritization; and risk analysis. These analytical procedures consider initial and discounted future agency, user, and other costs (such as external costs) over the life of each alternative investment option. They attempt to identify the option that will achieve established performance objectives at the lowest long-term cost, or provide maximum benefit for a given investment/funding level.

EEA can also quantify the risk of not realizing, in practice, the level of benefits and costs predicted by the economic/engineering models for the strategy implemented. There is inherent uncertainty in many of the assumptions—such as resource availability, costs, weather, and travel demand—that drive the engineering/economic models. This risk is important to decisionmakers and should be provided for consideration. Risk analysis models can assist with this.

Forecasting Tools. Forecasting tools are critical to Asset Management, particularly those that relate future investment levels to future condition and performance. These tools help to assess the impact of, say, inadequate routine maintenance and deferred capital maintenance. Examples include probabilistic and deterministic performance prediction models and traffic forecasting models.

Group Decision-Making Analytical Methods. As a cautionary note, implementing an integrated systems approach to investment analysis presents the potential of creating adversarial situations as a result of the newly introduced competition between assets within and among modes. This is most probable in the case of setting performance standards where higher or lower standards imply changes in funding levels. Objective tools are available to assist in conflict resolution by helping the parties to find "win-win" solutions, where all participants gain.

STRATEGIES FOR IMPLEMENTATION (HOW DO WE GET THERE?)

AASHTO and FHWA have made Asset Management a national priority. AASHTO is providing national leadership and guidance to States as they work to incorporate Asset Management principles and practices into their business process. The goal 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 directly utilized ("as is") or be applied after in-house and/or customized revisions. The potential advantage of adopting the generic approach is cost-effectiveness, as well as the opportunity to share technical expertise and experience with other States.

Although the fundamental tenets of Asset Management will be visible in each State practicing the discipline, the assumptions made, the tools employed, and the information used will vary from State to State. Each State will bring its unique organizational strengths and perspective to the implementation process. In addition, each State's Asset Management system will reflect its unique decision-making process and individual goals. One size will never "fit all" in State Asset Management.

AASHTO and FHWA jointly sponsored two major executive workshops in 1996 and 1997 to explore and benchmark the application of Asset Management in transportation agencies. These workshops introduced the Asset Management concept and provided information on private-sector activities in this area. The first workshop emphasized the importance of a comprehensive approach to managing the Nation's transportation system. Participants included high-level executives from AASHTO, FHWA, and State DOTs and leaders in Asset Management from private nontransportation sectors that shared Asset Management–related concerns with the transportation community.

During the second conference, participants were charged with evaluating current Asset Management practices and techniques. As discussed earlier in this Primer, the current approach to managing assets is component-by-component. Participants also began to explore what an integrated, comprehensive approach to managing assets might mean for their agencies. A major goal of the workshop was to formulate a strategy for advancing Asset Management as a national initiative. AASHTO responded to input from this conference with the establishment of an Asset Management Task Force, development of a Strategic Plan, and sponsorship of an Asset Management Guide for State Transportation Agencies.

AASHTO, with technical assistance from FHWA, is sponsoring a National Cooperative Highway Research Program (NCHRP) project to develop the Guide (NCHRP Project 20-24[11]). The objective of this project is to provide:

- A first-generation Asset Management Guide for use by AASHTO member agencies that will (1) offer advice on how to effectively apply and/or enhance Asset Management principles to their organizations; and (2) highlight case studies of best practices among the States;
- A synthesis of current Asset Management practices and available tools;
- A framework for an Asset Management system; and
- Recommended research for filling gaps in existing knowledge and developing tools for the next generation of the Guide.

This work will lay the foundation for defining initiatives to advance integration efforts within State DOTs. Upon completion of the NCHRP activity in 2001, AASHTO, in consultation with FHWA, will determine the appropriate next steps to continue to assist the States in advancing Asset Management.

The executive workshop series is recognized as a valuable forum for exchanging information and was continued with a peer review seminar in December 1999 focused on current State capabilities in various aspects of Asset Management:

- Moving from a concept to an action plan
- Integrating maintenance management systems
- Integrating management systems
- Integrating data
- Assessing preservation and improvement trade-offs

Details of State experience in these areas were shared as part of the peer exchange.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS INITIATIVES

AASHTO has traditionally set standards and provided guides for many different aspects of transportation system design, construction, management, and investment. This information provides a point of reference and guidance for AASHTO member agencies as they develop their own approaches; AASHTO standards and guides are intended to suggest and not to mandate.

In this context, AASHTO is assisting States in improving their business practices through the advancement of Asset Management principles and practices. AASHTO has taken the lead in bringing together States and facilitating knowledge sharing and resource pooling to enhance existing tools and procedures and to fill gaps with new approaches and tools.

