Transportation Asset Management Guide

November 2002

prepared for

National Cooperative Highway Research Program
(NCHRP) Project 20-24(11)

American Association of State Highway and Transportation Officials
444 North Capitol Street, NW
Suite 249
Washington, DC 20001

Pub Code: RP-TAMG-1

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prepared by

Cambridge Systems, Inc.

with

Parsons Brinckerhoff Quade & Douglas, Inc.
Ray Jorgenson Associates, Inc.
Paul D. Thompson, Consultant

Acknowledgement of Sponsorship

This work was sponsored by the American Association of State Highway and Transportation Officials, in cooperation with the Federal Highway Administration, and was conducted in the National Cooperative Highway Research Program, which is administered by the Transportation Research Board of the National Academies.

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State Member

Arizona (AZ)

Frank McCullagh
Research Engineer
Arizona Department of Transportation
206 S. 17th Ave, MD 075R
Phoenix, AZ 85007
Phone Number (602) 712-3132
Fax Number (602) 712-3400
Email Address fmccullagh@dot.state.az.us

California (CA)

Steve Takigawa
California Department of Transportation
P.O. Box 942874, 1120 N Street
Sacramento, CA 94274-0001
Phone Number (916) 323-7806
Fax Number
Email Address steve_takigawa@dot.ca.gov

Georgia (GA)

Frank L. Danchetz P.E.
Chief Engineer
Georgia Department of Transportation
Room 122
#2 Capitol Square, S.W.
Atlanta, GA 30334-1002
Phone Number (404) 656-5277
Fax Number (404) 463-7991
Email Address frank.danchetz@dot.state.ga.us

Idaho (ID)

David S. Ekern P.E.
Director
Idaho Transportation Department
P.O. Box 7129
Boise, ID 83707-1129
Phone Number (208) 334-8807
Fax Number (208) 334-8195
Email Address dekern@itd.state.id.us

Maryland (MD)

Peter Stephanos
Deputy Chief Engineer, Office of Materials and Technology
Maryland Department of Transportation
State Highway Administration
2323 West Joppa Road
Brooklandville, MD 21022
Phone Number (410) 321-3100
Fax Number (410) 321-3099
Email Address pstephanos@sha.state.md.us

Montana (MT)

Sandra S. Straehl
Program and Policy Analysis
Montana Department of Transportation
P.O. Box 201001
Helena, MT 59620-1001

Phone Number (406) 444-7692
Fax Number (406) 444-7671
Email Address sstraehl@state.mt.us

Nebraska (NE)

John L. Craig
Director
Nebraska Department of Roads
P.O. Box 94759
Lincoln, NE 68509-4759

Phone Number (402) 479-4615
Fax Number (402) 479-3758
Email Address jcraig@dor.state.ne.us

New York (NY)

Thomas Clash
Director, Statewide Planning Section
New York Department of Transportation
Statewide Planning
Building 5, State Office Campus
1220 Washington Avenue
Albany, NY 12232

Phone Number (518) 457-1716
Fax Number (518) 485-8276
Email Address tclash@gw.dot.state.ny.us

Timothy J. Gilchrist
Director, Planning and Strategy
New York Department of Transportation
Building 5, State Office Campus
1220 Washington Avenue
Albany, NY 12231-0414

Phone Number (518) 457-6700
Fax Number (518) 485-8276
Email Address tgilchrist@gw.dot.state.ny.us

Pennsylvania (PA)

Gary L. Hoffman
Deputy Secretary for Highway Administration
Pennsylvania Department of Transportation
Keystone Building, 8th Floor
400 North Street
Harrisburg, PA 17120-0095

Phone Number (717) 787-6875
Fax Number (717) 787-5491
Email Address gahoffman@state.pa.us

South Carolina (SC)

Carl Chase
Assets Manager
South Carolina Department of Transportation
P.O. Box 191
Columbia, SC 29202-0191

Phone Number (803) 737-1960
Fax Number (803) 737-2038
Email Address chasec@dot.state.sc.us

Tennessee (TN)

Michael R. Shinn
Chief of Administration
Tennessee Department of Transportation
James K. Polk Building, Suite 700
505 Deaderick Street
Nashville, TN 37243-0339

Phone Number (615) 741-5374
Fax Number (615) 741-0865
Email Address mike.shinn@state.tn.us

Virginia (VA)

Mary Lynn Tischer Ph.D.
Advisor to the Governor on Transportation Reauthorization
Virginia Department of Transportation
1401 East Broad Street
Richmond, VA 23219

Phone Number (804) 225-2813
Fax Number (804) 786-2940
Email Address mary.tischer@virginiadot.org

Washington (WA)

John F. Conrad
Assistant Secretary
Washington State Department of Transportation
Engineering and Regional Operations
P.O. Box 47316
Olympia, WA 98504

Phone Number (360) 705-7032
Fax Number (360) 705-6823
Email Address conradj@wsdot.wa.gov

Wisconsin (WI)

Mark J. Wolfgram
Administrator
Wisconsin Department of Transportation
Transportation Investment Management
P.O. Box 7913
Madison, WI 53707-7913

Phone Number (608) 266-5791
Fax Number (608) 267-1856
Email Address mark.wolfgram@dot.state.wi.us

U.S. DOT Member

District of Columbia (DC)

Frank Botello
Leader, System Mngt and Monitoring Team
Federal Highway Administration
System Mngt and Monitoring Team
400 7th Street, S.W., Room 3211
Washington, DC 20590

Phone Number (202) 366-1336
Fax Number (202) 366-9981
Email Address frank.botello@fhwa.dot.gov

Regina McElroy
Leader, Evaluation and Economic Investment Team
Federal Highway Administration
Office of Asset Management
HIAM-33, Room 3211
400 7th Street, S.W.
Washington, DC 20590

Phone Number (202) 366-9216
Fax Number (202) 366-9981
Email Address regina.mcelroy@fhwa.dot.gov

David Winter
Evaluation and Economic Investment Team
Federal Highway Administration
Room 3211
400 7th Street, S.W.
Washington, DC 20590

Phone Number (202) 366-4631
Fax Number (202) 366-9981
Email Address david.winter@fhwa.dot.gov

Florida (FL)

James E. St. John
Division Administrator, Florida
Federal Highway Administration
227 N. Bronough Street, Suite 2015
Tallahassee, FL 32301-1330

Phone Number (850) 942-9650
Fax Number (850) 942-9691
Email Address jim.stjohn@fhwa.dot.gov

AASHTO

District of Columbia (DC)

Jim McDonnell P.E.
Associate Program Director for Engineering
American Association of State Highway
and Transportation Officials
444 North Capitol Street, N.W., Suite 249
Washington, DC 20001

Phone Number (202) 624-5448
Fax Number (202) 624-5469

Email Address jimm@aashto.org

Affiliate Member

Nova Scotia (NS)

Kenton Speiran
Manager, Asset Systems
Nova Scotia Department of Transportation
and Public Works
P.O. Box 186
Halifax, NS B3J 2N2

Phone Number (902) 424-3510
Fax Number (902) 424-0571

Email Address speirakd@gov.ns.ca

FOREWORD

State transportation officials at all levels face the task of managing a wide range of assets to meet public, agency, and legislative expectations. These assets include the physical transportation infrastructure (e.g., guideways, structures, and associated features and appurtenances) as well as other types of assets: e.g., an agency's human resources, financial capacity, equipment and vehicle fleets, materials stocks, real estate, and corporate data and information.

Recognizing its growing importance to transportation agencies worldwide, the American Association of State Highway and Transportation Officials (AASHTO) in 1998 adopted transportation asset management as a priority initiative. AASHTO created a Task Force, reporting to the Board of Directors, to guide this national initiative and to develop and implement a ***Transportation Asset Management Strategic Plan***. To respond to several tasks in this ***Strategic Plan***, the National Cooperative Highway Research Program (NCHRP) awarded Project 20-24(11) to a study team headed by Cambridge Systematics, Inc. The goal of this NCHRP project is to develop information on transportation asset management and to apply these findings in producing a ***Transportation Asset Management Guide*** for use by AASHTO members and other transportation agencies. The ***Guide*** is designed to help agencies develop and apply the principles, techniques, and tools that can advance the management of their transportation assets.

The overall management framework that has been developed in this study is flexible enough to be adapted and refined for use with, respectively, each type of transportation agency asset listed above. To develop the depth as well as breadth of material needed to build a meaningful first-edition ***Transportation Asset Management Guide***, however, the scope of this study has focused on the particular set of assets that constitutes an agency's **transportation infrastructure**. This concentration enables asset management principles, methods, examples, and research recommendations to be developed in a concrete, practical, and understandable way. It facilitates comparisons with corresponding work by transportation agencies overseas and by the private sector, which have for the most part adopted a similar scope in their studies. It provides a specific frame of reference within which differences among state departments of transportation (DOT) can be addressed by particular business management models, approaches, and procedures.

This study therefore interprets transportation asset management as a **strategic approach to managing physical transportation infrastructure**. Transportation asset management in this context promotes more effective resource allocation and utilization based upon quality information. This concept covers a broad array of DOT functions, activities, and decisions: e.g., transportation investment policies; institutional relationships between DOTs and other public and private groups; multimodal transportation planning; program development for capital projects and for maintenance and operations; delivery of agency programs and services; and real-time and periodic system monitoring. All of these management processes have important implications for an agency's attainment of its goals in public policy, financial resource availability, engineering standards and criteria, maintenance and operations levels of service, and overall system performance.

A number of support activities are involved as well. Information technology can inform many of these management processes, and agencies have already expended considerable sums to develop asset management systems, databases, and other analytic tools. These systems must, however, complement the decision-making processes and organizational structures of individual agencies if they are to operate effectively and support good asset management at all organizational levels. Effective communication of information on asset management between an agency and its governing bodies, stakeholders, and customers is likewise critical to success.

The objectives of this study have been to gather information on asset management practices in the United States and overseas, develop a framework for transportation asset management, and apply this framework to produce a ***Transportation Asset Management Guide.*** The study has been organized in two phases:

- **Phase I** encompassed information gathering, framework development, and recommendation of a research program; and
- **Phase II** has produced this ***Guide***.

The work in Phase I has been documented in three reports:

1. A comprehensive framework for transportation asset management that established the basis for developing this ***Guide***;

2. A synthesis of current information and practices in asset management; and

3. A prioritized program of research in asset management.

This ***Guide*** builds on this earlier work to provide state DOTs and other transportation agencies guidance on implementing asset management concepts and principles within their business processes. At its core, asset management deals with an agency's decisions in resource allocation and utilization in managing its system of transportation infrastructure. Asset management is a way of looking at an agency's "way of doing business" to see if there are better ways to reach decisions in infrastructure management – e.g., by basing decision methods and criteria on current policy guidance, considering a range of alternatives, focusing on outcomes of decisions, and applying more objective information to decisions.

Asset management therefore relates to existing agency functions – e.g., participating in and informing the development of transportation policies, long-range planning, priority programming and development of the statewide transportation improvement program (STIP), delivering programs and services, and monitoring system condition. It is not a separate function on its own, nor is it a complete departure from current practice. In fact, while all agencies reflect good asset management to some degree in their daily operations, all have room for improvement: "Everyone is doing something, but no one is doing everything." The intent of this ***Guide*** is to provide individual agencies with the flexibility to tailor and customize their asset management efforts to their particular needs and situations, with an effort as broad or as narrow as they choose to undertake. The ***Guide*** provides a self-assessment exercise to assist agencies in identifying where they may wish to focus their asset management efforts.

This edition is the initial version of the ***Transportation Asset Management Guide***. It will assist transportation agencies in becoming familiar with the ideas and techniques by which asset management can influence their resource allocation and utilization processes and decisions. Since transportation asset management is a continually and rapidly evolving field, the AASHTO ***Strategic Plan*** envisions periodic updates of this ***Guide*** to reflect changes in transportation policy and to be able to report current DOT experiences and practices. The ***Strategic Plan*** also recommends a number of tasks and research efforts, results of which will likewise be useful additions to future versions of this ***Guide***.

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S.1 STRATEGIC INFRASTRUCTURE MANAGEMENT

Transportation asset management represents a strategic approach to managing transportation infrastructure assets. It focuses on a department of transportation's (DOT) business processes for resource allocation and utilization with the objective of better decision-making based upon quality information and well-defined objectives. Recognizing its growing importance to transportation agencies worldwide, the American Association of State Highway and Transportation Officials (AASHTO) in 1998 adopted asset management as a strategic initiative, and formed a Task Force to develop and implement a ***Strategic Plan for Transportation Asset Management***.[1] This NCHRP Project 20-24(11) has completed several tasks in the AASHTO ***Strategic Plan***:

- **Task 2-1-1 –** Identify and document the state-of-the-art in asset management, specifically applicable to the state departments of transportation.
- **Task 2-2-1 –** Identify and document the state-of-the-practice in asset management among the AASHTO member states.
- **Task 2-3-1 –** Identify knowledge and technology gaps and define future research projects.
- **Task 2-4-1 –** Propose a generic framework for transportation asset management that can be adopted by member states to meet their individual needs.
- **Task 5-1-1 –** Develop an AASHTO ***Guide for Transportation Asset Management***.

S.2 GOALS AND BENEFITS OF ASSET MANAGEMENT

The value of asset management will be reflected in its outcomes and benefits to transportation agencies and their customers. The key principles of asset management represent a way of doing business – a perspective that a department can adopt in looking at its current procedures and seeing how better decisions on infrastructure management can be made with better information. The goals of asset management are to:

- Build, preserve, and operate facilities more **cost-effectively** with **improved asset performance**;
- Deliver to an agency's customers the **best value** for the public tax dollar spent; and
- Enhance the **credibility and accountability** of the transportation agency to its governing executive and legislative bodies.

Asset management can touch nearly every aspect of a transportation agency's business, including planning, engineering, finance, programming, construction, maintenance, and information systems. Asset management should not be viewed, however, as yet another new program, requiring another new bureaucracy. Rather, asset management is a "way of doing business." It brings a particular perspective to how an agency conducts its existing procedures, reaches decisions, and applies its IT capabilities. It suggests principles and techniques to apply in policy-making, planning, project selection, program trade-offs, program delivery, data gathering, and management system application. This ***Guide*** is designed to help you identify where improvements in these processes can be made, and to suggest ideas and methods to do so. It will enable you to answer the following questions:

- How can your agency improve the way it currently is managing its assets?
- Are current and planned initiatives sufficient, or do they require modification, addition, or redirection?
- What approaches may work well in your agency or have worked well in other agencies similar to yours?

The benefits of asset management may be seen in many different ways, depending upon an agency's transportation system, management philosophy, and current resources and priorities. Following are some possible outcomes when an agency takes action to improve its asset management practices:

- Lower long-term costs for infrastructure preservation;
- Improved performance and service to customers;

[1] This ***Strategic Plan*** was adopted by the AASHTO Board of Directors in December 2000.

- Improved cost-effectiveness and use of available resources;
- A focus on performance and outcomes; and
- Improved credibility and accountability for decisions and expenditures.

S.3 PRINCIPLES OF ASSET MANAGEMENT

- **Asset Management Is a Strategic Approach.** A strategic perspective takes a long view of infrastructure performance and cost, and considering options in a comprehensive, proactive, and informed way. It is driven by policy goals and objectives and relies on systematic assessments of asset performance and cost in making decisions on future actions.
- **Asset Management Encompasses Multiple Business Processes.** Asset management encompasses a number of business processes related to infrastructure management in DOTs, including those related to planning, program development and recommendation, engineering of projects and services, and program delivery. Decisions on allocating resources are policy-driven and performance-based, consider a range of alternatives, have clear criteria for decision-making, and investigate the most cost-effective solutions through analyses of tradeoffs. The business processes are managed to elicit effective contributions from all levels of the organization, and to foster communications on asset management needs and accomplishments both within and outside the agency.
- **Asset Management Relies on Good Information and Analytic Capabilities.** Quality information – accurate, complete, timely – is important at all stages of asset management. Information technology is a practical necessity in supporting asset management, although there are many ways in which automated techniques can be beneficially applied.

S.4 MANAGEMENT FRAMEWORK AND SELF-ASSESSMENT

This ***Guide*** formalizes the principles above within a management framework that agencies can apply to guide improvement in their asset management practice. This framework is organized within a set of evaluation matrices that structure the concepts, principles, and "ideal" practices of asset management in four major areas:

- **Policy goals and objectives**, including the role of policy formulation in asset management and ways in which policy guidance can benefit from improved asset management;
- **Planning and programming**, focusing on best practices in reaching decisions on resource allocation for investments in transportation infrastructure;
- **Program delivery**, looking at options in resource utilization and management methods to deliver programs and services; and
- **Information and analysis**, including use of information technology (IT) at each stage of asset management; monitoring of asset performance and feedback of this information to improve decision processes in the future; and reporting and communication of key information and results.

In each of these areas the matrices build the management framework through descriptions of the following information:

- Basic **characteristics** of good asset management practice applicable to transportation agencies;
- Specific **evaluation criteria** for each characteristic; and
- The current **state-of-the-art** practice for each criterion.

While the specific entries in these matrices reflect the organizational, institutional, and financial setting of state DOTs in the United States, the underlying principles of asset management are applicable more generally to other transportation agencies.

These matrices are the foundation of the approach to transportation asset management presented in this ***Guide***. Subsequent chapters in the ***Guide*** develop more specific information in each of the major areas above, illustrating how the concepts, principles, and techniques of asset management can apply to a particular agency.

In addition to this management framework, the ***Guide*** also provides a method for agencies to assess current

asset management practices within their own organizations and to determine what areas of asset management may need improvement or be given priority. While the evaluation matrices describe state-of-the-art, or "benchmark," practices as guidelines, DOTs may elect to focus on specific areas for improvement, to work toward benchmark practices in stages, or to adopt practices that differ from the benchmarks to accommodate particular agency needs, priorities, or constraints. This method consists of a self-assessment that can be conducted with the agency's executives and senior managers in functional areas that will be critical to asset management implementation. The self-assessment can be used to identify existing agency functions that conform well to asset management best-practice; to identify other areas where improvement may be beneficial; to build agreement on priorities in asset management improvement; and to reach a consensus among organizational units on an agenda for asset management implementation.

The self-assessment is structured in very simple statements that managers can respond to, and does not take long to complete. The self-assessment exercise can then suggest other portions of the ***Guide*** that agency managers can consult for additional information.

S.5 ORGANIZATION OF THE GUIDE

The ***Guide*** is structured in the following parts:

- **Chapters 1 and 2** define transportation asset management, provide background information on past work in the field, and develop a framework for asset management of transportation infrastructure that is appropriate to U.S. DOTs.
- **Chapter 3** contains the self-assessment exercise that agencies can apply to identifying areas where asset management improvement may be helpful.
- **Chapter 4** describes how to develop an asset management implementation strategy and plan, based on the results of the self-assessment above. It stresses that the role of the ***Guide*** is to help an agency shape its own asset management implementation plan, tailoring and customizing the principles and techniques in the ***Guide*** to its particular situation, capabilities, and expectations.
- **Chapters 5 through 8** describe asset management concepts, principles, and techniques that apply to several agency functions in managing transportation infrastructure and decisions in resource allocation and utilization:
  - Policy formulation;
  - Planning and priority programming;
  - Program delivery; and
  - Information and analytic support, including the role of information technology, transportation system performance monitoring and feedback, and communication and reporting.
- **Chapter 9** concludes the ***Guide*** with a discussion of implementation issues.

1. INTRODUCTION

1.1 TRANSPORTATION ASSET MANAGEMENT

1.1.1 BACKGROUND

WELCOME!

This ***Transportation Asset Management Guide*** has been developed for you – a transportation agency executive or manager. This ***Guide*** helps you to examine, strategically and systematically, how investment decisions affecting your transportation infrastructure are made. It helps you to identify areas and priorities for possible improvement through initial and periodic self-assessment and benchmarking. It provides ideas, methods, and examples to accomplish more effective resource allocation and utilization. It does all of this by developing and applying the principles and practices of what is referred to as "transportation asset management."

This ***Guide*** has been structured to help you address your asset management needs in several ways. Some pointers on different ways to use this ***Guide*** are provided in Section 1.4. First, though, some basics on the format of the ***Guide*** and its features:

- Discussions and explanations of asset management are normally in the double-column format illustrated on this page. Tables and figures are interspersed as needed.
- Points of special attention or importance are emphasized by calling them out in text boxes.
- Examples or case studies that illustrate useful lessons in asset management are described in a text box (see below).

Case Study Example
Examples of agency practice that illustrate useful lessons in asset management will be described in a format like this.

- Annotations and citations of sources are listed in footnotes.
- Chapters covering technical material may include a section at the end labeled "Further Information." These sections include additional bibliographic and web site references where you can obtain additional information on related topics or examples of agency practice.

MANAGING MANY "ASSETS"

Transportation officials manage a wide range of "assets" to meet public, agency, and legislative expectations. These assets include the physical infrastructure of the transportation system (e.g., guideways, structures, and associated features, utilities, and appurtenances) as well as other types of assets: e.g., an agency's human resources, financial capacity, equipment and vehicle fleets, materials stocks, real estate, and corporate data and information. The overall management framework that is developed in this ***Guide*** is flexible enough to be adapted and refined for use with each type of transportation agency asset listed above.

To provide the depth needed for meaningful explanations and examples, however, the scope of this ***Guide*** focuses on the particular set of assets that constitutes an agency's **transportation infrastructure**. This concentration enables asset management principles, methods, and examples to be developed in a concrete, practical, and understandable way. It facilitates comparisons with corresponding work by transportation agencies overseas and by the private sector, which have for the most part adopted a similar scope in their studies. It provides a specific frame of reference within which differences among state departments of transportation (DOT) can be addressed by particular business management models, approaches, and procedures.

Transportation infrastructure provides critical national lifelines for commerce, commuting and pleasure travel, support of national defense, and disaster response. Transportation facilities account for a major share of public-sector investment, and are among the most highly valued financial assets of state and local governments. Among transportation modes, the U.S. highway infrastructure itself represents an estimated $1 trillion in replacement value.[1] Expenditures to build, operate, preserve, and improve transportation infrastructure are critical to meeting national goals of economic progress, social welfare, national defense, domestic security, environmental protection, and emergency preparedness. Transportation officials at all levels are faced with the responsibility of making the

[1] Anthony R. Kane, "Why Asset Management is More Critically Important Than Ever Before," **Public Roads**, March-April 2000.

best possible use of limited resources to manage a wide range of transportation assets in a way that responds to these important objectives and satisfies the needs of transportation users – their customers.

As Used in this Guide...
Asset Management is a strategic approach to managing transportation infrastructure.

1.1.2 A STRATEGIC APPROACH

This ***Guide*** therefore defines and treats transportation asset management as a set of concepts, principles, and techniques leading to **a strategic approach to managing transportation infrastructure**. Transportation asset management enables more effective resource allocation and utilization, based upon quality information and analyses, to address facility preservation, operation, and improvement. This concept covers a broad array of DOT functions, activities, and decisions: e.g., transportation investment policies and priorities; relationships and partnerships between DOTs and other public and private groups; long-range, multimodal transportation planning; program development for capital projects and for maintenance and operations; delivery of agency programs and services; and real-time and periodic system monitoring and data processing. All of these actions are accomplished within the limits of available funding.

A number of support activities are involved as well. Information technology (IT) can inform many of these management processes, and agencies have already expended considerable sums to develop asset management systems, databases, and other analytic tools. These systems must, however, complement decision-making processes and organizational roles and responsibilities if they are to operate effectively and support good asset management at all organizational levels. Effective communication of information on asset management between an agency and its governing bodies, stakeholders, and customers is likewise critical to success.

The definition of asset management above is intentionally broad. It recognizes that there are differences in needs and priorities across agencies in how they manage their infrastructure. For example, those agencies with mature transportation systems may concentrate asset management on strategies to facilitate preservation (e.g., through preventive maintenance, or new materials and technology) and to gain greater operations efficiencies (e.g., by deploying intelligent transportation systems (ITS) devices and building urban operations centers). Those agencies facing strong population and economic growth may need to include system capacity improvement (including construction of new facilities), together with preservation and operations, in their implementation of asset management. Regardless of the scope and areas of priority with which transportation agencies view asset management, all agencies will benefit from having a strong, performance-based approach backed by credible information. A basic premise of this ***Guide*** is that "good asset management" involves applying general principles smartly, effectively, and tactically to resource allocation and utilization – the heart of asset management. Actions can be tailored to particular situations, but generally will include core elements such as the following:

- Well-defined policies that can be related to clear objectives and measures of performance;
- Organizational roles and responsibilities and business processes that reflect these policy and performance objectives;
- A reliance on good information at all stages of infrastructure management, and the capability to develop and continually update this information base;
- Examination of a range of options for solving infrastructure problems;
- A comprehensive decision-making approach to transportation investment, viewing the transportation system as an integrated whole, and considering tradeoffs among modes and categories of investment;
- An ability to deliver capital, maintenance, and operations programs in terms of time, cost, engineering quality, and effective use of departmental and outside resources; and
- Management emphasis on customer service and accountability for system performance and cost-effectiveness.

In summary, the notion of asset management as a "strategic approach to managing transportation infrastructure" can be understood as "getting the best results or performance for the preservation, improvement, and operation of infrastructure assets given the resources

available." The specific concepts, principles, and practices that characterize the asset management approach to achieve these ends are developed in Chapter 2.

1.2 BENEFITS AND OUTCOMES

The goals of asset management are to:

- Build, preserve, and operate facilities more **cost-effectively** with **improved performance**;
- Deliver to an agency's customers the **best value** for the public tax dollar spent; and
- Enhance the **credibility and accountability** of the transportation agency.

Asset management can touch nearly every aspect of a transportation agency's business, including planning, engineering, finance, programming, construction, maintenance, and information systems. Asset management should not be viewed, however, as yet another new program, requiring another new bureaucracy. Rather, asset management is a "way of doing business." It brings a particular perspective to how an agency conducts its existing procedures, reaches decisions, and applies its IT capabilities. It suggests principles and techniques to make better decisions based on better information in policy and planning, capital programming and project selection, maintenance budgeting, program delivery and management, data gathering, and management system application. This ***Guide*** is designed to help you identify where improvements in your existing processes can be made, and to suggest ideas and methods to do so. It will enable you to answer the following questions:

- How can your agency improve asset performance?
- Are current and planned agency initiatives in infrastructure management sufficient, or do they require modification, addition, or redirection?
- What infrastructure management approaches and techniques have worked well in other agencies similar to yours?

The benefits of asset management may be seen in many different ways, depending upon an agency's transportation system, management philosophy, and current resources and priorities. Following are some possible outcomes when an agency takes action to improve its asset management practices:

- Lower long-term costs for infrastructure preservation;
- Improved performance and service to customers;
- Improved cost-effectiveness and use of available resources;
- A focus on performance and outcomes; and
- Improved credibility and accountability for decisions.

What "Quick Gains" Can Asset Management Provide*?*

- *A snapshot of current infrastructure condition and performance – its status, what has been accomplished, areas of need.*
- *A framework for understanding investment needs – whether for structural repair, congestion mitigation, preservation of asset value, safety, operational improvements, environmental protection (e.g., at what locations and relative values?)*
- *A direct way to tie public perceptions of agency performance to your agency's methods of identifying and selecting projects and prioritizing services.*
- *Something better than anecdotal stories – facts, figures, and systematic methods by which to justify needed investments or additional resources.*
- *A "key to competition" – helping your agency to compete for scarce program funding, helping your staff to compete with other potential service providers in the quality and cost-effectiveness of their actions, and helping your organizational units to "sharpen their thinking" in looking for new ways to solve problems and delivering quality services cost-effectively.*

Achieving these benefits requires a willingness to evaluate current business practices and to take steps to improve where needed. Successful business process improvement will require:

- Strong executive leadership;
- Buy-in by managers and staff at all organizational levels;
- A multi-disciplinary perspective within the agency; and
- A sustained and consistent commitment through implementation.

1.3 BUILDING ON PREVIOUS WORK

This ***Guide*** is an outgrowth of earlier work by the American Association of State Highway and Transportation Officials (AASHTO) and the Federal Highway Administration (FHWA) to promote the understanding and application of asset management in the U.S. transportation industry. It also complements work by transportation and public works agencies abroad and by private-sector firms to develop and apply concepts and techniques of asset management for their respective inventories of infrastructure.

Other Useful Resources

Asset Management Primer. *Published by FHWA Office of Asset Management. Explains how early asset management concepts relate to U.S. transportation organizations.*

AASHTO's Strategic Plan for Transportation Asset Management. *Establishes AASHTO's agenda for advancing asset management practice over the next 10 years.*

Asset Management for the Roads Sector. *Published by Organization for Economic Cooperation and Development (OECD). Documents asset management efforts by 13 member countries.*

NCHRP Transportation Asset Management Guidance *Phase I Study Reports, NCHRP Project 20-24(11): www4.nas.edu/trb/onlinepubs.nsf/web/nchrp_web_documents*

"Transportation Asset Management Today" – a Community of Practice web site*: http://assetmanagement.transportation.org*

FHWA Office of Asset Management web site*: http://www.fhwa.dot.gov/infrastructure/asstmgmt/*

TRB Research & Technology Forum web site*: www4.nas.edu/trb/homepage.nsf/web/r&t_forum*

1.3.1 AASHTO

In 1998 AASHTO formed a Task Force to develop and implement a 10-year ***Strategic Plan on Transportation Asset Management.***[2] This ***Strategic Plan*** has five goals:

1. To establish partnerships with other agencies and stakeholders in pursuing asset management;
2. To promote a better understanding of asset management and how it can be used by member states;
3. To foster the development of better asset management techniques, tools, and associated research;
4. To communicate with and inform the leadership of member states on how they can use asset management; and
5. To assist member states as they evaluate and use asset management.

AASHTO's Board of Directors approved this ***Strategic Plan*** in December 2000. The AASHTO Task Force now continues its active involvement in promoting a wider understanding and use of transportation asset management among its member agencies:

- It meets several times each year to review progress on its ***Strategic Plan*** and to identify next steps.
- It reviews research priorities annually and recommends specific topics supporting asset management to AASHTO's Standing Committee on Research (SCOR).
- Its members have participated in the Pilot offering of a National Highway Institute (NHI) training course on this ***Guide***, and provided key input to the final versions of both the NHI course and the first edition of this document.

1.3.2 FHWA

The FHWA has established its Office of Asset Management to provide leadership, technical assistance, and advocacy for more systematic management of highway infrastructure as a public investment. It plays a strong role in promoting several concepts and methods useful to asset management:

- System preservation;
- Management systems for pavements, bridges, tunnels, and road hardware;
- Economic analysis of system investments;
- New technology;

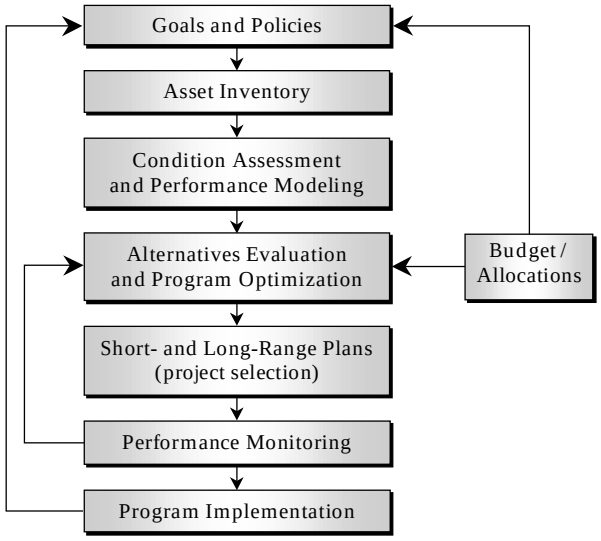
[2] AASHTO Task Force on Transportation Asset Management, **Strategic Plan 2000-2010,** adopted December 2000.

- Training and research; and
- Outreach and partnering activities.

It works with the public and private sector and academia to conduct nationwide programs in asset management.

An ***Asset Management Primer*** developed by the FHWA in 1999 describes transportation asset management as a systematic, fact-based, and reproducible decision-making approach to analyzing the tradeoffs between investments and improvement decisions at the system and project levels. (See Figure 1.1.)

Figure 1.1 FHWA's Overview of Transportation Asset Management



The ***Primer's*** definition of assets includes physical infrastructure, operational hardware, equipment, vehicles, real estate, materials, human resources, and data. The FHWA has produced several other documents on matters useful to transportation asset management, including primers on data integration and on the financial reporting standards of the Governmental Accounting Standards Board's Statement 34 (GASB 34).[3]

[3]The documents produced by FHWA's Office of Asset Management include: **Asset Management Primer** (December 1999), **Primer: GASB 34** (November 2000), and **Data Integration Primer** (August 2001).

1.3.3 ASSET MANAGEMENT WORKSHOPS

In 1996 AASHTO and the FHWA began co-sponsoring a series of workshops on asset management practice that have become major forums for exchanges of ideas and updates of progress in the field.[4]

- The September 1996 workshop in Washington, D.C., helped crystallize asset management as a concept in the United States. It defined asset management as "a systematic process of maintaining, upgrading, and operating physical assets cost-effectively." It recognized that principles, practices, and tools of good asset management practice exist. It noted that asset management can apply to public as well as private organizations.
- A second workshop was held in October 1997 at the Center for Infrastructure and Transportation Studies at Rensselaer Polytechnic Institute. This session built upon the findings of the earlier seminar to explore in greater depth the practices, processes, and tools of asset management as they apply to state DOTs. Presentations were given in several relevant areas to describe current practice and identify areas of potential improvement: e.g., the need for higher-level systems and integration of single-focus systems, for stronger forecasting and analytic tools to evaluate scenarios and tradeoffs, for new metrics to support strategic, performance-based decision-making, and for more effective application of technology and information systems.
- Subsequent workshops have focused on updates in latest knowledge and practice in asset management by transportation agencies, researchers, and industry experts. A peer exchange was held in Scottsdale, Arizona, in December 1999 to share ideas and experiences among DOT managers and to increase understanding of tools and

[4]The first three asset management workshops are documented in reports produced under the sponsorship of AASHTO and the FHWA: **Asset Management: Advancing the State of the Art Into the 21st Century Through Public-Private Dialogue** (September 1996); **21st Century Asset Management – Executive Summary** (October 1997); and **Asset Management Peer Exchange: Using Past Experience to Shape Future Practice** (December 1999). The fourth workshop is described on the Midwestern Regional University Transportation Center web site: www.mrutc.org

processes that can improve their asset management practice. A national workshop on transportation asset management was held at the University of Wisconsin in September 2001, jointly sponsored by AASHTO, the FHWA, the Midwest Regional University Transportation Center, and the Midwest Transportation Consortium. This workshop brought together representatives of public and private sector groups interested in transportation asset management at a state and local level for discussion of the latest research and applied techniques.

- Asset management continues to be a subject of strong interest at national and regional meetings sponsored, for example, by AASHTO and the Transportation Research Board (TRB).

1.3.4 ASSET MANAGEMENT COMMUNITY OF PRACTICE WEB SITE

AASHTO and FHWA collaborated on an Asset Management Community of Practice web site, "Transportation Asset Management Today".[5] This web site contains links to information on asset management, provides a forum for discussions and collaboration on documents-in-progress, and organizes resources in several topic areas relevant to asset management and GASB 34. This web site is evolving continually, particularly during this fast-paced period in transportation asset management development and implementation nationwide. Please check it periodically for new and updated material.

1.3.5 RESEARCH AND TECHNOLOGY FORUM

The Research and Technology (R&T) Forum is a cooperative effort organized by TRB, AASHTO, and the FHWA to provide "a new framework for coordinating highway research and technology activities among research sponsors, practitioners, researchers, and other stakeholders in highway transportation."[6] The intent is not to duplicate existing mechanisms for conducting, managing, and disseminating research, but rather to provide a way to coordinate the investments in highway-related research, recognizing the numerous and diverse stakeholders in highway transportation. Goals of this effort include more effective and efficient R&T investment, greater awareness of research underway, fostering of research partnerships, and demonstration of the needs and opportunities for research and resulting benefits.

Five Working Groups have been organized in the following areas: Safety, Infrastructure Renewal, Operations and Mobility, Planning and Environment, and Policy Analysis and System Monitoring. Each of these groups is drafting a report outlining research needs that advance good asset management practice within its respective area.

1.3.6 TRANSPORTATION RESEARCH BOARD

The Transportation Research Board has recently instituted a Task Force to undertake activities in transportation asset management. This group is looking at asset management across all transportation modes, considering its application to agencies and service providers at different levels of government. Its focus includes gathering and disseminating information on asset management practice, developing research recommendations, and recommending ways in which the subject can best be addressed through TRB.

1.3.7 JOINT TASK FORCE RECOMMENDATIONS

The AASHTO and the TRB Task Forces and FHWA held a joint meeting in Providence, Rhode Island, in June 2002 to recommend an action plan for the next two years, 2002-2004, on "Asset Management: 'Making It Reality.'"[7] A draft of these recommendations is now being reviewed for consideration at the AASHTO Annual Meeting in October 2002. While this action plan has not yet been formally adopted, many of its recommendations represent specific proposed implementations of tasks already included in AASHTO's ***Strategic Plan for Transportation Asset Management***. The plan recommends that AASHTO assume the leadership of transportation asset management activities by pursuing the following actions:

[5] http://www4.nas.edu/trb/homepage.nsf/web/r&t_forum.[5] http://assetmanagement.transportation.org

[6] http://www4.nas.edu/trb/homepage.nsf/web/r&t_forum

[7] **Asset Management: "Making It Reality**," Working Draft, 2002-2004 Joint Recommended Action Plan, TRB Asset Management Task Force, AASHTO/TRB/FHWA Joint Meeting, Providence, Rhode Island, July 12, 2002.

- Taking the lead in forming a national partnership to support and promote transportation asset management;
- Convening a national summit on asset management;
- Adopting and maintaining this ***Transportation Asset Management Guide*** and subsequent products being developed through NCHRP;
- Developing an implementation support plan for near-term actions in the period 2002-2004;
- Developing an outreach and promotion plan;
- Seeking to enlist the support of critical stakeholder associations;
- Advocating an asset-management emphasis in the 2003 reauthorization of federal transportation legislation;
- Creating organizational capacity within AASHTO to foster programs called for in the Strategic Plan through creation of an Asset Management Institute; and
- Securing commitment of a sustainable level of funding of $30 million over six years through reauthorization and/or joint agreement with the U.S. DOT/FHWA and partner associations.

1.2.8 PHASE I STUDY FINDINGS

This ***Guide*** builds on the findings of Phase I of NCHRP Project 20-24(11). These results are documented in three companion volumes[8] that provide additional information on transportation asset management:

1. **Transportation Asset Management Framework** describes the concepts and principles of asset management and provides examples of state-of-the-art practice. The management approach established in this report provides the basis of the guidance in Chapter 2 of this ***Guide***.

2. **Synthesis of Asset Management Practice** summarizes asset management practices and techniques used by public agencies throughout the United States and abroad, and by the private sector. Sources of information additional to those cited above can be found in this report.

3. **Recommended Research Program** outlines a 10-year, prioritized program of research in the following areas to advance the practice of asset management in U.S. transportation agencies: policy and institutional aspects; information, analytic tools, and technology; planning, program development, and program delivery; training and information sharing; and academic programs and materials.

[8] The Phase I reports of NCHRP Project 20-24(11) are available on NCHRP's web page: http://www4.trb.org/trb/crp.nsf

1.4 GETTING STARTED

YOUR CURRENT RESOURCES WILL WORK

You can start to implement better asset management practices **with the resources you already have.** The key to realizing immediate benefits is to utilize the best available people and tools to apply the underlying principles to current practices. Asset management principles will help guide the evolution of new processes, IT, and institutional relationships in the future. Work to begin investigating where improvements are needed, and with what priority, can begin immediately. Similarly, while upgraded IT capabilities may be recommended as part of improved asset management practice, substantial up-front software investments are not necessary. For example, you do not need a fully integrated "asset management system" to begin taking advantage of the concepts and best practices outlined in this ***Guide***.

What is needed at all organizational levels is a shared desire to improve current ways of doing business, a willingness to deal with change where needed, and a continuing focus on outcomes in terms of improved transportation system performance and service to the customer. Asset management is not a "silver bullet" that magically overcomes existing problems and constraints; rather, it is a framework within which you can look at these existing problems and constraints to see how to deal with them better. Many constraints are imposed on transportation agency procedures and decisions from outside, whether by statute, regulation, or political necessity. Practically and realistically, these constraints often cannot be easily or quickly removed. What asset management concepts and principles can provide, however, is a focus on the desired result, emphasis on options to achieve this

result, and recommended techniques to pursue and measure attainment of this result.

HOW THIS GUIDE CAN HELP

Applying the principles presented in this ***Guide*** to your current situation will enable you to **get started quickly.** This ***Guide*** describes steps that are helpful for improving asset management at your agency:

1. Motivation – Review asset management principles and framework – *Chapters 1 and 2*.

2. Self-assessment – Identify strengths and weaknesses and prioritize areas needing improvement – *Chapter 3*.

3. Approach – Define the scope of asset management at your agency and establish roles and responsibilities – *Chapter 4*.

4. Potential Initiatives – For each of the four topic areas of transportation asset management (policy goals and objectives, planning and programming, program delivery, and information and analysis) review key topics, best practices, and practical implementation steps – *Chapters 5-8*.

5. Action Plan – Identify areas needing improvement, formulate tasks, and set priorities and timeframes – *Chapter 4*.

6. Implementation – Perform tasks identified in the asset management action plan, track progress, and update the plan as fundamental changes occur – *Chapter 9*.

WHAT THIS GUIDE ADDRESSES

This ***Guide*** covers many aspects of an agency's resource allocation and utilization functions in describing how asset management "best practices" may apply to planning, priority programming, program delivery, infrastructure maintenance management, system monitoring, and IT applications. It focuses explaining and illustrating how asset management principles, techniques, and tools apply to each of these functions. It is not intended to be a primer on these individual functional areas, however. A wide variety of literature exists in each area for those desiring general information on planning, programming, maintenance management, and so forth. This ***Guide's*** purpose is only to show how an asset management perspective may influence an agency's management philosophy, methods and techniques, organizational roles, and IT applications as they may apply to one or more of these functional areas.

2. FRAMEWORK AND PRINCIPLES

2.1 DEVELOPING THE CONCEPT

2.1.1 RESOURCE ALLOCATION AND UTILIZATION

Asset management is, at its core, a process of resource allocation and utilization. In this ***Guide***, the term "resource" is used to refer to all of the ingredients at an agency's disposal that can be applied to managing the physical transportation infrastructure. Resources include revenues, human resources, equipment, materials, real estate, and corporate information, to name the most familiar.

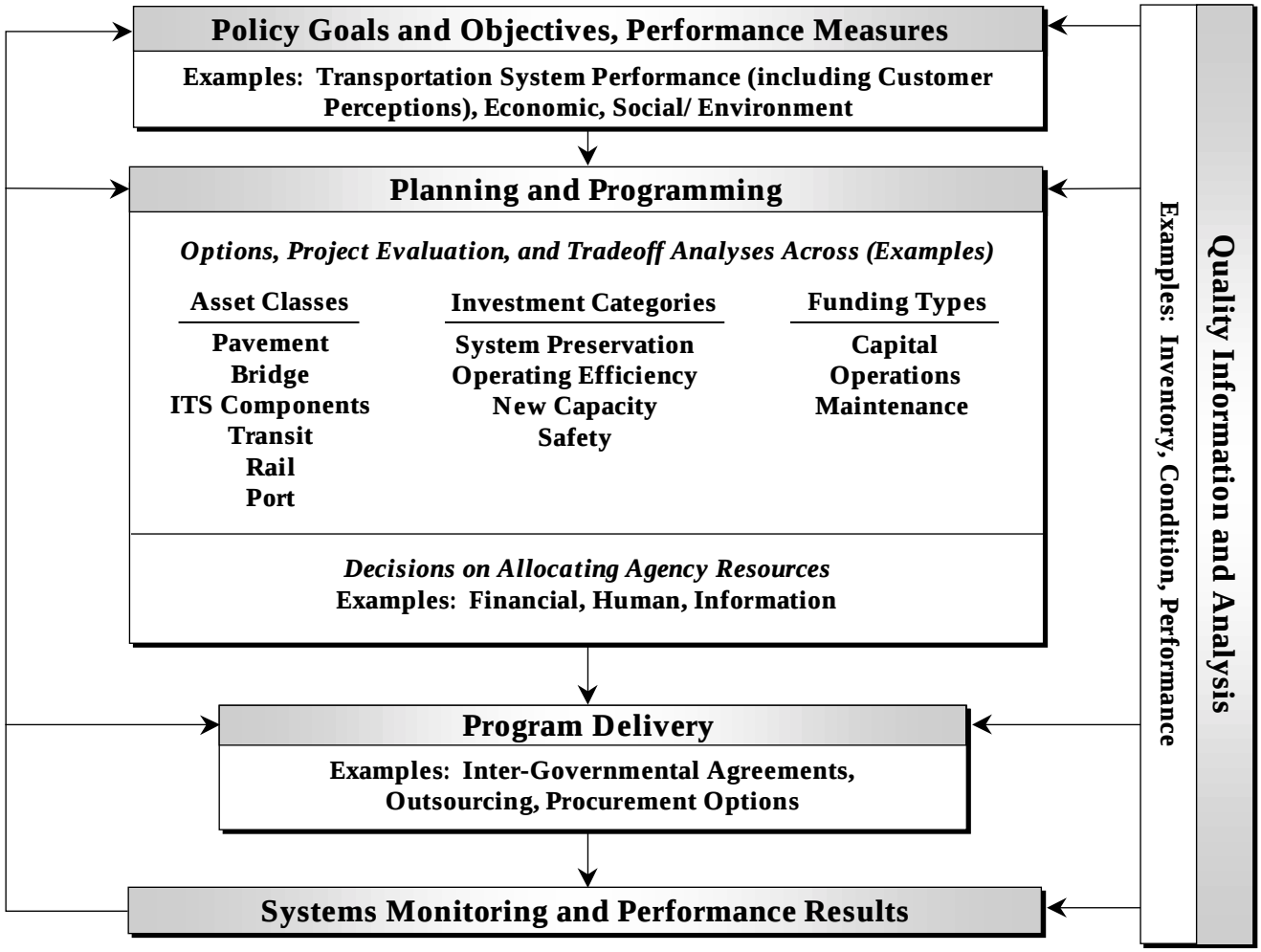
These resources also can be viewed in their own right as "assets" that likewise need to be managed effectively. For clarity and to provide meaningful examples and detail, this ***Guide*** focuses exclusively on ***physical transportation infrastructure*** as "the asset." The general principles in this ***Guide*** could be applied to managing other types of assets in the appropriate context. Supporting explanations and examples of good practice could be developed in a manner corresponding to this ***Guide*** for managing human, financial, real, information, and other classes of assets listed above.