Task Force

On November 16, 1997, AASHTO created an Asset Management Task Force composed of nine experts drawn from State DOTs. The Task Force's mission is to provide guidance for State Asset Management activities and develop and distribute to member States innovative Asset Management approaches, processes, and tools. Early work has included organizing the executive seminars that were discussed earlier, developing a strategic plan (see below), and sponsoring the NCHRP Guide, also discussed previously.

Strategic Plan

In November 1998, the AASHTO Board of Directors approved an Asset Management Strategic Plan. The plan establishes AASHTO's vision, mission, and goals, and it recommends actions regarding Asset Management. It also points the way toward work that will fill technological gaps.

The goals specified in the Strategic Plan are to (1) document the state of the practice, (2) conduct major seminars and information sharing, (3) develop an Asset Management guide that will document the state of the practice and the state of the art, as well as bridge the gap between the two; and (4) provide needed training.

FEDERAL HIGHWAY ADMINISTRATION INITIATIVES

In conjunction with AASHTO efforts and as part of the agency's reorganization, FHWA created an Office of Asset Management in February 1999. (See Figure 4.) The Office affirms the Agency's commitment to partnering with AASHTO to advance Asset Management principles. The Office's primary role is to provide technical assistance by developing tools, techniques, training, and consultative services for the States, as they work to adopt a comprehensive, fully integrated Asset Management program.

The Federal government is uniquely suited to provide technical assistance in the area because all 50 States can benefit from a nationally coordinated technical program, rather than 50 disparate efforts. Although the States own and operate the assets targeted by Asset Management, AASHTO has asked FHWA to help with research and development, training, and other technical areas because of the expense and requirements for staff expertise associated with these activities.

The Office is composed of a multidisciplinary staff drawn from economics, engineering, policy, planning, and technology assessment areas. Three teams make up the new Office:

- Construction and System Preservation
- System Management and Monitoring
- Evaluation and Economic Investment

The teams work together on overlapping activities.

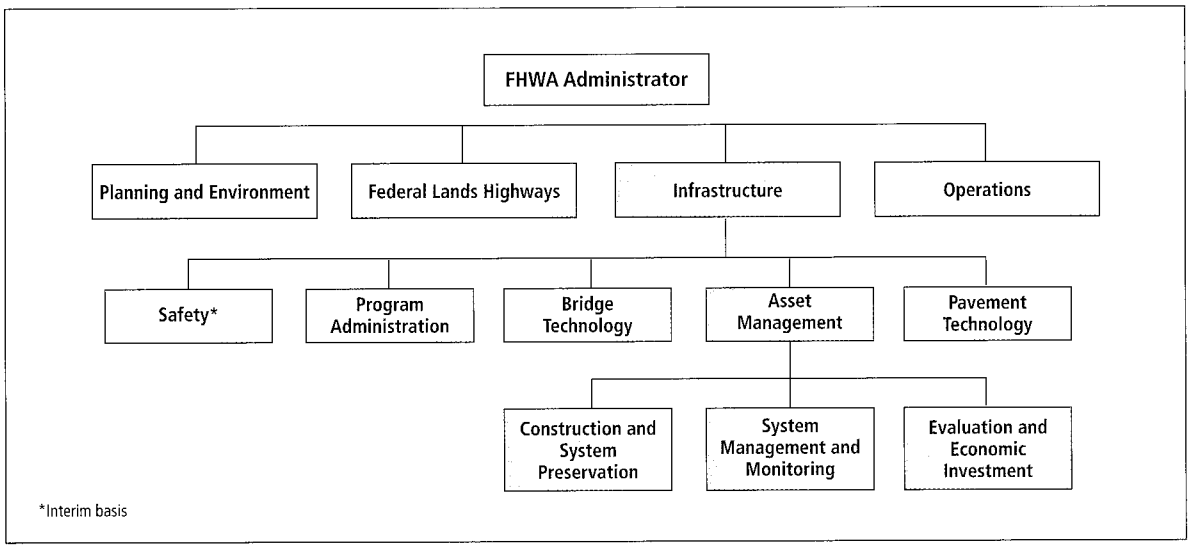


FIGURE 4. **Office of Asset Management, Federal Highway Administration**

The Construction and System Preservation Team is responsible for construction and maintenance technical support and outreach, quality management, pavement smoothness, and system preservation. FHWA has placed a special emphasis on preservation as the Agency's mission has shifted from building the Interstate System to preservation of infrastructure assets. The National Quality Initiative (NQI), a partnership effort among AASHTO, FHWA, and related industry associations, is housed within this team. The NQI objective is to focus attention on continuous quality improvements within the highway industry. New team initiatives include the establishment of a joint AASHTO/industry/FHWA agreement on optimizing highway performance.