Figure 2.1 presents a strategic, integrated, systematic, and interdisciplinary approach to asset management as a resource allocation and utilization process. The "best-practice benchmark" represented by this diagram embodies the following elements:

- **The approach is policy-driven**. Policies include system performance goals as well as broader guidance, such as economic development or social or environmental initiatives, that affect transportation. Ideally, customer perceptions of the priority and quality of agency services also are factored into policy guidance. Other elements of resource allocation – e.g., planning methodology, program prioritization factors, and system performance measures – are consistent with these policy goals.
- **The identification and analysis of options, evaluation of candidate projects, and tradeoffs is strategic, interdisciplinary, and integrated**. It potentially encompasses a number of modes and their associated infrastructure, rather than focusing solely on individual classes of assets (as in pavement or bridge management, for example). Policy goals and objectives are explicitly considered in evaluating investment and funding alternatives to meet transportation needs. Tradeoffs among asset classes or modes, program investments, and funding availability are conducted to seek the best performance at the lowest life-cycle cost. Resource allocation decisions consider a range of agency resources: e.g., human resources and corporate information, as well as financial resources. Quality information is applied throughout these processes.
- **Programs, projects, and services are delivered in the most effective way available**. Options for delivery are periodically evaluated in terms of the agency's own labor, financial, and information resources, and those of other service providers in the public or private sectors.
- **Decisions at each step are based upon quality information**. The various steps in Figure 2.1 are based upon current, complete, and accurate information on system condition, performance, and forecasted trends. Management systems and supplementary analytic tools (e.g., for benefit/cost analyses or tradeoff analyses) are applied to these decisions, not as "black-box" solutions, but rather as aids to managers and executives in diagnosing problems and identifying the most effective projects and services. Value is placed on the capabilities and resources to provide this quality information.
- **The information base for asset management is continually renewed, with feedback for updates and improvement.** Working upward from the bottom in Figure 2.1 to consider the several feedback loops shown:
  - Program delivery monitoring documents whether projects and services have been delivered on time and budget, and identifies causes of problems that may require remedy.
  - System performance monitoring quantifies the results of past investment decisions in planning and priority programming, establishes baselines for future decisions, and identifies updates needed in project selection and resource allocation criteria. System and customer surveys update information on current asset inventory, condition, and performance, and the cost and effectiveness of project treatments and service delivery methods for use in future analyses.

- Performance trends and comparisons to target values and customer expectations provide information on the status of program accomplishments, needed adjustments (either in areas of program emphasis, or in the target goals and objectives), providing a basis for future policy formulation.

Figure 2.1 Example Resource Allocation and Utilization Process in Asset Management



The framework presented in Figure 2.1 can be refined to meet the needs of organizations in different policy, institutional, organizational, technological, and financial settings. Later sections of this ***Guide*** will help you customize this general framework and apply it to your agency.

2.1.2 WHY SUCH A BROAD VIEW?

Figure 2.1 encompasses several major transportation agency functions in which many departmental units participate. It is a purposefully broad view. Improving your agency's asset management does not mean, however, that you must mount a massive effort to address all of the functions in Figure 2.1. Rather, the broad scope of coverage indicated by Figure 2.1 is to serve the needs of different agencies better:

- State DOTs differ from one another substantially in how they perceive the scope and priority of needed improvements in asset management.[1]

[1] These differences were revealed qualitatively in interviews with several DOTs during Phase I of this study. More quantitative indicators of the considerable variation in perception and practice among state agencies are presented in Chapter 3.

This ***Guide*** covers its subject broadly to meet the diverse needs of its constituency.

- Senior managers may wish to focus on high-priority areas for asset management improvement, but may not be sure which needs are most important. A broad treatment of the subject, including the self-assessment exercise in Chapter 3, allows managers to assess information on different aspects of asset management and to make more informed judgments on where to start.
- Agency needs and priorities in asset management may change over time. A DOT that perceives its top priority today, for example, in analytic support for its preservation program may experience future growth that refocuses its attention on system expansion and operational improvements. A broadly based ***Guide*** maintains its usefulness.
- Managers may wish to use the ***Guide*** as a source book for ideas on asset management as it applies to a range of agency functions. The broad view of resource allocation and utilization in the ***Guide*** serves this purpose well.

Agencies may tailor their implementation of asset management to the scope, depth, and timetable that is best suited to their needs and available staffing and budget. The breadth of the ***Guide*** is intended to give agencies flexibility in how they approach their individual exercises, not to direct them to an effort that is larger or more diffuse than they intended. Suggestions on ways to tailor and focus transportation asset management are given in Chapters 3 and 4.

2.1.3 HALLMARKS OF THIS APPROACH

The definition of transportation asset management in Chapter 1 as "a strategic approach to managing transportation infrastructure" can now be elaborated upon through descriptions of typical "best practice" characteristics and examples. In Sections 2.2 and 2.3 these characteristics will be formalized to build a framework for asset management of transportation infrastructure. The characteristics of asset management include the following:

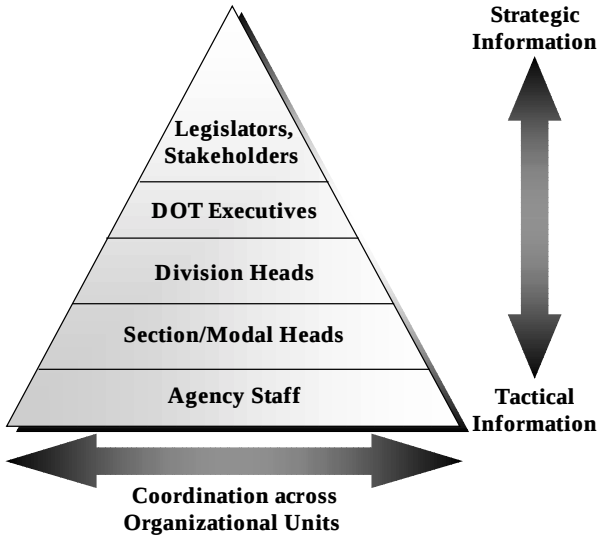
- Transportation asset management is a policy-driven, performance-based approach with a focus on outcomes or results:
  - Resource allocation decisions are driven by policy goals and objectives and related to performance;
  - Clear measures of performance are defined;
  - Both customer service and efficiency / effectiveness are recognized; and
  - Progress is tracked and communicated.
- An integrated approach is applied across asset classes, investment categories, and funding mechanisms:
  - Common analytic approaches are established across asset types: e.g., a life-cycle view of performance and cost; benefit / cost analysis; valuation of assets; and consideration of alternative strategies and investments.
  - Resource allocation decisions are based upon explicit tradeoffs among modes and their asset classes, types of investments, and available funding sources: e.g., preservations versus expansion alternatives; capital improvements versus maintenance activities versus operations enhancements; rural economic development versus urban congestion relief; and highway versus non-highway modes.
  - Business processes, evaluation procedures and criteria, and analytic information are consistent with, and inform judgments about, policy objectives and values of associated performance measures.
  - Organizational roles are developed to encourage integration across departmental units (Figure 2.2).

Transportation Asset Management ...

- *Is policy-driven;*
- *Is performance-based;*
- *Considers alternatives or options;*
- *Evaluates competing projects and services based on cost-effectiveness and anticipated impact on system performance;*
- *Considers tradeoffs among programs;*
- *Employs systematic, consistent business processes and decision criteria; and*
- *Makes good use of information and analytic procedures.*

- Good asset management implies that the right information is available to the right levels of management at the right times:
  - Complete, current, and accurate information on asset condition and performance, and on customer perceptions of the quality of infrastructure condition and the provision of services;
  - An appropriate suite of management systems and databases that informs the agency of the status, trends, and needs regarding its infrastructure assets;
  - Tools that predict future system performance, and support what-if analyses to understand the relationship between investment levels and resulting performance;
  - Information on condition, performance, and investment need that is integrated across asset types; and
  - Effective decision support tools for managers at different levels in the organizational structure.
- Principles of good asset management can suggest ways in which an agency's current business processes should be strengthened. It is a "way of doing business," not a separate business line or function:
  - Clear linkages exist among goals, policies, plans, investment strategies, operating procedures and delivery approaches;
  - A proactive rather than reactive approach is taken, seeking constant improvement to ensuring the best use of available resources for improved performance;
  - Strong top-down and bottom-up communication ensure that strategic decisions are well-informed by tactical information, and that tactical decisions are aligned with strategic direction (Figure 2.2);
  - Interdisciplinary decisions are coordinated across different agency divisions; and
  - Clearly defined organizational roles and responsibilities provide accountability for decisions and resulting system performance.

Figure 2.2 Managed Business Process



2.1.4 How Might Your Agency Improve?

Several examples of how an agency may improve in moving from a "conventional" management approach to one based on the best practices inherent in asset management are illustrated in Table 2.1. These examples are not meant to be prescriptive, but only to express the typical characteristics of asset management above in a more tangible way. The principles to guide change of this nature are formalized in the following section.

2.2 Principles of Good Practice

2.2.1 Asset Management Is a Strategic Approach

Asset management represents an approach to managing infrastructure that is strategic and proactive, and places a premium on good information in all aspects and in all departmental units.

- **Asset management is comprehensive**. It entails a broad view across a range of assets. It encourages consideration of a full range of options to meet problems or needs. Tradeoffs are explicitly considered among programs, modes, or strategies.
- **Asset management as a philosophy** may be applied broadly to virtually all functional areas

of an organization or targeted to particular areas. Increasingly, asset management is being seen as a comprehensive approach that may be successfully applied at virtually all levels and across virtually all functions of an infrastructure-based organization. However, in its evolution, asset management also may be focused on particular areas of emphasis, such as system preservation or, alternately, system improvement and operations. This need for adaptability in responding to the current policy objectives and priorities of different agencies explains why the term "transportation asset management" is often interpreted differently. It also explains why asset management is simultaneously powerful, rigorous, yet flexible.

- **Asset management is driven by policy goals and objectives based upon performance**. Strategies are analyzed in terms of objective assessments of costs, benefits, and other impacts on the transportation system and levels of service provided to transportation users.
- **Asset management takes a long-term view of infrastructure performance and cost**. The costs and benefits of different actions are assessed throughout the infrastructure service life, applying economic as well as technical criteria.
- **Asset management is proactive**. An agency has the latitude to make decisions based on merit. Preventive strategies are encouraged where they are cost-effective.
- **Asset management policy is influenced and informed by good information**. This information includes current and projected system condition and performance that would result from different policies or strategies. It also encompasses user perceptions of system condition and performance, as obtained through surveys or focus groups.
- **Asset management is explicit and visible**, and serves to clarify and communicate the process and outcomes of resource allocation and program delivery. Asset management, by virtue of its rational and objective qualities, demystifies and fosters confidence in those decision processes that influence the allocation and utilization of scarce resources. In doing so, asset management fosters increased stakeholder participation, buy-in, and adherence to adopted strategies and decisions.
- **Viewed as "a way of doing business,"** asset management can influence the business practices of virtually every organizational element involved in the functions to which it is applied.

2.2.2 ASSET MANAGEMENT ENCOMPASSES MULTIPLE BUSINESS PROCESSES

The principles of good asset management can suggest ways in which an agency's business processes and organizational roles and responsibilities can be strengthened. These process improvements can occur in those activities prior to budget approval (i.e., planning and program development) and in the program delivery and system performance monitoring phases subsequent to budget approval. Major principles governing process improvements are listed below.

- **Investment choices and decisions on allocating and applying resources are policy- and performance-driven**. Procedures to reach these decisions are consistent with objective information and criteria based on merit. Performance measures consistent with policy goals and objectives are established for management review of both system performance and program delivery.

Table 2.1 Examples of How Asset Management May Influence Current Business Practices

Practices That May Exist Now	Asset Management Best Practice
POLICY GOALS AND OBJECTIVES	
Policy statements "say all the right things" but do not differentiate what are the true priorities.	Policy goals and objectives are clearly defined and can be translated into explicit performance measures and targets.
The policy framework expresses a very broad and idealized vision of the transportation mission. The implications of this policy framework are not analyzed directly, but rather are left to specific planning and programming stages later.	The agency proactively influences policy formulation with realistic estimates of agency resources that are needed to achieve specific goals. It works with its governing bodies to instill this realistic vision in resulting policy statements and objectives, as well as measurable performance targets.
Policies are developed in the context of "guidance" from governing bodies to the transportation agency, and have little or no input from outside sources.	Policy formulation seeks input from customers and other stakeholders, and reflects customer priorities and concerns in resulting policy statements and objectives, and performance targets.
Policies are used essentially in an attempt to "micromanage" outcomes.	The policy framework gives an agency the latitude to frame alternative solutions to problems and to decide among these based on their merits.
PLANNING AND PROGRAMMING	
Transportation options that are considered in the long-range plan reflect primarily the choices included in the current transportation program.	The long-range plan identifies transportation options broadly in terms of potential modes and intermodal linkages, types of investments, and program or funding alternatives.
Methods, formulas, and criteria to prioritize projects reflect an historical evolution of engineering, financial, and political factors.	Methods, formulas, and criteria to prioritize projects reflect stated policy objectives and performance measures and targets.
Projects are evaluated largely in terms of initial cost and judgment as to potential benefit.	Projects are evaluated in terms of realistic estimates of life-cycle costs, benefits, and performance impacts.
Programming is based mainly on intuitive judgment.	Programming is based to the degree possible on objective information, supported by sound analytical procedures.
Management systems and condition surveys are used as engineering or research tools, but are not applied to program building or budgeting.	Information from condition surveys and management systems directly informs the process that builds the recommended program and budget.
Management systems are used only to rank the condition of assets; needs are programmed based on "worst first."	Management systems guide the programming of projects based on valid engineering and economic criteria.
PROGRAM DELIVERY	
Project delivery issues are dealt with only as emerging problems are brought to management's attention.	Well-understood project delivery measures and procedures are used to track adherence to scope, schedule, and budget.
Project changes and resulting program adjustments are dealt with as ad hoc processes that "keep things in balance" as situations arise.	A process exists and is enforced to approve changes in project scope, schedule, and cost, and make related program adjustments.
Traditional methods of program delivery are used from year to year, with no perceived need to consider alternatives or compare costs among different methods.	An agency periodically evaluates availability, relative cost, and potential use of different methods of program delivery.

Table 2.1 Examples of How Asset Management May Influence Current Business Practices (continued)

Practices That May Exist Now	Asset Management Best Practice
INFORMATION AND ANALYSIS	
Collection of data on transportation inventory, condition, and performance is accomplished only occasionally or incompletely. Processing of these data occurs when funds are available.	Collection of data on transportation inventory, condition, and performance is accomplished by a statistical sampling technique of acceptable precision that is designed to be affordably maintained annually.
Management system reports provide detailed information on asset engineering and materials characteristics, life-cycle performance, and life-cycle costs.	Management system reports are designed for a range of management needs, encompassing items listed to the left, but also including information on trends in performance versus cost (scenario testing), prioritization of projects, value and timing of preventive and corrective maintenance needed, and benefits of proposed investments.
Surveys of customer perceptions are conducted for information and public relations purposes, but are not applied in program decision processes.	Information on customer perceptions of asset condition and performance is routinely applied to assist in capital and maintenance program development.

- **Investment choices and decisions on allocating resources are based upon explicit tradeoffs among modes, programs, or strategies**. You can assess the tradeoffs and impacts of more or less investment in a mode, program, or strategy, and help to craft final recommendations on how resources will be allocated across competing needs. Managers also understand the implicit tradeoffs in their programs and budgets, and the consequences thereof.
- **Asset management entails the translation of policies and plans into cost-effective investment strategies, and the translation of investment strategies into cost-effective program delivery**. The essence of asset management involves a combination of resource allocation decisions and program delivery strategies that reflect policy-driven criteria and the resources available.
- **Organizational roles and responsibilities regarding asset management are developed to encourage more strategic and integrated approaches.** While strong vertical organizational units may exist to maintain core expertise, business processes and decisions involve wider participation, as noted below.
- **Asset management is interdisciplinary.** Decisions on investment choices and resource allocation are based upon expertise and judgment from several quarters of an agency.
- **The agency strives for more effective program delivery**. The agency explores innovative methods to deliver the range of projects and services required. All available methods are considered, including use of departmental employees, intergovernmental agreements, outsourcing, managed competition, and privatization.
- **Asset management requires effective communication within and outside the agency**. Within the agency, strong communication channels are needed both vertically and horizontally. External communications need to inform policy-makers and other stakeholders of the status of transportation assets and recommended policies and their benefits.

2.2.3 ASSET MANAGEMENT RELIES ON GOOD INFORMATION AND ANALYTIC CAPABILITIES

Effective management systems and complete, current, and accurate information on transportation infrastructure are practical necessities in meeting the policy and process requirements of asset management. Good asset management implies a systematic, integrated approach to project selection, analysis of tradeoffs, and program and budget decisions. It also implies that the right information be available to the right levels

of management at the right times. The principles below support the availability and application of better information to make better decisions in asset management.

- **Complete, current, and accurate information** on transportation infrastructure assets, including descriptions, location, usage, unique or specialized characteristics, functional and other classification, and data needed for management systems as discussed below.
- **An appropriate suite of management systems and databases** informs the agency of the status, trends, and needs regarding its infrastructure assets. Typical capabilities of these systems include the following:
  - **Organization of information within databases** describing infrastructure inventory, condition, performance, and cost;
  - **Analytic models** that predict the rate of future change in condition or performance, enabling the agency to forecast future infrastructure needs;
  - **Decision rules or procedures** for applying treatments or actions to maintain, rehabilitate, replace, or expand transportation infrastructure, with analytic models of resulting costs, benefits, and other impacts; and
  - **Reports** tailored to different organizational levels of management, including senior and executive levels, as well as for public distribution.
- **Information on system performance** in terms of both proposed targets and values actually achieved in the field. These data may be obtained in a number of ways:
  - Periodic surveys and assessments of system condition or levels of service;
  - Customer surveys of satisfaction with system condition and agency performance; and
  - Incorporation of performance measures and associated backup information within management systems.
- **Specialized technical applications** that support an agency's asset management procedures. These will vary by agency, but may include capabilities such as use of geographic information systems (GIS) as a system/data integration platform, economic analysis applications (e.g., generalized life-cycle benefit/cost procedure), and other decision-support tools.
- **Applications that assist in program and service delivery**, including financial applications (e.g., to compute "total" or "true" cost of agency and contracted services), and management systems for construction project pipeline and construction delivery.

2.3 MANAGEMENT FRAMEWORK

Key concepts, principles, and state-of-the-art techniques have been organized within a set of four evaluation matrices in Tables 2.2 through 2.5. These matrices lay out a range of options in improved asset management and identify "ideal" practices to which your agency can strive.

- **Policy Goals and Objectives –** How does policy guidance benefit from improved asset management?
- **Planning and Programming –** Do resource allocation decisions reflect good practice in asset management?
- **Program Delivery –** Are appropriate options and management methods used to delivery the program?
- **Information and Analysis –** Do information resources effectively support asset management policy and decisions?

The information in each matrix is organized into three columns:

- The first column identifies the most important basic characteristics of good asset management practice applicable to transportation agencies.
- The second column lists specific evaluation criteria for each characteristic.
- The third column describes the current state-of-the-art for each criterion. These ideal practices define benchmarks that agencies can aim toward in seeking to improve their current approach.

Table 2.2 Policy Goals and Objectives

How Does Policy Guidance Benefit from Improved Asset Management Practice?

Characteristics	Criteria	Benchmark – State-of-the-Art
1. Policy goals and objectives reflect a comprehensive, long-term view of asset performance and cost.	Defined goals and objectives	Goals and objectives are comprehensive, integrated with other statewide policy objectives, and supported by quantitative and measurable performance measures or criteria.
	Asset management as a catalyst for decision and action	Principles of good asset management are articulated in an agency business plan and clearly recognized throughout the agency as the driving force for resource allocation and utilization.
	Life-cycle perspective	Goals and objectives embody the perspective of life-cycle economic analyses of asset performance and cost, and encourage strategies with long-term benefits.
2. Goals and objectives embody the public interest in good stewardship of transportation assets.	Recognition of asset condition, performance, and public acceptance in policy formulation	This recognition entails the following characteristics: ➢ Policy goals and objectives encourage a business-model, customer-oriented approach to asset management. ➢ Reliable information on asset condition and public perceptions thereof is accounted for in updating policy objectives.
	Public reporting and accountability	System performance is measured against policy goals and objectives.
3. Policy formulation allows the agency latitude in arriving at performance-driven decisions on resource allocation.	Political process	Political decisions on resource allocation among modes or programs are strongly influenced by objective information on expected performance.
	Agency decision-making	The agency makes resource allocation decisions among programs and across geographic regions/districts based on expected performance rather than by historical splits or formulas that do not correlate with an objective indication of system condition.
4. The agency proactively helps to formulate effective asset management policy.	Engagement with policy-makers	The agency actively engages with political leaders and other policy-makers to define expectations of system performance, frame alternative approaches, and outline the consequences of decisions and courses of action relative to these expectations.
	Provision of information	The agency's asset management systems are designed and applied to yield meaningful information on policy choices and consequences.

Table 2.3 Planning and Programming

Do Resource Allocation Decisions Reflect Good Practice in Asset Management?

Characteristics	Criteria	Benchmark – State-of-the-Art
1. Planning and programming procedures and criteria are consistent and reinforce policy goals and objectives.	Fiscally responsible planning	Development of statewide and urban-area long-range plans can be demonstrated to be consistent with policy goals and objectives and with realistic projections of future revenue.
	Program prioritization	Funding allocation and project prioritization criteria are consistent with and support the state's and the agency's policy goals and objectives.
	Updates and revisions	Updates and revisions to the planning and program development process are performed regularly to reflect changes affecting asset management priorities in the areas of: ➢ **Policy** (e.g., preserving existing investments, economic development) ➢ **Technology** (e.g., new design procedures or materials) ➢ **Emerging Issues** (e.g., updated environmental regulations; identification of potentially catastrophic risks to asset condition or performance).
2. Planning and program development consider a range of alternatives in addressing system needs or deficiencies.	Planning alternatives	Long-range planning identifies and evaluates a range of program alternatives and, as appropriate, modal alternatives to meet present and future transportation demand.
	Project scope, cost, benefits, impact on performance	Program development, guided by adopted plans, formulates projects of appropriate scope and develops realistic estimates of their costs, benefits, and impacts on system performance.
3. Performance-based concepts guide planning and program development.	Performance-based budgeting	Recommended programs and budgets relate costs to levels of service or performance measures.
	Benchmark achievement	The planning and programming processes identify the resources required to maintain existing assets at target performance levels and at least life-cycle cost.
4. Resource allocations and program tradeoffs are based on relative merit and an understanding of comparative costs and consequences.	Program building	Organization of projects within programs (program building) results from statewide competition among projects based on objective criteria.
	Consistency	Projects being designed and built respond to, and are consistent with, overall policy guidance for system performance.
	Program tradeoffs	Tradeoffs between programs (e.g., Preservation versus Improvement, or System Expansion versus Operations) are based upon analyses of life-cycle benefits and costs, rather than arbitrary formulas or historical splits.
	Communication	The implications of more or less resources allocated to each program are clearly communicated in terms of selected performance measures.

Table 2.4 Program Delivery

Are Appropriate Options and Management Methods Used to Deliver the Program?

Characteristics	Criteria	Benchmark – State-of-the-Art
1. The agency considers all available methods of program delivery.	Cost tracking	The agency knows its costs for delivering its programs and services (e.g., by activity, bid item, or resource class).
	Options for delivery	The agency periodically evaluates its options for delivering programs and services (e.g., agency employees, inter-governmental agreements, partnering, outsourcing, managed competition).
2. The agency tracks program outputs and outcomes.	Feedback mechanism	The agency has the ability to easily track actual project and service delivery against the program plan so that adjustments can be made.
	Change process	A formal program change process exists to make needed adjustments in cost, schedule, and scope; document causes; and reallocate funds.
3. Reports on program delivery accomplishments are communicated and applied.	Internal	Department executives and program managers are regularly informed of progress; a well-understood mechanism exists to make needed adjustments.
	External	Policy-makers and key stakeholders are kept informed of program status and adjustments.
4. The approved program is delivered efficiently and effectively.	Delivery measures	Measures are defined and tracked to gauge successful program delivery in terms of schedule, cost, and scope.
	Project and program adjustments	The agency has a process to review and approve project changes and resulting program adjustments.

Table 2.5 Information and Analysis

Do Information Resources Effectively Support Asset Management Policies and Decision?

Characteristics	Criteria	Benchmark – State-of-the-Art
1. The agency maintains high-quality information needed to support asset management.	Asset inventory	The agency maintains an inventory of assets that is a complete, accurate, and current description of infrastructure for which the agency is responsible or in which it has a statewide transportation interest.
	Asset condition	Asset condition data (including data that affect condition, such as usage, environment, etc.) are updated on a predetermined schedule sufficient to provide timely and accurate information on status and performance.
	Customer perceptions	Information on customer perceptions is updated regularly through surveys, focus groups, complaint tracking, or other means, to gauge public perception of asset condition and agency performance, and to respond thereto.

Table 2.5 Information and Analysis (continued)

Do Information Resources Effectively Support Asset Management Policies and Decision?

Characteristics	Criteria	Benchmark – State-of-the-Art
1. The agency maintains high-quality information needed to support asset management, continued.	Program outputs	Information on actual costs and accomplishments by project, program, network, asset category, work type, and location are maintained in a form that can be used to track program delivery. Cost estimation techniques are continually improved.
	System monitoring	Performance measures or levels of service are defined and regularly applied to quantify the impacts of program decisions and actions.
	Reporting	Progress toward stated transportation system performance targets is measured and reported regularly for each program.
	Feedback	Performance measures provide feedback for future planning and program priorities, or consideration of adjustments in policy objectives.
2. The agency collects and updates asset management data in a cost effective manner.	Data collection technology	The agency applies the appropriate mix of data collection technology (e.g., visual, automated, remote sensing) to ensure high quality data and to provide cost-effective coverage needed to maintain the quality information base discussed above.
	Sampling methodology	The sampling methodology is demonstrated to be appropriate in terms of network coverage, sample size, and frequency, and in the training and team assignments needed to ensure objectivity, consistency, and repeatability.
3. Information is automated and on platforms accessible to those needing it – relates to both databases and systems.	System technology and integration	The agency's single-asset management systems and databases have been updated and integrated to enable consistent information on all asset categories to be accessible to multiple applications, and to provide managers at various organizational levels the information and tools needed for effective asset management.
	Data administration	Information requirements and/or standards for asset management are in place to ensure that future system and database development efforts within the agency will integrate with existing systems and meet asset management information and analysis improvement needs.
	Geo-referencing	Systems and information are based upon a common geographic referencing system and a common map-based interface for analysis, display, and reporting.
4. Effective decision-support tools are available for asset management.	Strategy analysis	The agency has decision-support tools that facilitate exploration of capital versus maintenance tradeoffs for different asset classes.
	Project analysis	The agency has tools that support consistent analysis of project costs and impacts, using a life-cycle cost perspective.

Table 2.5 Information and Analysis (continued)
Do Information Resources Effectively Support Asset Management Policies and Decision?

Characteristics	Criteria	Benchmark – State-of-the-Art
4. Effective decision-support tools are available for asset management, continued.	Program analysis	The agency has tools that provide an understanding of the system performance implications of a proposed program of projects.
	Program tradeoff analysis	The agency has tools to help explore the system performance implications of different levels or mixes of investments across program categories or subcategories.
5. Financial value of assets.	Conformity with GASB statement 34	The agency reports the value and condition of its transportation capital assets in a manner that conforms to the modified approach specified in GASB standards.
	Information support for condition and financial reporting	Information on asset condition and the level of expenditure needed to meet target condition is available from the agency's asset management systems.

2.4 CUSTOMIZING AN ASSET MANAGEMENT APPROACH

The previous section presented a detailed management framework for asset management, including examples of best practices in several key agency functions. The question now is: How can your agency implement this management framework in a practical way? Chapters 3 and 4 address this question in terms of a self-evaluation that your agency can conduct, and steps to developing an implementation plan. The management framework, self-evaluation, and implementation plan are adaptable to many different agency situations – agencies with various organizational structures, management cultures, business processes, funding environments, and technological capabilities.

While the asset management framework and principles presented in this chapter are relevant to transportation agencies generally, this ***Guide*** recognizes that there is no single asset management approach that is appropriate for all agencies. Your approach to implementing these ideas and concepts within your agency will likely differ from the approach of other agencies. Therefore, Chapters 3 and 4 also will explain how to customize the principles in Tables 2.2 through 2.5 to your particular agency's situation.

3. SELF-ASSESSMENT

3.1 INTRODUCTION TO SELF-ASSESSMENT

3.1.1 OVERVIEW

This chapter will help your agency characterize its asset management practices and identify specific opportunities for improvement. While the self-assessment is an optional step in asset management planning, it is extremely useful to help organize thinking, develop a consensus among top-level managers as to where your agency's strengths and needs for improvement lie, and structure an agenda for asset management planning. Section 3.1 introduces the asset management self-assessment process; Section 3.2 presents the self-assessment survey; and Section 3.3 provides a series of quick reference figures that list state-of-the-art benchmarks and possible gaps. These figures provide you a point of reference from which to evaluate your agency and to link the results of your agency's self-assessment to pertinent sections of the ***Guide***.

3.1.2 OBJECTIVES

The asset management self-assessment exercise presented in this chapter has the following objectives:

- Develop a consensus among managers within your agency regarding the status of asset management.
- Assist your agency to identify asset management strengths, weaknesses, constraints, and opportunities for improvement.
- Develop priorities and recognize critical areas that need immediate attention.
- Provide a foundation for implementing your agency's asset management improvement strategy.

Self-assessment is a quick diagnostic tool that yields an overall impression, not a precise analytic measure, of where your agency is now regarding asset management practice. The statements in each survey form are designed to probe basic functions and capabilities that contribute to good asset management regardless of the particular characteristics and situation of your agency. They should prompt you to reflect on current business practices with a broad view.

"Even if we are constrained to do business or report information in a certain way, is there a better approach that satisfies asset management principles more closely?"

The self-assessment results will reflect your agency's individual institutional, organizational, financial, and IT environments. Involving top managers in this exercise will provide needed context for interpretation of the results. ***Because the results are specific to your agency's management environment and financial, organizational, institutional, and technological situations, they do not provide a meaningful basis for comparisons with peer agencies.*** The value of self-assessment is to help you move beyond possible preconceptions of where you are in asset management, and to provide a broad perspective from which you can plan asset management improvements more comprehensively.

3.1.3 THE EXERCISE

The self-assessment survey presented in Section 3.2 lists a series of statements organized around the four key areas of asset management:

- Policy Goals and Objectives;
- Planning and Programming;
- Program Delivery; and
- Information and Analysis.

Each statement covers a key aspect of asset management practice and is stated in a declarative form (e.g., "Our agency conducts life-cycle cost analyses for project alternatives."). Respondents are asked to rate the extent to which they agree with each statement, using a scale of 1 to 4. A "4" indicates strong agreement with the statement, whereas a "1" indicates strong disagreement.

3.1.4 THE PROCESS

Clearly, there are several ways by which you can apply the self-assessment process. The following is a suggested approach.

1. Appoint leader. It is recommended that the leader of the self-assessment effort have a broad understanding of asset management issues across the entire agency.

2. Establish core group. It is highly recommended that the group responsible for completing the self-evaluation comprise the CEO, deputy CEO, and senior executives from different disciplines (e.g., key asset managers, finance, planning, maintenance, operations, information technology, and so forth).

3. Complete assessment form. Distribute the assessment form in Section 3.2 to each member of the group and ask them to complete it individually. The exercise is designed to take about a half-hour to complete. It may be helpful to review the diagnostic figures in Section 3.3 beforehand to understand better the intent of each set of questions.

4. Compile the responses. At a minimum, it is recommended that the leader calculate the average response and identifying the high and low responses for each statement (e.g., responses to statement A4 ranged from 2 to 3 and had an average of 2.75). The leader also may choose to calculate summary scores. Guidelines for a simple scoring tabulation are described at the end of Section 3.2. This scoring method is optional, and is provided for those who may find it useful to have a "bottom-line" indicator. The scoring also can be useful in framing the discussion that should occur as part of defining future strategies and directions for asset management. Of course, alternative scoring methods also could be used. For example, the leader may calculate the percentage of statements in each area receiving a 3 or 4. Again, the purpose is not to try to translate results into a precise measure. Rather, the result is an approximate indicator of how your managers see your agency's performance of each function or capability described in the statements.

5. Discuss results. It is recommended that the leader facilitate a discussion among core group members to review the results. Two types of results in particular should be highlighted in the review:

- a. Statements where managers' assessments of current agency practice are significantly lower than the state-of-the-art benchmark, which is scored as 4 (i.e., areas uniformly receiving a low score – say, in the range of 1 to 2).
- b. Statements where managers' assessments of an agency's current practice vary widely from one another (i.e., some respondents strongly agree with a statement, while others strongly disagree). Where there are significant differences it is recommended that the group discuss their varying perspectives, focusing on underlying reasons for differences and strategic options for addressing them.

In the case labeled a, the group should identify potential needs for improvement. In the case labeled b, the group should discuss the variance in responses and try to reconcile different perspectives by exploring the institutional, organizational, IT-related, or other factors that may help explain these differences. From this discussion, any potential improvements in asset management practice should be identified and added to those identified for a) above.

6. Identify priorities. To conclude the discussion, the leader should work with the group to identify a set of priority areas for development of asset management improvements. Buy-in at this point by your agency's executives and line managers is essential for the success of future efforts.

3.2 SELF-ASSESSMENT EXERCISE

3.2.1 PART A. POLICY GUIDANCE

How Does Policy Guidance Benefit from Improved Asset Management Practice?

		Strongly Disagree			Strongly Agree
POLICY GUIDANCE BENEFITING FROM GOOD ASSET MANAGEMENT PRACTICE					
A1.	Policy guidance supports preservation of existing infrastructure assets.	**1**	**2**	**3**	**4**
A2.	Policy guidance encourages resource allocation and project selection based on cost-effectiveness or benefit/cost analysis.	**1**	**2**	**3**	**4**
A3.	Policies support a long-term, life-cycle approach to evaluating investment benefits and costs.	**1**	**2**	**3**	**4**
A4	Policy guidance considers customer perceptions and expectations.	**1**	**2**	**3**	**4**
A5	Our customers contribute to the process that formulates policy goals and objectives.	**1**	**2**	**3**	**4**
STRONG FRAMEWORK FOR PERFORMANCE-BASED RESOURCE ALLOCATION					
A6.	Policy guidance on resource allocation allows our agency sufficient flexibility to pursue a performance-based approach.	**1**	**2**	**3**	**4**
A7.	Our agency has a business plan or strategic plan with comprehensive, well-defined goals and objectives to guide resource allocation.	**1**	**2**	**3**	**4**
A8.	Our agency's goals and objectives are linked to specific performance measures and evaluation criteria for resource allocation.	**1**	**2**	**3**	**4**
PROACTIVE ROLE IN POLICY FORMULATION					
A9.	Our agency estimates the resources needed to accomplish particular objectives as part of policy development.	**1**	**2**	**3**	**4**
A10.	Our agency regularly communicates to customers and other stakeholders our accomplishments in meeting policy objectives.	**1**	**2**	**3**	**4**
A11.	Our agency works with political leaders and other stakeholders to present funding options and consequences as part of our budget proposal.	**1**	**2**	**3**	**4**

3.2.2 PART B. PLANNING AND PROGRAMMING

Do Resource Allocation Decisions Reflect Good Practice in Asset Management?

		Strongly Disagree			Strongly Agree
CONSIDERATION OF ALTERNATIVES IN PLANNING AND PROGRAMMING					
B1.	Our agency's long-range plan includes an evaluation of capital, operational, and modal alternatives to meet system deficiencies.	**1**	**2**	**3**	**4**
B2.	Capital versus maintenance expenditure tradeoffs are explicitly considered in the preservation of assets like pavements and bridges.	**1**	**2**	**3**	**4**
B3.	Capital versus operations tradeoffs are explicitly considered in seeking to improve traffic movement.	**1**	**2**	**3**	**4**
PERFORMANCE-BASED PLANNING AND A CLEAR LINKAGE AMONG POLICY, PLANNING, AND PROGRAMMING					
B4.	Our agency's long-range plan is consistent with currently established policy goals and objectives.	**1**	**2**	**3**	**4**
B5.	Our agency's long-range plan includes strategies that are consistent with plausible projections of future revenues.	**1**	**2**	**3**	**4**
B6.	Our agency's long-range plan provides clear and specific guidance for the capital program development process.	**1**	**2**	**3**	**4**
B7.	Our agency periodically updates its planning and programming methods to keep abreast of current policy guidance, customer expectations, and critical performance criteria.	**1**	**2**	**3**	**4**
PERFORMANCE-BASED PROGRAMMING PROCESS					
B8.	Criteria used to set program priorities, select projects, and allocate resources are consistent with stated policy objectives and defined performance measures.	**1**	**2**	**3**	**4**
B9.	Our agency's programs are consistent with realistic projections of future revenues.	**1**	**2**	**3**	**4**
B10.	Our agency's programs are based on realistic estimates of costs, benefits, and impacts on system performance.	**1**	**2**	**3**	**4**
B11.	Project selection is based primarily on an objective assessment of relative merits and the ability to meet performance targets.	**1**	**2**	**3**	**4**
B12.	The preservation program budget is based upon analyses of least-life-cycle cost rather than exclusive reliance on worst-first strategies.	**1**	**2**	**3**	**4**
B13.	A maintenance quality assurance study has been implemented to define levels of service for transportation system maintenance.	**1**	**2**	**3**	**4**

3.2.3 PART C. PROGRAM DELIVERY

Are Appropriate Program Delivery Processes that Reflect Industry Good Practices Being Implemented?

		Strongly Disagree			Strongly Agree
CONSIDERATION OF ALTERNATIVE PROJECT DELIVERY MECHANISMS					
C1.	Our agency periodically evaluates the use of alternative delivery options such as maintenance outsourcing, intergovernmental agreements, design-build, design-build-maintain, and similar options.	**1**	**2**	**3**	**4**
C2.	Our agency has an incentive program for recognizing or rewarding outstanding performance in improving upon schedule, quality, and cost objectives.	**1**	**2**	**3**	**4**
EFFECTIVE PROGRAM MANAGEMENT					
C3.	Our agency solicits input from all affected parties to ensure that project scope is consistent with objectives of the project.	**1**	**2**	**3**	**4**
C4.	Our agency uses well-defined program delivery measures to track adherence to project scope, schedule, and budget.	**1**	**2**	**3**	**4**
C5.	Our agency has a well-established and functioning process to approve project changes and program adjustments.	**1**	**2**	**3**	**4**
C6.	When adding projects or changing project schedules, our agency considers effects on the delivery of other projects in the program.	**1**	**2**	**3**	**4**
C7.	Projects with significant changes to scope, schedule, or cost are reprioritized to ensure that they are still competitive in cost and performance.	**1**	**2**	**3**	**4**
C8.	Agency executives and program managers are regularly kept informed of program delivery status.	**1**	**2**	**3**	**4**
C9.	External stakeholders and policy-makers feel that they are sufficiently updated on program delivery status.	**1**	**2**	**3**	**4**
COST TRACKING AND ESTIMATING					
C10.	Our agency maintains and uses information on the full unit costs of construction activities.	**1**	**2**	**3**	**4**
C11.	Our agency maintains and uses information on the full unit costs of maintenance activities.	**1**	**2**	**3**	**4**

3.2.4 PART D. INFORMATION AND ANALYSIS

Do Information Resources Effectively Support Asset Management Policies and Decisions?

		Strongly Disagree			Strongly Agree
EFFECTIVE AND EFFICIENT DATA COLLECTION					
D1.	Our agency has a complete and up-to-date inventory of our major assets.	**1**	**2**	**3**	**4**
D2.	Our agency regularly collects information on the condition of our assets.	**1**	**2**	**3**	**4**
D3.	Our agency regularly collects information on the performance of our assets (e.g., serviceability, ride quality, capacity, operations, and safety improvements).	**1**	**2**	**3**	**4**
D4.	Our agency regularly collects customer perceptions of asset condition and performance.	**1**	**2**	**3**	**4**
D5.	Our agency continually seeks to improve the efficiency of data collection (e.g., through sampling techniques, use of automated equipment, other methods appropriate to our transportation system).	**1**	**2**	**3**	**4**
INFORMATION INTEGRATION AND ACCESS					
D6.	Agency managers and staff at different levels can quickly and conveniently obtain information they need about asset characteristics, location, usage, condition, or performance.	**1**	**2**	**3**	**4**
D7.	Our agency has established standards for geographic referencing that allow us to bring together information for different asset classes.	**1**	**2**	**3**	**4**
D8.	Our agency can easily produce map displays showing needs / deficiencies for different asset classes and planned / programmed projects.	**1**	**2**	**3**	**4**
D9.	Our agency has established data standards to promote consistent treatment of existing asset-related data and guide development of future applications.	**1**	**2**	**3**	**4**
USE OF DECISION-SUPPORT TOOLS					
D10.	Information on actual work accomplishments and costs is used to improve the cost-projection capabilities of our asset management systems.	**1**	**2**	**3**	**4**
D11.	Information on changes in asset condition over time is used to improve forecasts of asset life and deterioration in our asset management systems.	**1**	**2**	**3**	**4**

3.2.4 PART D. INFORMATION AND ANALYSIS (CONTINUED)

Do Information Resources Effectively Support Asset Management Policies and Decisions?

		Strongly Disagree			Strongly Agree
USE OF DECISION-SUPPORT TOOLS (CONTINUED)					
	Our agency uses asset management decision-support tools to:				
D12.	Calculate and report actual system performance;	**1**	**2**	**3**	**4**
D13.	Identify system deficiencies or needs;	**1**	**2**	**3**	**4**
D14.	Rank candidate projects for the capital program;	**1**	**2**	**3**	**4**
D15.	Forecast future system performance given a proposed program of projects; and	**1**	**2**	**3**	**4**
D16.	Forecast future system performance under different mixes of investment levels by program category.	**1**	**2**	**3**	**4**
SYSTEM MONITORING AND FEEDBACK					
D17.	Our agency monitors actual system performance and compares these values to targets projected for its capital preservation program.	**1**	**2**	**3**	**4**
D18.	Our agency monitors actual system performance and compares these values to targets projected for its capital improvement program.	**1**	**2**	**3**	**4**
D19.	Our agency monitors actual system performance and compares these values to targets projected for its maintenance and operations program.	**1**	**2**	**3**	**4**
D20.	We periodically distribute reports of performance measures relevant to customer / stakeholder satisfaction with transportation system and services.	**1**	**2**	**3**	**4**

3.2.5 SCORING GUIDELINES (OPTIONAL)

A. POLICY GOALS AND OBJECTIVES

POLICY GUIDANCE BENEFITING FROM GOOD ASSET MANAGEMENT

(A1+A2+A3+A4+A5) / 5 = _____

STRONG FRAMEWORK FOR PERFORMANCE-BASED RESOURCE ALLOCATION

(A6+A7+A8) / 3 = _____

PROACTIVE ROLE IN POLICY FORMULATION

(A9+A10+A11) / 3 = _____

B. PLANNING AND PROGRAMMING

CONSIDERATION OF ALTERNATIVES IN PLANNING AND PROGRAMMING

(B1+B2+B3) / 3 = _____

PERFORMANCE-BASED PLANNING AND CLEAR LINKAGE AMONG POLICY, PLANNING, AND PROGRAMMING

(B4+B5+B6+B7) / 4 = _____

PERFORMANCE-BASED PROGRAMMING PROCESS

(B8+B9+B10+B11+B12+B13) / 6 = _____

C. PROGRAM DELIVERY

CONSIDERATION OF ALTERNATIVE PROJECT DELIVERY MECHANISMS

(C1 + C2) / 2 = _____

EFFECTIVE PROGRAM MANAGEMENT

(C3+C4+C5+C6+C7+C8+C9) / 7 = _____

COST TRACKING AND ESTIMATING

(C10+C11) / 2 = _____

D. INFORMATION AND ANALYSIS

EFFECTIVE AND EFFICIENT DATA COLLECTION

(D1+D2+D3+D4+D5) / 5 = _____

INFORMATION INTEGRATION AND ACCESS

(D6+D7+D8+D9) / 4 = _____

USE OF DECISION-SUPPORT TOOLS

(D10+D11+D12+D13+D14+D15+D16) / 7 = _____

SYSTEM MONITORING AND FEEDBACK

(D17+D18+D19+D20) / 4 = _____

3.3 WHERE NEXT?

It is important that the self-assessment address the objectives described in Section 3.1.2:

- **Consensus on current situation**. One of the benefits of discussing the results is to develop a shared perspective on your agency's current practices and the degree to which they exhibit "good asset management." This exercise can probe existing preconceptions to test whether they are legitimate or whether more fundamental issues exist. It also can help define the "scope" of asset management that your agency should deal with.
- **Strengths, weaknesses, constraints, and opportunities**. An assessment of relative strengths and weaknesses should be based on an analysis of your core group's responses to the statements and a critical assessment of these responses, rather than subjective opinions or "common departmental wisdom." For example, in discussing statement D14 where managers may have indicated that decision-support tools are used to rank candidate projects in the capital program, it is fair to ask, "Which systems and which programs?" This probing may help to identify not only those programs that are well supported by your IT tools, but other programs that also could be supported but are not now. Constraints on good practice resulting, for example, from statutory or institutional mandates on business processes should be approached not as

impediments to further improvement in asset management, but rather as opportunities to apply asset management principles through complementary activities that introduce needed incentives or checks and balances.