The System Management and Monitoring Team is charged with refining and advancing pavement and bridge management systems and with developing and promoting new systematic approaches for assets where they presently do not exist, such as for tunnels and roadway hardware. The team is partnering with States and FHWA field units to develop a toolbox for implementing the new AASHTO pavement standards for the International Roughness Index, rutting, faulting, and cracking, which were issued in the summer of 1999. In a related area, the team initiated a pilot study with selected States and with FHWA's Office of Pavement Technology to analyze the real-life performance of Superpave pavements through the use of PMS data as an "engineering analysis tool." This project will also demonstrate how PMS data can be used as input to future pavement designs.

The Evaluation and Economic Investment Team's portfolio includes outreach activities designed to explain and promote Asset Management. It also has the lead in developing, recommending, and advancing investment analysis tools and organizational structures. A major component of the team's business plan includes initiatives to facilitate strategic investment decisions that are centered on Asset Management principles. Two primary tracks have been delineated: (1) identification and development of procedures to facilitate horizontal and vertical integration and (2) development and promotion of an array of procedures for inclusion in an engineering economic analysis toolbox, such as life-cycle cost analysis and benefits-versus-costs analysis.

Essential to the FHWA Office of Asset Management are cooperative programs with AASHTO, the Transportation Research Board, industry, and other Federal and State agencies to support and advance Asset Management.

HIGHWAY ECONOMIC REQUIREMENTS SYSTEM

A major new initiative being sponsored by FHWA's Office of Asset Management is a program to provide an economic/engineering programming tool called the Highway Economic Requirements System (HERS) model to interested States. HERS is currently used by FHWA at the national level to identify the costs, benefits, and national economic implications associated with highway investment options.

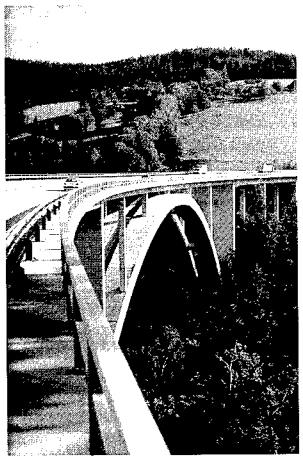
FHWA believes that HERS may also be useful for State-level highway investment planning. A pilot program is planned where a number of States will evaluate the applicability of the model for their use. If the model is found to be appropriate, FHWA is committed to bringing the HERS capability to all interested States.

HERS uses incremental benefits-versus-cost analysis to optimize highway investment. The model addresses highway deficiencies by quantifying the agency and user costs of various types and combinations of improvements, each subjected to a rigorous benefits-versus-cost analysis that considers travel time, safety, and vehicle operating and emissions costs.

Within the HERS process, State travel forecasts are analyzed, using a set of user-defined standards based on accepted engineering practice, to predict future pavement and capacity deficiencies. HERS selects the "best" set of highway improvements to satisfy economically sound highway performance objectives. When funding is not available to achieve "optimal" spending levels, HERS prioritizes economically worthwhile potential improvement options according to relative merit (that is, benefit-to-cost ratios) and selects the "best" set of projects. Given funding constraints or user-specified performance objectives, HERS minimizes the expenditure of public funds while simultaneously maximizing highway user benefits.

The State version of HERS (HERS-ST) has the potential to help State-level policy makers address resource allocation questions because it is able to perform "what if" analyses. For example, HERS-ST would allow users to examine the economic and system impacts of a 20 percent reduction in investment level. In this way, HERS could provide an objective platform by which State DOTs could communicate with other State officials. In addition, HERS-ST may assist State DOTs in meeting the new Governmental Accounting Standards Board provisions (see sidebar on page 12.)

CONCLUSION



AASHTO and FHWA are convinced that Asset Management is a better way of doing business. An Asset Management philosophy focuses on the benefits of investment, as well as its costs, and takes a comprehensive view of the entire portfolio of transportation resources. Objective, fact-based tools and techniques are systematically applied to determine how best to deploy available resources in order to achieve system-wide agency goals. Asset Management is an improved way of doing business that responds to an environment of increasing system demands, aging infrastructure, and limited resources.

Asset Management also provides the ability to show how, when, and why resources were committed. Transportation officials are being held increasingly more accountable by their customers—the American public. The public demands a consistently high return on the portfolio of transportation assets, which, of course, represents a collection of public resources.

Making Asset Management a reality requires new information and analytical tools, new approaches to organizational communication, and new management practices. AASHTO and FHWA are both committed to continuing to work together as partners to identify knowledge gaps, develop and fund a long-term research agenda, and assist the States in implementing new tools, techniques, and enhanced management approaches and business practices in Asset Management.

For further information on FHWA Asset Management initiatives, contact:

Office of Asset Management
Federal Highway Administration
U.S. Department of Transportation
400 7th Street, S.W., HIAM-1
Washington, DC 20590

Telephone: 202-366-0392
Fax: 202-366-9981