- **Priorities and critical areas**. Statements with responses that deviate significantly from the state-of-the-art (rating 4), or that exhibit a wide variance among core group managers, may be candidates for priority improvements in asset management. These results should be reviewed critically, though, before firming up these decisions. For example, while there may be a consensus on the need for better condition data, using these data effectively means having suitable business processes in place. Revising data collection procedures may therefore be a priority item, but revising business processes to apply these data to decisions may be the critical task. Similarly, self-assessment responses may point to a pattern of business process weaknesses in planning, programming, and program delivery, but a more fundamental problem may exist in how organizational roles and responsibilities are assigned by executive management.
- **Foundation for implementation plan**. All of these discussions and deliberations should keep the larger objective of self-assessment in mind: to forge the basis for improving asset management practice, and in so doing to secure buy-in by managers across departmental units. A clear vision of selected areas where improvements would advance asset management substantially is preferable to a long "wish list" in which there is no coherent direction for proceeding.

Diagnostic Tables 3.1 through 3.4 summarize the key benchmark characteristics in the same areas of asset management in which you conduct your agency's self-assessment. They also identify common gaps between actual practice and benchmark achievement, and relate benchmarks and gaps to later sections of the ***Guide*** where further information may be found.

Options for proceeding with the self-assessment results include the following:

- **"Quick-reference."** Once you have identified priority areas for asset management improvement, the diagnostic tables presented on the following pages (Tables 3.1, 3.2, 3.3, and 3.4) can point you directly to pertinent sections of this ***Guide*** that can assist you in developing solutions. (Note that each row in Tables 3.1 through 3.4 is integral. Each row contains a number of benchmarks and common gaps in practice; the sections that are cited to the right in each row apply generally to the sets of benchmarks and gaps, not to any one specifically.)
- **Asset Management Implementation Plan.** Once you have documented the results of the self-assessment, proceed to Chapter 4, which will guide you through the development of a comprehensive asset management implementation plan. Chapter 9 discusses additional issues in implementation, including concepts of change management and associated communications planning that can accompany asset management implementation.

You also may develop your own approach to acting on the results of the self-assessment. The important thing is that the exercise helps your agency to identify where to focus, and how to customize and tailor the aspects of asset management good practice to the priority areas for improvement within your organization.

Table 3.1 Policy Guidance Diagnostic

Benchmark	Common Gaps	See these Sections of the *Guide*
POLICY GUIDANCE BENEFITING FROM GOOD ASSET MANAGEMENT PRACTICE (A1 – A5)		
Polices allow agency latitude in its resource allocation decisions Policy guidance supports decisions based on cost-effectiveness or cost / benefit Policy guidance supports a long-term, life-cycle approach to evaluating investments	Most policy debate is about specific project choices and not about broader outcomes Changes in leadership make sustained initiatives difficult No clear relationship between policies and how resource allocation decisions are made Implications of policies are unknown	Section 5.3 Improved Policy-Making Section 5.5 Playing a Proactive Role in Policy Formulation
STRONG FRAMEWORK FOR PERFORMANCE-BASED RESOURCE ALLOCATION (A6 – A8)		
Comprehensive policy goals exist, with clear linkages to specific objectives and performance measures Policy guidance encourages resource allocation based on performance Policy guidance is well understood and reflected in business processes	Policies not aligned with more specific objectives or performance measures Internal and external policy guidance are not in alignment Funding decisions based purely on geography or history	Section 5.4 Relating Policy to Performance
PROACTIVE ROLE IN POLICY FORMULATION (A9 – A11)		
Agency clearly communicates current system performance with respect to policy goals and objectives to policy-makers and customers Agency proactively presents policy choices and implications to policy-makers Agency has latitude to make investment decisions based on performance	DOT lacks credibility with legislature or executive branch External guidance is overly specific, e.g., includes lists of specific projects or funding allocations Front-line decisions not consistently in line with priorities	Section 5.4 Relating Policy to Performance Section 5.5 Playing a Proactive Role in Policy Formulation

Table 3.2 Planning and Programming

Benchmark	Common Gaps	See these Sections of the *Guide*
CONSIDERATION OF ALTERNATIVES IN PLANNING AND PROGRAMMING (B1 – B3)		
Long-range plan evaluates capital, operational, and modal alternatives Capital-maintenance tradeoffs explicitly considered Current financial data used to develop project cost estimates and management system cost models	Lack of analysis of alternative approaches to problems Requiring long-term solutions Implications of different investment levels and mixes are not analyzed Lack of understanding of appropriate levels of maintenance versus capital investment	Section 6.2 Planning Section 6.3 Capital Programming Section 7.4 Cost Tracking
PERFORMANCE-BASED PLANNING AND CLEAR LINKAGE AMONG POLICY, PLANNING, AND PROGRAMMING (B4 – B7)		
Long-range plan is consistent with goals and objectives and realistic revenue projections Long-range plan provides clear guidance to programming process Project selection and resource allocation methods reflect current policies and priorities	Inability to translate policies into performance criteria Focusing too early on only one solution at project level Projects selected with poorly defined scopes, budgets, and schedules	Section 6.2 Planning Section 6.3 Capital Programming Section 6.4 Program Structure
PERFORMANCE-BASED PROGRAMMING PROCESS (B8 – B13)		
Candidate projects evaluated on benefit, cost, or performance impacts Project selection based on merit and considers least-life-cycle cost approaches Alternative maintenance levels of service defined and evaluated	Outcome-based performance measures not defined for all program categories Equity and political concerns have limited use of performance-based approach Criteria for project selection not clearly aligned with stated performance measures	Section 6.3 Capital Programming Section 6.5 Maintenance Programming

Table 3.3 Program Delivery Diagnostic

Benchmark	Common Gaps	See these Sections of the *Guide*
CONSIDERATION OF ALTERNATIVE PROJECT DELIVERY MECHANISMS (C1 – C2)		
Options for delivering programs and services are periodically considered and evaluated	Standard bid process used for all construction projects; options not evaluated No process in place to explore resource sharing or outsourcing options to improve maintenance cost-effectiveness	Section 7.2 Alternative Delivery Methods
EFFECTIVE PROGRAM MANAGEMENT (C3 – C9)		
Performance measures used to track program delivery Data used to make adjustments to program and delivery processes All stakeholders informed of program status	Insufficient review process to keep program changes in check and manage their impacts Program delivery indicators not reported regularly or used as effective management tool	Section 7.3 Program Management Section 8.5 Systems Monitoring and Feedback
COST TRACKING AND ESTIMATING (C10 – C11)		
Total costs of delivering programs and services are known by activity Current financial data used to develop project cost estimates and management system cost models	Lack of consistent breakdowns of activities and resources used for cost tracking No method in place to determine indirect cost allocations for activities Cost tracking information not in a form useful for budgeting, investment analysis, or asset management system cost model updates	Section 7.4 Cost Tracking

Table 3.4 Information and Analysis Diagnostic

Benchmark	Common Gaps	See these Sections of the *Guide*
EFFECTIVE AND EFFICIENT DATA COLLECTION (D1 – D5)		
Complete and current asset inventory and condition data	Data do not reflect full range of assets under agency responsibility	Section 7.4 Cost Tracking Section 8.2 Information Needs and Data Quality
Efficient data collection and processing methods provide credible data at acceptable cost	Existing data lack credibility; data collection perceived as not worth its cost	
Information on customer perceptions collected and used	Information on customer perception of condition / performance unavailable	
INFORMATION INTEGRATION AND ACCESS (D6 – D9)		
Managers at all levels can easily access information they need	Lack of data sharing across units; duplication and inconsistency	Section 8.3 Data Integration and Accessibility
Maps of asset condition, need, and projects are readily available	Staff lack good tools to access data or lack training on their use	
Geographic referencing and data standards in place	Lack of consistent geographic referencing	
USE OF DECISION SUPPORT TOOLS (D10 – D16)		
Tools are available to calculate performance measures	No systematic process for identifying needs	Section 8.4 Decision Support
Tools are used to systematically identify needs and projects	Project selection lacks credible justification	
Tools are used to analyze project or strategy benefits and costs and compare alternate solutions	Lack of ability to relate investment levels to resulting performance or benefit	
SYSTEM MONITORING AND FEEDBACK (D17 – D20)		
Agency monitors system condition / performance	No systematic process for monitoring capital programs	Section 7.3 Program Management
Actual condition / performance compared to target values	No systematic process for monitoring maintenance programs	Section 8.5 Systems Monitoring and Feedback
Information periodically provided to decision-makers and external stakeholders	No mechanism for providing monitoring results to decision-makers and external stakeholders	Section 8.6 Reporting and Documentation

4. DEVELOPING A STRATEGY

4.1 SETTING THE STAGE

4.1.1 OVERVIEW

The first part of this chapter discusses the need for agencies to customize their approach to asset management. The second part will help you develop a comprehensive asset management strategy based on the results of the self-assessment exercise presented in Chapter 3. This process entails three steps:

1. Define the scope of asset management at your agency;
2. Establish roles and responsibilities for implementation; and
3. Develop an asset management implementation strategy and plan.

4.1.2 TAILORING AND CUSTOMIZING ASSET MANAGEMENT TO YOUR AGENCY

WHY THE NEED FOR TAILORING AND CUSTOMIZATION?

While state DOTs share a fundamental mission and role in the public sector, they differ from one another in several important respects:

- **The transportation system that is managed by the agency** – e.g., its size and composition, degree of urbanization, the range of modes and facilities that are included, and current and projected condition and performance.
- **The agency's institutional and funding environment** – e.g., the policy framework governing its directions and priorities; relationships with the Governor's office, Legislature, Transportation Commission or Board, regional and local agencies, and other external stakeholders; customer expectations and perceptions of the transportation system and quality of service provided by the agency; status of transportation programs and funding; and projected revenue streams versus anticipated funding needs.
- **Organizational structure, capabilities, and management approach** – e.g., the effectiveness and efficiency of business processes to perform key asset management functions; management philosophy and culture; technological sophistication in IT applications, construction and maintenance practices, materials and testing, and level of training; and success in communicating mission, strategic and tactical objectives, accomplishments, and future directions.

These factors influence how each DOT will approach asset management. They affect how an agency perceives need for asset management improvement, where it identifies its most important priorities and why, what paths to implementation are realistic to consider, and what steps are feasible in terms of human, financial, information, and other resources available. While the asset management concepts and principles in Chapter 2 apply generally, the best approaches to asset management implementation will be specific to each agency, and implementation plans may differ considerably from one agency to another. The breadth of coverage of this ***Guide*** recognizes that a spectrum of potential situations and implementation strategies will occur among state DOTs and other transportation agencies, as noted in Chapter 1.

Modern-day asset management is evolving in the U.S. public-sector transportation industry. Data are sparse as to how the cross-section of state DOT characteristics would be expected to affect asset management implementation, and what strategies would work best in agencies having particular characteristics.[1] However, preliminary indications of the diversity in current state-of-practice and their implications for potential improvements were obtained at a June 2002 NHI Pilot Course on Transportation Asset Management. Approximately 50 professionals from the United States and Canada attended this Pilot Course, comprising executives and senior managers from state DOTs and the FHWA, together with professionals from the academic and consulting communities.

[1] The synthesis of practice completed in Phase 1 of this study provided examples of different asset management practices implemented by state DOTs and other public and private transportation organizations. The sample included fewer than 10 DOTs, however, and no attempt was made to relate current or planned state-of-practice to their respective characteristics regarding transportation systems and programs, and organizational and institutional characteristics. Lead-state and laboratory-state efforts as well as case studies proposed in AASHTO's ***Strategic Plan*** may begin to provide this more detailed information.

As part of the exercises, attendees completed a version of the self-assessment described in Chapter 3 for their respective state DOTs or based on their knowledge of such agencies. While the attendees did not constitute a scientifically selected sample, they did represent a body of senior managers with a broad perspective on agency practice and a good knowledge of asset management principles, methods, and potential applications and benefits to their organizations. The following section summarizes the results of this exercise. These results should be interpreted as a point of departure for discussion when an agency is interpreting its own results of the self-assessment, rather than definitive conclusions of the state of practice in asset management. Nonetheless, even within this sample, there are indications of the range of current practices and perceptions, and the corresponding implication to tailor and customize asset management recommendations to each agency.

COURSE RESPONSES ON STATE-OF-PRACTICE IN DOTS TODAY

NHI course attendees were asked to respond to a subset of 40 statements from the self-assessment forms similar to those in Chapter 3, reflecting their perceptions of their own state DOT or, if they were not employees of a DOT, their understanding of typical agency practices with which they were familiar. Rather than presenting all responses, selected but representative examples are given below that illustrate the diversity in current state-of-practice among agencies represented by the course participants. Since your agency may experience similar distributions of results in your own self-assessment, based on different perspectives of managers from different organizational units, you may wish to consider the examples below in analyzing results within your own organization. Another thought that is prompted by these results is that there is always room for improvement – no statement tested by the self-assessment has all responses at level "4," indicating strong agreement that the "best practice" advocated by good asset management is universally followed in all the agencies represented at the Pilot Course.

WHAT IS YOUR APPROACH TO ASSET PRESERVATION?

Two statements deal with an agency's approach to preservation of its infrastructure assets. Statement 1 (S1) below conveys a policy perspective, while Statement 2 (S2) reflects a business-process view.

- **S1 –** Policy guidance supports preservation of existing infrastructure assets.
- **S2 –** Asset preservation is based upon least-life-cycle-cost approaches rather than exclusive reliance upon worst-first strategies.

Responses to these statements are shown in Figures 4.1 and 4.2 respectively.

Figure 4.1 indicates that more than two-thirds of the respondents feel that their transportation policies do not explicitly support asset preservation. This does not mean that preservation is not being carried out by these agencies. More likely it reflects managers' judgments that a more explicit communication of the priority and objectives of preservation would be helpful.

Figure 4.1 Policies Support Preservation

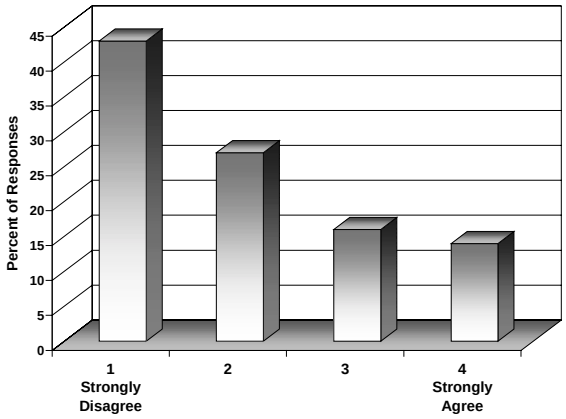


Figure 4.2 Life-Cycle-Cost Approach Used for Asset Preservation

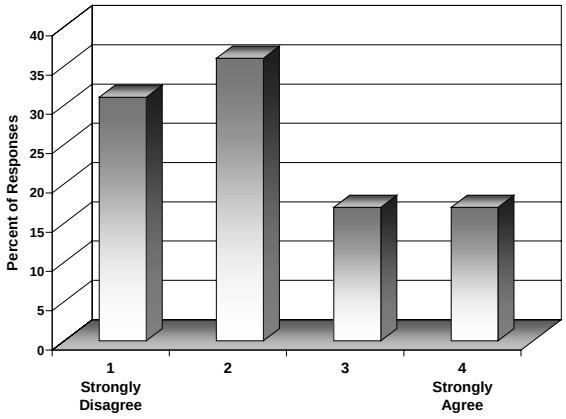


Figure 4.2 relates to the method of managing preservation. The implication is that only one-third of respondents perceive their approach to be based on a life-cycle-cost analysis; others rely more heavily on worst-first criteria. The responses were not analyzed to determine to what degree the results in Figure 4.2 are correlated with those in Figure 4.1, but this issue will not arise in the self-assessment of an individual agency.

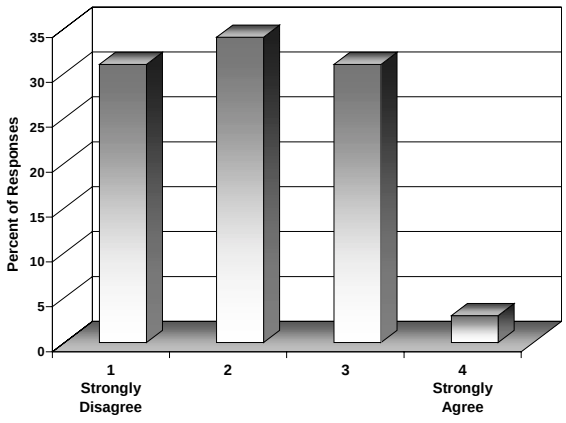
HOW DOES YOUR POLICY FRAMEWORK INFLUENCE ASSET MANAGEMENT PRACTICE?

Consider the responses to these statements regarding existing policy and the way in which transportation agencies respond to this guidance:

- **S3 –** Policies support a long-term, life-cycle approach to evaluating investment benefits and costs.
- **S4 –** Policy guidance on transportation resource allocation allows our agency sufficient flexibility to pursue a performance-based approach.
- **S5 –** Our agency works with political leaders and policy-makers to present policy options and consequences as part of our budget process.

Responses to these statements are shown in Figures 4.3 through 4.5. These graphs collectively indicate considerable variation in management responses to the statements above.

Figure 4.3 Policies Support Life-Cycle Approach



Taking Statement 4 as an example: Recommendations for improving asset management practice might be quite different in those agencies that responded positively in Figure 4.4 versus those that responded negatively. An agency that feels it can pursue performance-based approaches can, if it so chooses, move directly to consider resource allocation methods that conform to the principles outlined in Chapter 2, if it is not already using such approaches. An agency that does not feel that its policy framework supports performance-based approaches, however, may need to adopt different objectives and tactics, depending upon the particular situation at hand. For example, communication with governing bodies on the value of performance-based approaches and the fact that they are already used in certain programs (presumably pavement and bridge management, for example) may lead to expanded use of these techniques.

Figure 4.4 Policy Guidance Supports Performance-Based Approach

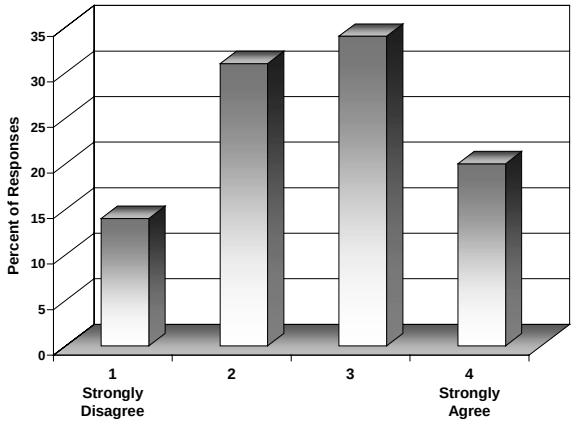
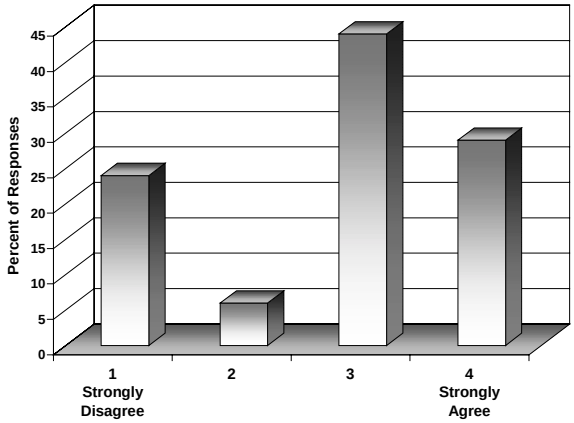


Figure 4.5 Agency Proactively Works with Policy-Makers



ARE YOUR BUSINESS PROCESSES CONSISTENT WITH ONE ANOTHER?

Consider the following statements that deal with basic work processes in resource allocation:

- **S6 –** Our agency's long-range plan provides clear and specific guidance for the capital program development process.
- **S7 –** Criteria that are used for allocating resources, setting program priorities, and selecting projects are consistent with stated policy goals and objectives and defined performance measures.

Responses are in Figures 4.6 and 4.7.

Figure 4.6 Long-Range Plans Provide Programming Guidance

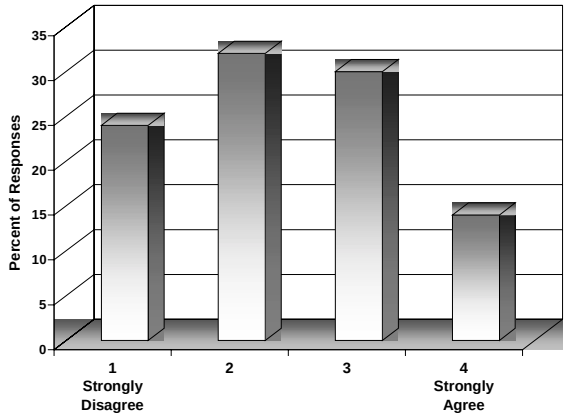
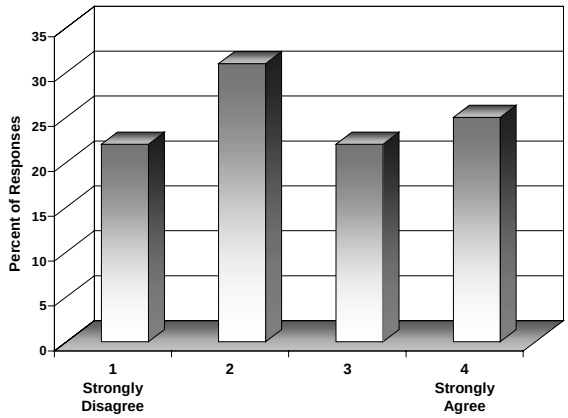


Figure 4.7 Evaluation Criteria Are Consistent with Policies



Again, it is not clear to what degree the responses in Figures 4.6 and 4.7 are correlated with one another. In each case, however, responses are distributed across the spectrum of agreement or disagreement. Once again, how and where asset management concepts and principles apply, and by what techniques they should be implemented, will typically vary among agencies depending upon where their responses to these and other self-assessment criteria fall.

By now the pattern of responses is becoming clear. A couple more examples will be provided just to illustrate the pervasiveness of these types of differences across agencies.

DOES YOUR AGENCY'S PROGRAM DELIVERY CONFORM TO GOOD ASSET MANAGEMENT PRACTICE?

Consider two aspects of program delivery that are probed in the self-assessment:

- **S8 –** Our agency periodically evaluates the use of alternative delivery options.
- **S9 –** Our agency has a well-established and smoothly functioning process to make program adjustments.

Responses to these statements are in Figures 4.8 and 4.9, respectively.

Figure 4.8 Alternative Delivery Options Evaluated

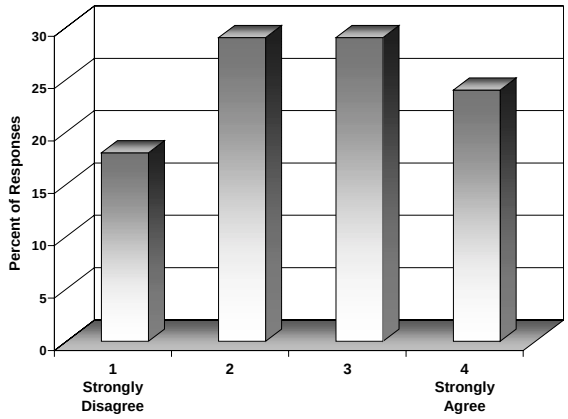
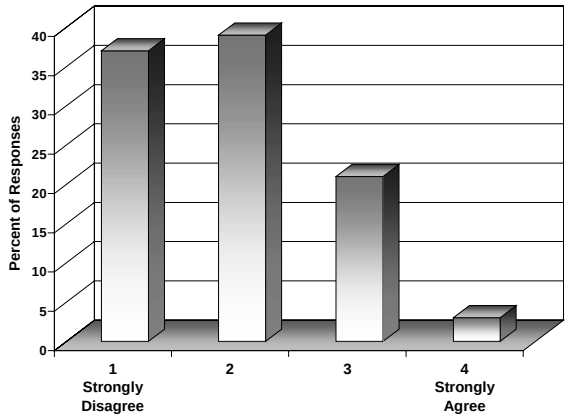


Figure 4.9 Process for Program Adjustments



Reactions to Statement 8 are dispersed fairly uniformly. Responses to Statement 9 are skewed toward the negative end of the scale, indicating that a process for program adjustments could be a candidate business process improvement for many DOTs. Nonetheless, Figure 4.9 indicates that this need is, again, not a universal one.

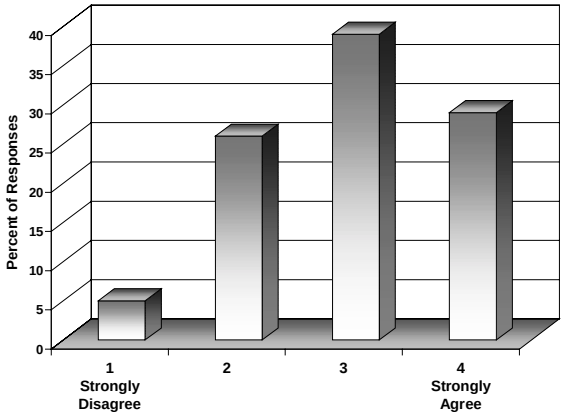
DOES YOUR AGENCY COLLECT AND USE DATA TO IMPROVE ASSET MANAGEMENT?

Two statements on the collection and use of data and information for basic functions in asset management also illustrate the diversity in current practice:

- **S10 –** We regularly collect information on the condition of our assets, sufficient to meet internal and external reporting requirements and guide maintenance and improvement planning.
- **S11 –** Our agency uses information on changes in asset condition over time to develop and improve forecasts of asset life and deterioration [models] in our asset management systems.

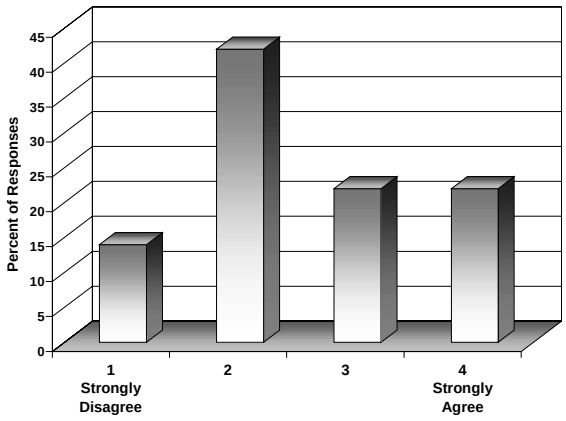
Responses are in Figures 4.10 and 4.11.

Figure 4.10 Sufficient Condition Information Collected



While Figure 4.10 indicates that about two-thirds of the respondents surveyed identify with the collection of condition data, only about 40 percent of respondents said their agency applies these data to develop improved models in management systems. It appears, based on these data, that some agencies have condition information and are applying it to improve analytic models; other agencies have this information but are not applying it to analytic updates; and a third group does not have this information, or at least in the way described in Statement 10. The agendas and priorities of asset management implementation will likely vary among agencies in this aspect as well.

Figure 4.11 System Models Reflect Actual Asset Deterioration Rates



OPPORTUNITIES TO TAILOR AND CUSTOMIZE

Key questions in asset management implementation – where to focus, what to do, and how to do it – depend on the characteristics, needs, and priorities of individual agencies such as yours. That is the lesson of the several examples above. It is for this reason that ***there is no single, "correct" approach to improving asset management***. As the examples above show, tasks that may be entirely appropriate and important for one agency may be unnecessary or peripheral to another. The subsequent chapters of this ***Guide*** cover a number of DOT functions and situations broadly because your agency and others should understand the scope and range of options available. You are then able to make your own informed decisions on how to advance asset management practice in the way that best applies to your organization.

One way of focusing on the elements of asset management most important to your agency is by tailoring implementation: i.e., limiting its breadth or scope initially. The self-assessment in Chapter 3 is one tool to help you do this. Another approach is to select particular assets, programs, functions, or other elements of your agency's infrastructure management, and implement asset management principles and practices in these areas first. This approach provides a laboratory in which you can see how implementation proceeds before extending it more widely. Subsequent sections of this chapter give several examples of tailoring asset management implementation.

Customization refers to specific techniques and tactics that you choose to achieve the objectives of asset management given the management characteristics, constraints, and culture of your particular organization. The discussion in relation to Figure 4.4, which suggests ways to deal with varying degrees of policy support for performance-based infrastructure management, provides a few examples of how to customize an asset management approach. Additional examples related to policy, planning and programming, program delivery, and information and analysis are presented in Chapters 5 through 8, respectively.

4.2 DEFINE THE SCOPE OF ASSET MANAGEMENT

Defining the scope of asset management requires an agency to answer the following four fundamental questions:

- Which assets will our asset management efforts address?
- Which actions will be covered in our asset management implementation plan?
- Which business processes will be included in the effort?
- Which asset management concepts will be emphasized?

Defining the scope early in the process will provide clear focus for the effort, insure that the initiative is appropriately scaled, and provide basic direction for both process and information systems initiatives.

4.2.1 WHICH ASSETS?

Transportation agencies can design and implement asset management systems for a wide variety of infrastructure portfolios. Assets can be selected for inclusion in the asset management implementation plan by the following categories:

- **Physical Asset Classes –** Travel ways, structures, operations equipment, and features associated with highways, airports, rail, ports, transit, etc.
- **Ownership** – State-owned assets, and other assets that are not owned by the DOT but in which a state has an interest (e.g., locally owned bridges that receive state funds).

- **Other Asset Classifications –** For example, urban versus rural, functional class, traffic volume served, type of usage, or other tiers or classifications.

4.2.2 WHICH ACTIONS?

Asset management strategies can be designed to enhance various types of investments (e.g., preservation activities, capital improvements, operational improvements, etc.). The full benefits of applying asset management principles are realized when all of these investments are considered in unison. Examples include tradeoff analyses between preventive maintenance strategies with a deferred maintenance strategy that will lead to major capital improvements, and tradeoff analyses between widening a section of road and implementing an ITS project to address congestion.

However, benefits also are possible by applying asset management principles to any one of your agency's investment types or programs. For example, a performance-based maintenance level-of-service program can lead to improvements in the cost-effectiveness and customer-orientation of maintenance budget decisions.

4.2.3 WHICH BUSINESS PROCESSES?

Asset management principles are relevant to the entire infrastructure management process – policy development, planning, programming, budgeting, project development, program delivery, maintenance, operations, etc. Again, maximum benefits are gained when the concepts and techniques are applied consistently throughout the resource allocation and utilization processes. However, improvements may be focused on a single process or program, or a subset of processes, particularly if there is a strong priority for improvement here; if an agency wishes to implement asset management on a trial basis first; or if resource constraints preclude addressing all relevant functions or programs at once.

4.2.4 WHICH ASSET MANAGEMENT CONCEPTS?

Your agency should reach agreement on common asset management principles and approaches to be applied consistently throughout its asset management efforts. Examples include:

- Consideration of user benefits and costs in a life-cycle analysis framework;
- Strategic applications of asset management systems;
- Tradeoff analyses across programs;
- Integration of information using existing, single-focus legacy systems;
- Advanced applications in data acquisition;
- Consistent cost, delivery, and accomplishment tracking; and
- State-of-the-art applications in GIS, data warehousing, or other IT techniques.

4.2.5 SCOPING ISSUES

The following issues should be considered when evaluation scoping options within your agency.

- **Buy-in and capabilities of responsible parties –** As the scope of asset management is expanded, more and more parties will be required to evaluate and potentially revise their business processes. For example, limiting the scope of asset management to state-owned assets will require significantly smaller education effort than including both state-owned and locally owned assets.
- **Availability of data and analytical tools –** As illustrated in Chapter 2, every step of asset management is supported by accurate and current data and decision support tools. Including assets, actions, or processes for which data are not complete or for which significant system work is necessary may significantly increase the resources required for implementation.
- **Appropriate scope size –** Developing a detailed implementation plan for improving asset management for all assets, all actions, and all processes will be more expensive, take longer, and require significantly more resources to implement than a more focused effort. Developing an all-encompassing plan may be less manageable and therefore hinder progress in priority areas.
- **Legislative or institutional constraints –** Barriers outside of the control of your agency may limit the scope of its asset management efforts. For example, consider a situation in which state legislators mandate all available funds to particular

modes. In this case, it is likely that program-level tradeoffs will be omitted from the scope of asset management. Section 4.3 addresses this situation in the context of developing a plan around a set of constraints.

4.3 ESTABLISH ROLES AND RESPONSIBILITIES

4.3.1 LEAD ROLE

Each task in the asset management implementation plan is likely to entail a number of detailed issues and interactions with other tasks that will need to be resolved. To provide continuing guidance in the effort, establish clear accountability for success of the initiative, and ensure that activities are complementary to each other and performed in a logical sequence, it is recommended that lead responsibility for asset management be assigned to one individual. Responsibilities of this person may include:

- Chair an executive steering committee;
- Oversee development of a state implementation strategy and plan;
- Coordinate implementation efforts;
- Track implementation and modifying plan as needed;
- Communicate with other departments on asset management issues;
- Coordinate departmental units and resolving organizational issues; and
- Act as an authoritative point of contact for Legislature, Commission, or key stakeholders.

These responsibilities suggest a profile for the ideal asset management "owner."

- Effective communication and facilitation skills;
- High-level understanding of the several organizational units that will be involved in plan implementation; and
- Demonstration of executive leadership and commitment by example.

4.3.2 SUPPORTING ROLES

To maintain cross-disciplinary support and coordinate asset management activities throughout agency, it is recommended that support roles be established early in the implementation process.

One type of support role that may be considered is an **executive steering committee** to guide development of the asset management implementation plan and agree on organizational roles and responsibilities. This committee should include representatives of infrastructure managers, planning and programming, maintenance and operations, financial management, information technology, and administration; district representatives; and potentially external agencies and interest groups.

Another support role to consider is a **technical committee**. As one example: depending on the make-up of the steering committee and the extent to which your agency's priorities are IT-related, a technical committee may be needed to guide data and system-application-related initiatives that cross agency sections and divisions. This committee should comprise representatives from across the agency with an in-depth understanding of the agency's IT issues, including technical experts for major asset classes.

A third type of support role may be **individual activity or task "owners."** It is recommended that as the asset management implementation plan is developed, the steering committee assign an individual owner to each of the actions called for. There will likely be instances when the individual with overall responsibility for the asset management implementation will also be responsible for individual activities or tasks. However, this decision should be made on a case-by-case basis.

4.4 BUILD AN ACTION PLAN

4.4.1 IDENTIFY AREAS NEEDING IMPROVEMENT

Once the scope has been defined and responsibilities have been established, the next step is to define objectives and formulate tasks to achieve each one. This process requires an agency to bring together the asset management principles presented in Chapters 1 and 2, the results of the self-assessment exercise in Chapter 3,

and the implementation guidance provided in Chapters 5 through 8. These chapters organize key concepts and examples of typical implementation activities by the four areas of asset management focus:

- **Chapter 5 –** Policy goals and objectives;
- **Chapter 6 –** Planning and programming;
- **Chapter 7 –** Program delivery; and
- **Chapter 8 –** Information and analysis.

Formulating tasks requires an over-arching look at the self-assessment results to understand the connections that may exist among issues raised in each area. This requirement does not imply that your agency should try to address every item all at once. Rather, a broad perspective will enable your agency to identify priority actions for improving asset management.

Following are examples of this process organized around several types of improvements, listed below, that could result from applying asset management. Other types of improvements are, of course, possible, and you should not be constrained by the examples below. Five areas of improvement are discussed below:

- Desired improvement in technique;
- Consistency among elements of asset management;
- Gaps in good asset management practice;
- Constraints on good asset management practice over which the agency has little or no control; and
- Desired improvement in the principles underlying an asset management practice.

These five categories are strictly for convenience in helping organize the examples. They are not fundamental to an asset management approach. What is important is the fact that the need for improvement is recognized explicitly, and recommendations for action are identified for inclusion in your agency's asset management implementation plan.

IMPROVING SPECIFIC TECHNIQUES OF ASSET MANAGEMENT

This type of improvement entails focusing on those techniques most in need of improvement: e.g., life-cycle analyses, strategic applications of asset management systems, tradeoff analyses, ways to integrate information using existing, single-focus legacy systems, advanced applications in data acquisition, state-of-the-art applications in GIS, etc.

An example objective in this category is the introduction of life-cycle cost considerations of preventive maintenance throughout an agency. Achieving this objective may involve: 1) adjustments to existing asset management systems (PMS, BMS, MMS, other systems for hardware, tunnels, etc.), or 2) development of a separate tool to identify and analyze feasible preventive maintenance strategies.

Chapters 5, 6, and 8 provide guidance on developing and evaluating tasks in this area.

ACHIEVING CONSISTENCY AND ALIGNMENT AMONG ASSET MANAGEMENT PRACTICES

An example objective in this area is enhancing current information technology to support an agency's current business processes. Achieving this objective may require a preliminary diagnosis of why information is not now used in the business process, and how to address the problem. Examples include:

- Lack of awareness of system capabilities? Plan to conduct workshops or training to advertise full system capability.
- Poor communication between organizational units? Plan to institute procedures that promote communication between affected business units.
- Political constraints on the business process that preclude use of system information? Plan ways to apply system information to inform the political process, or to provide a performance review of current decisions.
- Lack of system credibility? Plan to identify and achieve needed improvement in system data quality and analytic capability.

Chapters 5, 6, 7, and 8 provide guidance on formulating tasks to support this objective.

Another example in this area is development of planning and programming criteria that are more consistent with policy objectives. Achieving this objective may entail a top-to-bottom review of the planning and programming processes, including planning criteria, project prioritization and selection procedures and criteria, resource allocation procedures, and performance measures, all in comparison with policy objectives.

Chapters 5 and 6 provide guidance on formulating tasks in this area.

FILLING GAPS IN GOOD ASSET MANAGEMENT PRACTICE

An example objective in this category is development of the capability to track and manage program delivery where none currently exists. Achieving this objective may involve formulating procedures and information requirements to track and manage delivery according to schedule and cost targets at the project and the program levels, and identification of corresponding organizational responsibilities for review and approval of deviations.

Chapter 7 provides guidance on formulating tasks to support this objective.

Another example is providing high-level information on asset condition, performance, and implications of different investment options to executive management. Approaches to achieving this objective may involve creation of either a data warehouse or an executive information system (EIS) to process and organize information from existing asset management systems and to compose reports suitable for executives.

Chapters 5 and 8 provide guidance on formulating tasks to support this objective.

OVERCOMING CONSTRAINTS ON GOOD ASSET MANAGEMENT PRACTICE

Example of constraints on good asset management include statutorily defined priorities or designated funding of modes / programs. Such mandates limit an agency's latitude in achieving the state-of-the-art described in the asset management matrices in Chapter 2. Therefore, in developing an asset management implementation plan, an agency should focus on the aspects of its business process that are open to change. It should identify asset management principles that suggest improvements within these constraints.

For example, if funding splits across programs are legislatively mandated, how could an agency improve its asset management practices? It could assume that revision of the statute is unlikely, and focus on the aspects of operation that are under its control. It could establish procedures to ensure that within the specified priorities and funding rules, investments go to the most meritorious projects. It also could track the success of the revised allocation process by developing guidelines for monitoring system performance measures.

Chapters 5 and 6 provide guidance on formulating tasks in this area.

IMPROVING THE PRINCIPLE UNDERLYING ASSET MANAGEMENT PRACTICE

An example of an objective in this category is transition to a more performance-based resource allocation process. Achieving this objective may require several basic changes to the current resource allocation process to focus on applicable policy objectives and performance measures, and to define appropriate criteria for project ranking and selection. It also may entail accompanying changes in organizational roles, analytic and information system capabilities, and communication with local agencies involved in system planning and program development.

Chapters 5, 6, 7, and 8 provide guidance on developing actions to support this objective.

4.4.2 TIMEFRAME

An important aspect of developing an asset management implementation plan is to define a time frame for each of the improvement activities or tasks. Factors to consider include:

- 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.

4.4.3 ASSET MANAGEMENT IMPLEMENTATION PLAN

As the process described above unfolds, it is recommended that priority areas be documented in an asset management implementation plan. As an illustration, Table 4.1 organizes recommendations from earlier parts of this chapter into a sample implementation plan. The final format and content of your agency's action plan should reflect its unique set of needs. However, the table does highlight several types of information to consider.

- The first column identifies each of the agency's **objectives**. In practice, your agency may want to consider further organizing objectives by creating a table for each of the four key areas of asset management.
- The second column lists specific **activities** required to achieve the objective.
- The third column documents the expected **benefits** of each activity. Defining benefits will ensure that all parties understand the importance of the activities and may help to create buy-in for individual initiatives and answer the question, "Why do it?"
- The final column recommends a **timeframe** for each activity. In Table 4.1, "near term" and "mid term" are used to establish the relative timing of each activity. More specific timing information such as **start** date and **estimated duration** also may be beneficial.
- Additional information provided in an asset management implementation plan may include **activity "owner," cost**, **priority**, **linkages among recommendations**, and **agency-specific items** (e.g., agency-wide strategic planning areas that the activities support).

Table 4.1 Sample Implementation Plan Format

Objective	Activity	Intended Benefits	Timing
1. ESTABLISH ASSET MANAGEMENT OWNERSHIP	1.1 Assign lead for asset management coordination	• Clear accountability for asset management • Ensure that activities that are related to each one another are performed in a logical sequence	Near Term
	1.2 Form asset management steering committee with representatives from across the agency	• Cross-disciplinary support • Coordination of asset management activities throughout agency	Near Term
2. CLEARLY DEFINE SCOPE OF ASSET MANAGEMENT	2.1 Define which assets and activities to be included (e.g., all capital and maintenance activities on state-owned pavements and bridges)	• Clear focus for the effort • An effort that is appropriately scaled	Near Term
	2.2 Agree on the types of investments (e.g., preservation, capital, operational, etc.) to be considered in the asset management plan	• Clear focus for the effort	Near Term
	2.3 Agree on common principles and approaches to be applied to infrastructure decisions (e.g., life-cycle investment strategies, program-level tradeoffs, asset valuation methods, etc.)	• Basic direction for both process and information systems initiatives	Near Term
3. IMPROVE PUBLIC AND INTERNAL UNDERSTANDING OF ASSET MANAGEMENT	3.1 Hold periodic departmental workshops to discuss asset management and its implications for department activities	• More informed and committed staff	Near to Mid Term
	3.2 Develop and distribute public information describing asset management and its importance	• Increased public awareness and support	Mid Term

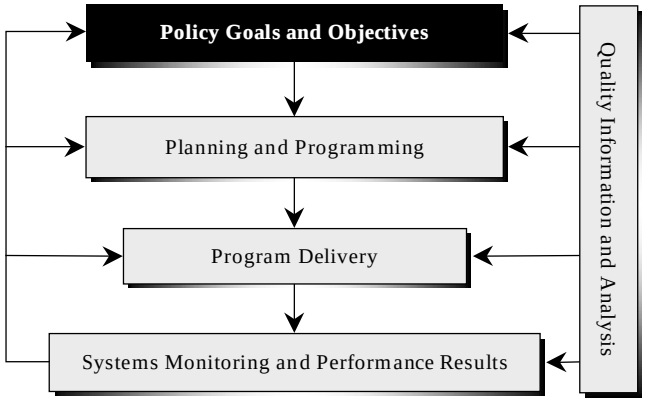
5. POLICY GOALS AND OBJECTIVES

5.1 INTRODUCTION

The resource allocation and utilization framework described in Chapter 2 represents a cyclic business process supported by systems monitoring, information, and feedback mechanisms. Interactions can occur throughout the process among these functions: e.g., between policy formulation and planning, and between planning and programming. Moreover, practices in these functions differ among DOTs. For clarity and organizational purposes in this ***Guide***, therefore, the stages of this framework are treated sequentially in individual chapters, recognizing that the actual business practices are more complicated.

In focusing on ***Policy Goals and Objectives***, this chapter looks at how asset management can improve policy formulation, the role of policy in driving other functions addressed by asset management (Figure 5.1), and the proactive role that your agency can play in policy formulation to advance asset management further.

Figure 5.1 Policy Goals and Objectives within Resource Allocation and Utilization



- **Section 5.2** describes the role of policy guidance in the context of the overall asset management framework;
- **Section 5.3** provides examples of improved policy development that can result from application of asset management principles;
- **Section 5.4** describes specifically how policy formulation is incorporated within a performance-based approach to infrastructure management; and
- **Section 5.5** describes proactive roles that a transportation agency can play with its external and internal stakeholders.

5.2 ROLE OF POLICY GUIDANCE

In the context of asset management, resource allocation and utilization in Figure 5.1 have a top-to-bottom consistency in the methods and criteria used for making decisions. The role of policy guidance in this context is to ***establish clear direction*** for the remaining functions. Planning, priority programming, program delivery, and system monitoring all need to be aligned with policy objectives and associated performance measures.

Policy guidance may be expressed in several ways that collectively define the directions and overall priorities for an agency's infrastructure management:

- State and federal statute or regulation;
- Policy statements and guidelines of the governor, legislature, and transportation commission or board;
- Directives issued by agency executives; and
- In some cases, agreements with other parties that define an agency role, responsibility, or target to be met.

The following items summarize key issues regarding policy formulation in an asset management context that will be dealt with in the remainder of this chapter:

- The importance of policy formulation, and of an agency's role in influencing how policies are formulated, can sometimes be overlooked.
- Policy guidance must be meaningful to all functions in resource allocation and utilization.
- The implications of policy statements should be explored by an agency, working with political leaders and stakeholders, during policy formulation rather than afterward.
- Policies should be related to objectives, performance measures, and performance targets right from the start.
- A customer perspective should be reflected in policy.

- A well-structured approach to policy formulation and adoption can help establish appropriate roles for the transportation agency and its governing bodies in subsequent program development and management.

5.3 IMPROVED POLICY-MAKING

The concepts and principles of asset management can improve the ways in which policies affecting transportation are conceived and formulated. This section will explore the following opportunities for improvement:

- Broadening thinking about potential transportation solutions;
- Relating "policy" to "process" more strongly; and
- Employing more analytic information in policy-making.

5.3.1 BROADENED THINKING

Asset management encourages the identification of options or alternatives at each stage of resource allocation and utilization. This broadened view of potential solutions to transportation needs can apply to policy formulation in the following ways:

- It encourages policy statements that focus on goals in terms of improved performance, rather than on the specific types of investments needed. For example, a policy goal may be to "reduce congestion." This goal can be met through a number of strategies such as investments in new capacity, operations projects to improve the efficiency of existing capacity, investments in other modes to divert excess demand, and spot improvements to relieve bottlenecks. Your agency should try to preserve its latitude to explore these options in long-range planning rather than at the policy formulation stage.
- If a policy-making body is intent on including proposed solutions as part of the policy statement (e.g., to explain the purpose of additional funding), it may be helpful to inform members of the several options available, and to try to encourage wording sufficiently broad to cover this range of possible solutions.
- Analyses of scenarios are being done increasingly in planning and programming; scenario testing can apply to policy formulation as well. "Scenario testing" in this context is the systematic investigation of the long-term costs to achieve different projected outcomes or results. It is a step in policy formulation that is often overlooked, but is critical to establishing realistic objectives and performance targets – or in setting the stage for additional resources. Increasing attention to the GASB 34 standards for the modified approach, which require disclosure of proposed values for asset condition and expenditures, also will encourage greater use of scenario testing.

These suggestions entail a proactive role for your agency in working with the legislature, governor's office, and transportation commission or board. It entails education, communication, and analytic support that leads to a greater shared understanding of the implications of particular policies. A by-product of this process is a more coherent set of policies, as will be discussed further below. Additional examples of how objective, analytic information can be usefully applied in policy formulation also are given below.

5.3.2 RELATING "POLICY" TO "PROCESS"

Policy formulation can sometimes appear detached from other agency functions. This situation is especially true if policy statements "say all the right things," but otherwise are not in a form that can be usefully applied to making judgments and decisions in infrastructure investments. Such policy statements may be too vague, numerous, or undifferentiated from one another to discern what are the tangible goals to be achieved and where are the priorities to be addressed.

Policy formulation in an asset management context "connects" directly to other functions in resource allocation and utilization. It leads to clear, specific, and preferably quantifiable targets for achievement in later stages of the process illustrated in Figure 5.1. If quantitative statements are not possible, qualitative statements can suffice if they are informative and meaningful (e.g., giving a sense of relative priority, or suggesting a measure of success). The mechanisms by which policy formulation can accomplish these purposes will be covered in Section 5.4, dealing with performance-based management. To have policy formulation fulfill this role of clear direction in asset management, however, your agency again must be proactive in working with policy-making bodies to

educate them on how performance-based management works, and what their roles are in the approach in relation to your agency's role (see Section 5.5.1).

Florida DOT Work Program Instructions

Each year, the Florida DOT's Program Development Office produces a set of "Work Program Instructions." The DOT's objective is to clearly communicate federal, legislative, gubernatorial, and DOT policies to the parties responsible for developing, adopting, and managing the DOT's work program. The document covers capital, maintenance, and operational activities. For example, the 2001 instructions include:

- *A matrix of legislative requirements that impact program development;*
- *The program development schedule and general instructions for developing, adopting, and managing the DOT's schedule of transportation projects (includes both capital and maintenance activities);*
- *Funding guidance, such as permitted use of federal and state funds, and program targets; and*
- *A discussion of alternative contracting mechanisms.*

This document is an example of the Florida DOT's efforts to tie policy to process. It can be found in its entirety at the following web site:

www11.myflorida.com/programdevelopmentoffice/work%20program%20instructions.htm

A benefit of relating policy to process is that the policies themselves become more coherent as a package – i.e., they give clearer direction collectively as well as individually. The reason for this greater consistency is that issues of relative priority of policy goals and expected outcomes are confronted during policy formulation rather than later; both your agency and your policy-making bodies can be on the same page regarding the purpose, importance, and expectations of your infrastructure investments. Moreover, this guidance can extend throughout your organization, providing the basis for clearer horizontal and vertical communication illustrated in Figure 2.2.

Connecting policy to process also can reduce the vulnerability created by the leadership turnover experienced by most transportation agencies every few years. Policy formulation that embodies the principles of transportation asset management (e.g., customer focus, performance-based, comprehensive view of assets, input from objective analytic tools, etc.) provides a framework for institutionalizing a correspondingly effective business process. Once ingrained as part of your agency's "way of doing business" and accepted by political bodies and other stakeholders, this method of policy formulation and the business processes that follow become easier to transmit to a succeeding administration.

5.3.3 Supporting Policy-Making with Objective Information

Objective information can assist policy-making in the following ways. First, current and projected information on transportation system condition and performance (including environmental, economic, social, and other impacts as available) can help identify trends and emerging situations requiring policy focus. Second, good information should inform policy formulation itself – i.e., policy objectives and targets should be set only after analyzing the costs to achieve different levels of condition and performance within a timeframe. Moreover, these scenarios need to be tested across the range of proposed policies, not just a single policy. (Relating policy to performance is discussed in more detail in Section 5.4.)

Analyzing the costs required to achieve and maintain various condition or performance levels would enable an agency to establish realistic targets (i.e., targets that are achievable given existing funding constraints, traffic usage, etc.). Such targets provide meaningful guidance for subsequent steps in the resource allocation and utilization process, and help to establish credibility with external stakeholders.

Many agencies now have the capability to conduct these types of scenario analyses at least for preservation, since modern pavement and bridge management systems often include a scenario testing capability. Maintenance management systems that are based on levels of service and performance budgeting also can develop these estimates for the maintenance program. Corresponding analyses in other areas (e.g., mobility, safety, economic development) may be available from long-range planning (Chapter 6). These tools can be employed in policy formulation as well as in planning and budgeting.

Executive Information Systems

One approach to providing policy-makers access to information is to create an executive information system (EIS). For example, the Washington State Transportation Executive Information System (TEIS) is a web-based tool designed to support legislative planning and oversight of transportation activities. Washington State Department of Transportation (WSDOT) managers and legislative transportation committees use the system to view executive-level information, perform queries, and generate reports. The TEIS consists of five components:

- *Fiscal and Performance Monitoring. This application is used to track all WSDOT expenditures, revenues, performance measure activities, and full-time employees*
- *Capital Projects and Facilities Reporting. This system is used by legislators, legislative committee members, and WSDOT staff to view the status of transportation-related capital projects. Information is available at both an individual project level and an aggregate level.*
- *Fund Balance and Fee Modeling. This application is used by legislative committee members to balance transportation fund forecasts and planned expenditures. With this component of the TEIS, users can view WSDOT's six-year program and financial plan and estimate income from proposed revenue sources.*
- *Transportation Resource Manual. This manual, which includes information regarding transportation finance, policy, and governance, is available online through the TEIS.*
- *Change Management System. This component is used to track suggestions for enhancements to any part of the TEIS.*

Further information is available on the TEIS web site: www.transinfo.state.wa.us/

5.3.4 How May These Steps Help?

The steps suggested above can help close gaps and overcome pitfalls in policy formulation in the following ways:

- They can improve the quality of policy guidance by encouraging consideration of alternatives, building a more coherent policy package, and applying good information and analytic support during policy formulation rather than afterwards.
- They can help overcome organizational impediments to more effective policy development. Seeing policy formulation as a stronger part of the resource allocation process and broadening the options and information technology support for policies can have several benefits:
  - It can encourage exploration of new options for transportation solutions and avoid an attitude of "business as usual."
  - It can combat the effects of turnover in leadership, establishing a core policy approach while recognizing that transitions between different policy perspectives are a fact of life.
  - It can build consensus among departmental units that would otherwise hold different perspectives on policies and agency priorities. It also can help to align internal organizational units that hold conflicting objectives.
  - It can encourage application of better information for use in current and future policy reviews.
- They can begin to address disconnects between current policies and existing decision criteria used in other functions shown in Figure 5.1. The exercise to define policy objectives and performance measures provides key elements by which to review procedures and criteria for decisions in planning, priority programming, and program delivery.

5.4 Relating Policy to Performance

5.4.1 Good Practice

Linking policy to performance is the foundation of the process in Figure 5.1. Good asset management in this context implies the following:

- Policy goals provide guidance on investment priorities and levels of performance.
- Policy goals are related to specific performance measures, which are consistent with the measures used in long-range planning, project evaluation, program tradeoffs, and system monitoring.
- Policies are evaluated with respect to the funding needed to attain particular levels of performance, prior to policy adoption.

- Policy formulation is revisited periodically or after major events affecting the policy framework (e.g., reauthorization of federal transportation legislation).

Preservation Policy and Asset Management

Preservation of existing assets is important to cost-effective management of existing infrastructure. It is for this reason that the management framework in Chapter 2 speaks to strategies that preserve existing infrastructure at least-life-cycle cost within available resources. These strategies can include both capital projects and maintenance activities. The framework also cites a benchmark practice to analyze capital-maintenance tradeoffs to determine the best overall strategy for preservation.

DOTs may be interested in a "preservation-first" policy, mindful of the value of their assets and the difficulty and expense of keeping these assets in good condition in the face of declining revenues. While the principles outlined in Chapter 2 certainly support cost-effective preservation, a "preservation-first" philosophy is a choice that is up to each DOT and its policy-making bodies.

Individual agencies and their policy-making bodies may adopt such a policy if they feel it is warranted. Asset management principles suggest that the merits of this policy be determined through a performance-based analysis of preservation versus competing needs of other programs, including scenario analyses of each program at different levels of investment and tradeoff analyses among programs. These analyses can help policy-makers determine whether a preservation-first policy should be adopted.

Policy formulation reflects public priorities regarding the role of transportation in a state. "Preservation of the existing system," "efficient and safe movement of people and goods," and "enabling growth and economic development" are ways of expressing different priorities. 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 to adopt the ones that are felt to be warranted.

5.4.2 ELEMENTS OF THE APPROACH

Policies in a performance-based context can be developed with the following elements:

- ***Goals*** are statements that define the basic aim of a policy. Example policy goals are statements promoting better pavement performance and safety, respectively. ***Objectives*** are specific aspects of goals to be attained. For example, the objective for pavement performance may be "to provide road users with a smoother ride"; and for safety, "to reduce motor vehicle crashes."
- ***Performance measures*** are observable, quantifiable measures that align with objectives. They provide the way to track progress toward meeting the objectives. For example, measures of pavement ride quality or serviceability could be used to gauge smoothness of ride. A measure of crashes per 100 million vehicle-miles (100 MVM) could be used as the performance measure for the safety objective.
- ***Performance targets*** are specific values of performance measures that provide the level expected to be attained. This target may be set for a specific time period and with the understanding of a particular level of funding. It provides the bar against which actual performance data will be compared. For example:
  - Regarding pavement smoothness, the target may be to increase the percent of pavement network in good condition with respect to ride quality from 75 percent to 85 percent by the year 2005.
  - Regarding safety, the target may be to reduce the crash rate from 1.38 to 1.35 per 100 MVM by 2005.

This approach implies a "tighter fit" than may have existed in the past between policy formulation and the other functions in Figure 5.1. All of these functions employ performance measures in an asset management context. This "tighter fit" also is the reason for the suggestion that performance measures be defined at the time that policy goals and objectives are developed, as discussed in relation to the management framework that is illustrated in Figure 2.1. In this approach, performance measures provide the mechanism both for setting targets and for obtaining feedback on actual system performance.

In some situations policy-making bodies (particularly transportation boards or commissions) may participate in setting quantitative policy objectives, particularly if these objectives are being tied explicitly to additional funding. More typically, the policy statements that are adopted by policy-making bodies are qualitative, comprising goals and priorities. Transportation agencies

can then translate these statements into quantitative objectives, in consultation with their policy-making bodies.

5.4.3 Policy Guidance and Funding That Are Not Performance-Based

Policy guidance and associated funding apportionments may not always reflect a performance basis. For example, legislative funding 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 current performance objectives or targets. (Refer to Section 5.5.1 for elaboration of these examples.) Institutional agreements with local or regional transportation organizations may result in agreed-upon funding splits that likewise may not reflect performance-based needs – or, if they are established with performance clearly in mind, are not reviewed and updated over time.

Situations such as these are realistically a fact of life. While they represent a different way of looking at transportation needs and priorities, they can nevertheless be made to work with performance-based methods. Some ways in which this can occur are as follows:

- To apply performance-based techniques within the existing policy framework or funding apportionment: i.e., to develop policy objectives, performance measures, and performance targets in the context of the existing political, institutional, and financial arrangements.
- To promote performance-based approaches with local and regional agencies that work with your DOT.
- To discuss transportation needs and priorities with other agencies to identify areas where strategic interests overlap, and to develop policy objectives and performance measures accounting for these.
- To conduct training, provide data support, and give other appropriate policy- and performance-related assistance to transportation agencies that provide services of state interest.

5.4.4 How May These Steps Help?

The steps suggested above can help close gaps and overcome pitfalls in policy formulation in the following ways:

- They provide a management structure and rationale to deal with broad, comprehensive, but vague policies (so-called "motherhood and apple pie" statements) that may enable agencies to gain widespread agreement, but do not provide concrete guidance for planning, programming, or budgeting. These statements need to be translated into policy objectives, together with definition of a consistent set of performance measures.
- They enable agencies to deal with policy guidance that does not reflect performance outcomes: e.g.,
  - Legislative or executive funding decisions that are not performance-driven;
  - Funding splits based purely on geography or history; or
  - Formula-based apportionments of funds that do not account for performance outcomes.

  Performance-based methods can be combined with the other criteria above to the degree that these other criteria cannot be changed directly.
- They provide a concrete basis to deal with internal guidelines or objectives that may not align with external policies. Again, policy objectives and target performance measures provide specific technical guidance that should be used to align internal guidelines in each affected department unit.

5.5 Playing a Proactive Role in Policy Formulation

Several situations described in previous sections call for active engagement by a transportation agency with policy-makers and other stakeholders. This section adds other examples to build a model of a proactive DOT role in policy formulation. The discussion is in two parts: one dealing with external policy-makers, the second with internal agency managers and staff.

5.5.1 EXTERNAL POLICY-MAKERS

Policy guidance can be issued in several ways. Previous sections discussed statutory and non-statutory policy statements at the state level provided by legislatures, the governor's office, and the transportation commission or board. Influences on policy also can originate with designated task forces, local and regional planning agencies, other transportation providers, and other bodies having political, administrative, fiscal, or regulatory oversight of a state DOT. A transportation agency needs to communicate with these groups to promote a policy framework that guides performance-based management, as described in earlier sections.

Legislative and executive priorities also can be expressed through funding decisions affecting specific asset classes or modes, program goals, or types of investments (e.g., preservation, system expansion or improvement, and operations). These decisions may not always follow the recommended program submitted by the DOT. For example:

- The legislature's decisions on funding transportation modes (e.g., highway, transit, bicycle and pedestrian ways) or assets (e.g., bridge seismic retrofit and pavement resurfacing) may result in amounts or schedules different from DOT recommendations.
- The governor's office or transportation commission may advocate funding for particular facilities (e.g., to support regional economic development); the legislature may include demonstration projects in the agency's budget likewise to achieve particular program goals.
- The legislature may fund particular highway programs in amounts or at a pace different from DOT recommendations, for experimental or demonstration purposes (e.g., to appropriate congestion relief funds among system expansion, system improvement, and system operations programs in specific ratios).

Texas DOT Briefing to Senate Interim Committee on Transportation

A Senate Interim Committee on Transportation was recently created in Texas and charged with, among other matters, reviewing the adequacy of the state's highway program and the financial resources supporting that program. The Texas Transportation Commission's testimony to the committee in 1998 is an example of proactively working with external policy-makers. The testimony emphasized long-term trends of factors such as traffic growth and safety, congestion levels and deteriorating road and bridge conditions. This information was presented as time-series data in concise graphics with clear messages. During presentation, this quantitative approach was complemented with anecdotes of specific instances designed to make the abstract data real.

The full testimony can be viewed in its entirety at: www.dot.state.tx.us/tdotnews/testimony/aug0498.htm

While funding decisions of this type are essentially expressions of policy, they also are decisions on resource allocation that are made outside a performance-based context. While legislative and executive authorities have this prerogative, DOTs need to deal with incorporating these decisions within an asset management framework that relies upon performance-based decisions. To the degree that designated programs, modes, asset classes, or investment categories are given statutory or funding priority, these areas of policy emphasis become a fixed part of an agency's asset management approach, and further decisions by the DOT must accommodate these policies.

The following sections outline strategies for an agency to focus policy-makers on policy guidance, and to reserve latitude for resource allocation decisions as much as possible to the DOT for deliberation during planning and priority programming.

ENGAGE EXTERNAL STAKEHOLDERS

Agencies ideally should engage their governing bodies whenever possible in discussions to frame and inform policy options. DOTs should communicate the implications of current asset conditions and current policies, and the costs and consequences of policy options. Regular briefings with policy-makers and dissemination of information to stakeholders and the public reinforce agency accountability for its decisions.

This engagement need not be limited to oral or written presentations. Agencies also can provide access to management systems for legislative, executive, and commission use. Executive Information Systems (EIS) that are based on the department's program management, financial, and technical data are excellent tools that can inform legislative, executive, and commission staffs regarding the department's programs and their status. (EIS are discussed further in Chapter 8.) Applications in maintenance quality assurance, based upon explicit levels of service and performance-based budgets, also have proven to be excellent tools for demonstrating the consequences of different levels of investment.

FOCUS ON KEY POLICY CHOICES

One potential benefit of asset management to DOT executives is to help avoid "external micromanagement" of programs during policy formulation. Asset management can be used to describe what responsibilities should be assumed by a policy-making body and by the transportation agency to have a policy-driven, performance-based approach work. It can be emphasized that policy-makers need to influence resource allocation at a strategic level. Tactical decisions on specific allocations will respond to these strategic directions (by meeting policy objectives), and the transportation agency is willing to be held accountable for these decisions (through performance measures). However, the specific decisions need to be examined in a number of dimensions (the asset management framework can be used to illustrate these), and the transportation agency needs to be staffed and equipped to carry out these analyses.

MAINTAIN A POLICY-BASED CONTEXT

An agency's engagement in policy development and its long-term perspective of asset management as a policy-driven process will help to maintain a policy-based context for resource allocation decisions. This continuity is needed through changes in political or agency executive leadership and during those periods when, in "the heat of the moment" as critical decisions are being deliberated, it is easy to lose sight of long-term objectives. An agency should continually reinforce and communicate the connection between long-term desired outcomes (as expressed in policy) and more immediate funding decisions (resource allocation) that is inherent in transportation asset management.

Policy direction may reflect other financial, institutional, and political considerations in addition to transportation system performance. This situation was discussed in Section 5.4.3, with practical suggestions on how to maintain a performance-based approach as much as possible.

5.5.2 INTERNAL STAKEHOLDERS

Internal stakeholders should be actively involved in the policy development process. Through their participation in this process, the units responsible for meeting policy objectives are more likely to understand DOT policies and support the subsequent objectives and targets. The involvement of front line workers from the very start of the policy-making process also may encourage them to begin considering a broader range of solutions to the issues they deal with on a daily basis.

The Benefits of Proactively Working with Legislators

Following is an example of one DOT's successful efforts to proactively work with policy-makers in two areas – system preservation and winter maintenance.

Preservation First

The DOT's key interaction with its legislature is through the legislative budget subcommittees that review and recommend approval of the agency's annual budget. Throughout the 1980s, the DOT worked with the subcommittees to establish the principle of "preservation first" – that preserving the existing system should have priority over creating new capacity.

The DOT's efforts were aided by the legislators' memories of the previous decade when the state had drifted away from this principle, with serious consequences for the condition of the highway network. However, it also was crucial to apply the principles of asset management (although it wasn't called that at the time) to present accurate life-cycle cost analysis that clearly demonstrated the economic benefits of the preservation priority. It also was important to consistently build this case year after year in a strategic context, rather than a one-time tactical approach to a particular budget.

The acid test for the preservation policy occurred in 1991, when a downturn in the economy and resulting curtailment of state revenues required the administration to stop advertising new projects at the peak of a major capital program. Many of these projects had been promised to the legislature and the general public as part of a transportation revenue program; deferral of these projects was thus a particularly sensitive issue. However, the general assembly had become advocates of the preservation-first philosophy, and the FY 1992/1993 budget reflected a 33 percent cut in capital programs and only a five percent reduction in maintenance.

Winter Maintenance

In the 1990s, the budget subcommittees questioned the DOT on whether contracting out additional winter maintenance services would result in cost savings. In responding to this inquiry, the DOT broadened the question into the larger issue of what was the appropriate level of the maintenance workforce, on the theory that winter maintenance requirements should be the primary basis for determining workforce size.

The DOT concluded that at least 50 percent of winter maintenance activity should be conducted by the maintenance workforce in dealing with an average peak storm (a snowfall of 6" – 8"), which suggested that a 10 percent cut in the size of the workforce could be accommodated. This analysis was based upon a combination of a quantitative review of snow clearance routes, a judgment as to what degree of presence was necessary to maintain operational control, and anecdotal evidence of the consequences of falling behind the curve in snow clearance in a major storm.

The budget subcommittees accepted this determination, and the workforce and winter maintenance policies were adjusted accordingly.

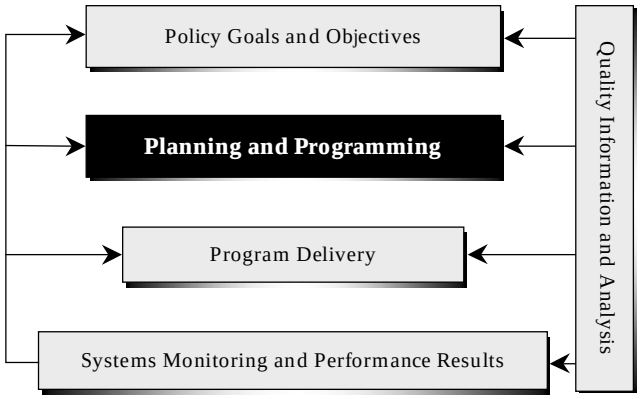
6. PLANNING AND PROGRAMMING

6.1 INTRODUCTION

Long-range transportation planning and priority programming are central to an agency's resource allocation decisions. This chapter discusses ***Planning and Programming*** as the second broadly defined stage in the asset management framework (Figure 6.1). It focuses on functions that lead up to program approval. Subsequent functions involved with program delivery are addressed in Chapter 7.

- **Section 6.2** discusses long-range planning in the context of asset management.
- **Section 6.3** is the first of three sections dealing with program development. It focuses on capital programming processes and tradeoff analyses.
- **Section 6.4** looks at the role of program structure and its effect on capital program development in an asset management framework.
- **Section 6.5** considers program development for maintenance and operations.

Figure 6.1 Planning and Programming within Resource Allocation and Utilization



State DOTs perform long-range planning and priority programming in accordance with ISTEA and TEA-21[1] requirements for the production of Long-Range Transportation Plans (LRTP) and Statewide Transportation Improvement Programs (STIP). The intent of this chapter is to illustrate how your agency's LRTP and STIP procedures can be strengthened from an asset-management perspective. It provides suggestions and examples of how planning and programming relate to the policy guidance described in Chapter 5, and how business processes and the program structure used in planning and programming are best organized for good asset management.

Your agency's existing procedures for developing the LRTP and the STIP are not "replaced by asset management"; the steps recommended in this chapter do not constitute another new or alternate process. The material in this chapter does not attempt to serve as a primer on planning and programming. The focus of this chapter is on how asset management ideas, principles, and techniques can shape your existing LRTP and STIP procedures, emphasizing capabilities such as the following:

- Applying procedures and decision criteria that are consistent with policy objectives and performance measures;
- Identifying alternative solutions at the planning and programming stages; and
- Having the information and analytic capabilities needed to evaluate alternatives and make resource allocation decisions that conform to good asset management practice.

6.2 LONG-RANGE PLANNING

A number of asset-management best practices apply to your long-range-planning process, regardless of whether your agency produces a "policy-based plan" or a "project-based plan." These benchmarks can be organized in three broad topic areas that are discussed in the sections below:

- Providing long-range guidance to agency resource allocation that is consistent with policy objectives;
- Identifying and evaluating strategic investment choices and analyzing tradeoffs between them; and
- Having the information and analytic tools available to conduct the analyses implied by a performance-based process.

6.2.1 CONSISTENCY WITH POLICY OBJECTIVES

The methods and criteria that are used in long-range planning need to reflect stated policy objectives and

[1] Intermodal Surface Transportation Efficiency Act, and Transportation Equity Act for the 21st Century.

performance measures. Inability to translate policies into performance targets can hinder an agency's ability to bring planning procedures into line with strategic priorities. A failure to achieve consistency with policy direction at the planning stage will likely have a ripple effect in subsequent stages of resource allocation. There are both strategic and tactical aspects to providing a coherent and systematic approach to resource allocation.

STRATEGIC CONSIDERATIONS

Strategic considerations deal with a meaningful translation of policy into action. They enable you to define investment options for consideration at the long-range planning stage that reflect and respond to strategic policy guidance.[2] In practical terms:

- Policy statements and other broad forms of policy guidance need to be translated into specific policy objectives, quantitatively to the extent possible. If this step has not been accomplished as part of your agency's review of transportation policy or in its strategic business planning, it needs to be completed at the start of long-range planning.
- Definitions of performance measures should accompany policy objectives that will guide transportation investments in each mode, program, major asset class, or other significant aspect of your transportation program. The selected measures should be able to reflect customer perceptions of system performance and quality of service where appropriate. Multiple measures may be needed to reflect different policies or to help understand what factors are driving changes in transportation trends. For example, measures reflecting both travel delay/congestion effects and impacts on economic development may be needed to assess investment options in mobility and accessibility. Performance measures should gauge outcomes in the transportation system rather than types of investments.[3] If performance measures have not already been defined in your agency's review of policy guidance or in its strategic business planning, they should be established at the start of long-range planning.
- Target values of performance measures should be established to guide the options to be considered in long-range planning. Performance targets should be realistic to avoid false expectations among external stakeholders and lack of sound direction to internal stakeholders. Targets should reflect realistic projections of revenues; scenario analyses of different revenue forecasts can provide useful guidance on the range of target values that can be attained with confidence. A continuing inability to meet targets and policy objectives can discredit your planning process and reduce the credibility of the LRTP itself if the plan cannot achieve the intended goals.
- Policy objectives and performance targets need to be tempered by other guidance that is not derived from performance-based considerations. This additional guidance, which was discussed in Sections 5.4.3 and 5.5.1, needs to be carried through the long-range-planning function as well (and into capital programming, as discussed in Section 6.3). The effect of this guidance can be accounted for in an adjustment in policy objectives and targets among programs or districts, or it may influence the type and expense of investments considered in different parts of a program.

TACTICAL CONSIDERATIONS

Tactical considerations deal with more specific issues in translating policy into action:

- In setting performance targets for particular assets, modes, corridors, programs, etc., your agency also should account for sources that provide specific guidance (e.g., in the form of recommended standards or levels of development) or explore different strategies for investment. Level-of-development plans, corridor plans, corridor preservation plans, access plans, special studies (e.g., of future transportation strategies or of long-term needs) and similar documents are examples of sources of guidance that may be focused on particular subsets of the transportation network. It also is important that all levels of your agency – field planning offices as well as central office staff – be aware of these studies

[2] Please review Section 5.3.2 on translating policy into process, and Section 5.4 on relating policy to performance, if you have not already done so.

[3] Refer to discussion of this point in Section 5.3.1.

and understand how they are to be used in the planning process.

Program Investment Categories

Colorado DOT has defined Program Investment Categories to facilitate a performance-based environment for its planning and programming activities. Its Program Investment Categories include:

- *Strategic Projects;*
- *Mobility;*
- *System Quality;*
- *Safety; and*
- *Program Delivery.*

Important characteristics of these Investment Categories are the following:

- *The Investment Categories overlay the conventional program structure; they do not replace the programs used for funding and tracking accomplishment by different organizational units.*
- *The Investment Categories map directly to transportation policy goals and performance measures.*
- *Investment Categories include projected funding from both capital construction programs and maintenance and operations programs.*
- *Conventional program funds are applied in the Investment Category structure according to primary policy objective served. For example, preservation activities in Maintenance and Operations map to System Quality; sign and striping activities in Maintenance and Operations map to Safety; and snow removal performed by Maintenance and Operations maps to Mobility.*
- *Investment Categories help CDOT to see what funding is available to meet strategic policy goals and to relate investment levels to performance measures, regardless of program funding source. The Investment Category structure also is suitable to be applied in the future to tradeoff analyses.*

- Existing policies may call for environmental reviews or other long-lead-time assessments of project characteristics. Criteria and procedures should be established to determine when these reviews or assessments need to begin in the planning stage.
- The results of the planning stage should inform project identification during priority programming. The nature of this guidance should be agreed to by the planning and the capital programming units within your agency, so that a consistent thread is maintained throughout these stages of resource allocation.

6.2.2 ALTERNATIVES AND TRADEOFFS

Investment alternatives are appropriately defined in long-range planning as well as in priority programming. Options at the planning stage may involve a number of different choices as illustrated below. The specific options that you may need to consider will depend upon the structure of your agency's programs and its responsibilities for different modes and infrastructure assets, the characteristics of your transportation system, and the areas of emphasis in current policy objectives. Potential options in planning include the following:

- **Modal Options**. Choices between modes may be direct and obvious when both modes fall under the responsibility of your DOT. Defining alternatives becomes more complicated when the solution is an indirect one (e.g., highway congestion will be relieved by an improvement to a parallel rail line or transit line), where service providers other than the DOT are involved, and where funding eligibility guidelines may preclude consideration of this option. Engaging policy-makers, service providers, and other stakeholders can identify options that might be available.
- **Program Investment Options**. With increasing demands on transportation programs and funding, alternatives in the types of investments may offer an option to meet transportation needs more quickly and economically. In the mobility area, for example, investments in operations improvements may defer the need to undertake new construction for capacity expansion. In the preservation area, preventive maintenance strategies can reduce the long-term cost of keeping facilities in good condition as compared to capital-intensive, worst-first approaches.
- **Other Options**. Other ways of visualizing options include corridor alternatives (already familiar to transportation planners), staged implementation strategies, technological options (e.g., use of innovative materials and procedures for preservation, or ITS technologies for traffic

management), and combinations of all of the above.

Multimodal Trust Funds

The use of multimodal trust funds can provide agencies the flexibility to meet varying transportation service and infrastructure needs. For example, in the early 1970s one DOT established an integrated trust fund to support all of its activities, which include modal agency operations, capital construction projects, and debt service expenses for highways, transit, ports, airports, railroads, and motor vehicles.

This fund consists of motor fuel taxes, motor vehicle excise (titling) taxes, motor vehicle fees (registrations, licenses, and other fees), corporate income taxes, operating revenues (e.g., airport fees, transit fares, port fees), federal aid, and bond proceeds. Bonds are issued to support the cash flow requirements of the planned capital program while maintaining coverage requirements.

These revenues are not earmarked for specific programs. The disbursement of funds to projects and programs is made in conjunction with state- and local-elected officials and is not constrained by the source of revenues. Unexpended funds at the close of the fiscal year do not revert to the state's General Fund, but remain in the Trust Fund.

This financing structure encourages optimization of the transportation system without regard to modal bias. As a result, the agency has been in a position to analyze and pursue modal tradeoffs and intermodal opportunities. One illustration is an aggressive program to provide direct-access connections from the freeway network to suburban rail stations with large parking lots. A common funding source and a strategic, customer-focused approach to asset management has enabled these projects to avoid the institutional rivalries that often handicap such intermodal proposals.

Options should be given due consideration appropriate to their importance and cost, avoiding too early a focus on a single solution. Failing to consider feasible options across programs, modes, or other dimensions may lead to missed opportunities and less than "optimal" LRTPs. Support information that may be needed to evaluate options effectively (e.g., early "scoping" studies to evaluate technical, economic, and financial feasibility, or environmental reviews of potentially complex projects) may need to be developed at an early planning stage.

Options can address needs at a project, corridor, or "major project" level (e.g., a project of statewide interest that may comprise multiple network segments from different but related corridors). Evaluations of these options should be "apples to apples" – that is, project alternatives compared to each other, corridor alternatives compared to each other, and so forth.

Options need to be evaluated against one another in a planning-level tradeoff analysis. One of the main considerations in planning-level tradeoffs is the availability of analytic tools; this issue will be discussed in the next section. In the context of this discussion, tradeoffs should identify the comparative costs, benefits, and performance impacts of different options in a life-cycle context. The tradeoff results should indicate the relative strengths and weaknesses of each option, and which option overall presents the best balance of characteristics for your agency. A tradeoff analysis also may suggest other options for investigation.

6.2.3 Information and Analytic Methods

Good information in long-range planning can assist in a number of ways to support good asset management practice:

- Performance targets need to be realistic both technically and financially, based upon realistic forecasts of revenue. Unrealistic performance targets can call into question the long-range-planning process and its products.
- Estimates of costs, benefits, and performance used in the analyses of options and tradeoffs should reflect realistic technical, economic, financial, and environmental characteristics. Lack of good information in these estimates can limit the effectiveness of planning in evaluating the relative merits of different options and in the guidance given to priority programming. Existing applications such as management systems (e.g., PMS, BMS) and other analytic procedures (e.g., network models, economic impact models) can assist in these estimates.
- Criteria for early scoping, environmental reviews, and other pre-engineering studies that may need to begin during planning (e.g., for major, complex, long-lead-time projects) can clarify information needs at various timeframes in the 20-year planning horizon and focus the application of different analytic tools properly.

Analytic tools and well-organized data collection and processing techniques could assist in providing the

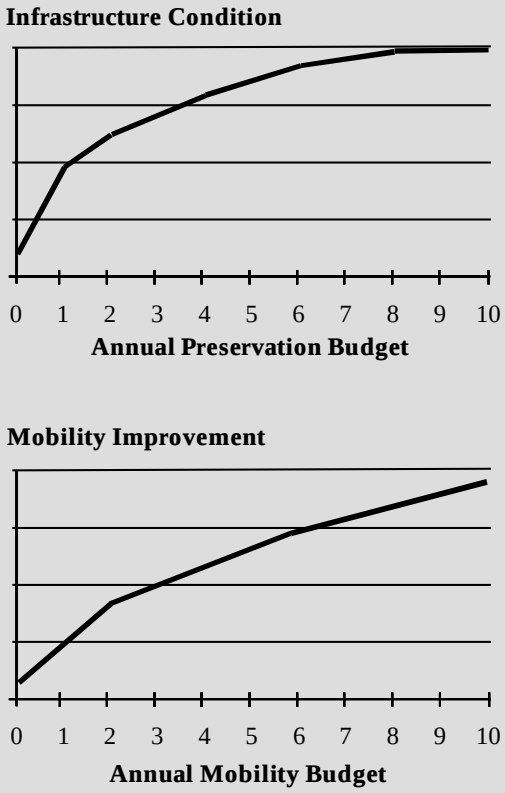
information needed to evaluate performance targets as well as planning options. While DOT planning organizations already apply IT applications to evaluate travel demand and the network impacts of different proposed investments, tools to consider a broader set of options, performance impacts, and tradeoffs – for example, in a multimodal context – are still in a state of development, and data quality remains an issue as well. A number of current efforts promise improvement in the state-of-practice in the future:

- Development of sketch planning tools that enable an analysis of options that is relatively quick, inexpensive, and not too data-intensive.
- Application of FHWA's HERS/ST system to look at preservation versus improvement tradeoffs.
- Work in NCHRP Project 8-32A to develop a methodology for structuring and evaluating multimodal tradeoffs at the planning stage.
- New analytic procedures and recommended approaches may emerge from the ongoing NCHRP Project 20-57 that is looking at analytic tools that support asset management.

Tradeoff Analysis

Figure 6.2 illustrates information that can be used for a tradeoff analysis in long-range planning. The analysis considers the impact of varying the funding levels in two programs: Preservation and Improvement. The upper graph shows the impact of different Preservation budget levels on forecast infrastructure condition; the lower graph shows the impact of different Improvement budget levels on forecast mobility improvements. These graphs can help an agency understand the implications of different investment options, frame planning-level tradeoffs, and illustrate the consequences of planning-level decisions. While the example is developed for two programs, other programs, as well as more detailed breakdowns of the programs shown, can be considered in the tradeoff process. Management systems, other analytic tools, and analyses of performance impacts of similar investments can assist in obtaining these estimates.

Figure 6.2 Example of Information for Use in a Planning Tradeoff Analysis



At a minimum, there is benefit to be gained from structuring existing information in a way that informs tradeoffs: i.e., by organizing information based upon a baseline analysis and scenarios representing different performance targets or investment options. Scenario-testing capabilities, if available in existing systems, should be used to populate this matrix. If such capabilities are not available as a feature, it may be possible to use existing applications to test scenarios indirectly – for example, by exercising these systems repetitively while varying boundary conditions (such as engineering threshold values or financial budget constraints) in each run to assess system behavior and performance impacts under different conditions.

6.2.4 How May These Steps Help?

The recommendations in the preceding sections are intended to help your agency instill in its long-range planning a number of asset-management best practices:

- Planning efforts reflect stated policy objectives and performance expectations.
- A range of investment options (e.g., capital, maintenance, and operations) and modal alternatives are considered during the planning process, with an analysis of tradeoffs among these choices.
- The LRTP is based on realistic revenue forecasts and evaluation of new funding options or levels of funding where appropriate.
- The planning process provides clear guidance for subsequent program development (e.g., project identification, ranking, and selection).
- The planning process is supported by management systems, "sketch planning" tools, and other analytic procedures that help analyze options and scenarios in terms of cost and performance.

6.3 Capital Programming Process

6.3.1 Overall Context of Program Development

Program development is the stage of resource allocation that recommends specific investment actions, whether for capital construction projects, preventive or corrective maintenance activities, or maintenance and operations services. Asset management speaks to several aspects of program development. This is particularly true for capital construction programming[4], which typically accounts for a major portion of a state DOT's annual budget, and corresponds to the production of its STIP.

The discussion of this critical function and other aspects of program development is therefore organized in the ***Guide*** as follows:

- Section 6.3 focuses on the capital programming process, and how asset management concepts and principles apply to identification and selection of projects for infrastructure preservation, expansion, operations, and safety.
- Section 6.4 also focuses on capital programming, but from the perspective of the program structure and how different organizations of programs and categories of work can influence the ease and effectiveness with which you can apply asset management techniques.
- Section 6.5 discusses program development for maintenance and operations work, dealing with delivery of services as opposed to construction projects. Current concepts of maintenance quality assurance and performance-based budgeting are highly relevant to asset management, and are covered in this section.

6.3.2 Capital Programming Best Practices

Best practices in capital programming follow many of the themes outlined in policy formulation and long-range planning:

- Policy objectives are explicitly represented in methods and criteria applied in capital programming:
  - Project identification, scoping, prioritization, and selection criteria;
  - System performance measures, and predictions of the impacts of candidate project investments on these performance measures;

[4] Priority programming is also used synonymously in this ***Guide***.

  - Program tradeoff criteria; and
  - Periodic updates of programming process to reflect and reinforce changes in policy.

- The programming process considers alternative project solutions to transportation needs, problems, and deficiencies, consistent with program objectives and guidance from the LRTP. Examples include the following:
  - Solutions representing different types of investments: e.g., operations versus capacity improvements to congested segments; repair versus rehabilitation or reconstruction;
  - Different project concepts, designs; or technologies; and
  - Different strategies for staging work over time.
- Economic principles are applied to the analysis of project worth. At the heart of each analysis is a comparison of benefits and costs on a life-cycle basis and, where applicable, minimization of long-term costs. Cost/benefit calculations incorporate performance measures within a performance-based budgeting framework.
- While the economic criterion is important, it is not the sole basis for selecting projects. Other factors also may be considered: e.g., environmental protection, intermodal service, network connectivity, neighborhood cohesion, preservation of corridor standards, and economic necessity.
- Project selection is based on realistic project scopes, costs, and schedules. Accurate estimates ensure that project prioritization is based on reliable gauges of project merit, and reduce the likelihood of subsequent project changes that may result in "non-optimal" adjustments to programs.
- The programming process considers alternative solutions also at the program level in terms of tradeoffs analyzing potential shifts in funding among programs and their implications for overall transportation system performance.
- Quality information and analytical tools are applied throughout the programming process. An agency has the capability to project realistic estimates of costs, benefits, and impacts on system performance using management systems, other analytic tools, activity-based approaches to cost recording, and performance budgeting tools.

Washington State Life-Cycle Techniques

In 1993, state legislation RCW 47.05 mandated revisions to the Washington State DOT's programming process. This legislation required the agency to prioritize projects based upon rational methods, considering factual needs and an evaluation of life-cycle benefits and costs. In response, WSDOT developed a programming process based on project prioritization using benefit/cost criteria. WSDOT applied its existing pavement management system to analyze least-life-cycle-cost strategies for pavement preservation. In other program areas it formed task forces to develop evaluation procedures based upon engineering and economic criteria appropriate to each type of project work considered. These analytic procedures are now used to develop benefit-cost estimates for project prioritization.

For further information, RCW 47.05 is available on the following web site:

search.leg.wa.gov/pub/textsearch/ViewRoot.asp?Action=Html&Item=7&X=726112422&p=1

The "Washington State DOT Programming and Operations Manual" is available at:

www.wsdot.wa.gov/FASC/EngineeringPublications/Manuals/P_OManual.pdf

6.3.3 EXAMPLE PROCESS INCORPORATING BEST PRACTICES

The best practices described in the preceding section can be incorporated within your existing capital programming and STIP development framework. The following example process comprises a cycle of program development steps that reflects the best practices above. This process is not meant to be prescriptive or exhaustive, and your existing process may have a different sequence of steps or reflect a different approach.[5] This example is included only to show how program development can be organized in an asset management framework, illustrating both project-level and program-level decisions. The steps are presented in sequential fashion for simplicity; however, iterations of individual steps may occur in

[5] For example, certain DOTs allocate funding to districts for programs based on policy and system performance rather than projects, as illustrated in the example given. Thus, a range of programming approaches are possible. The principles of asset management should nevertheless apply across this range.

practice. Your agency can adapt this example to your own capital programming and STIP development process in considering asset management best practices.

1. **Issue program guidance and instructions**. Program guidance contains a summary of policy goals and objectives and their implications for financial and performance targets. Program instructions contain financial, accounting, and administrative details that need to be adhered to in the current programming cycle.

2. **Nominate and submit candidate projects**. Nominations are typically submitted by program managers, district engineers, and other designated managers on behalf of stakeholders.

- Project submittals are guided by the LRTP and by other relevant studies (e.g., analyses of preservation strategies in pavement or bridge management; corridor studies or special planning studies).
- Nominations are conducted in a formal process using forms that provide, at a minimum, the description of proposed work and its justification, proposed funding source, estimated cost, calculated impact on performance, local support, and special considerations.
- The preferred measures of performance impacts are 1) technical performance measure(s) that are associated with the respective program and are responsive to policy objectives, and 2) translation of technical impacts into an economic benefit if possible. Advantages of a monetary measure of benefits are that:
  - They can be used in benefit/cost calculations as part of project prioritization;
  - Dollar benefits are additive (meaning that they can be summed for all projects to obtain a program-level indicator useful in tradeoff analyses); and
  - They are commensurate with dollar benefits calculated for other programs (even if the technical performance measures are different), facilitating tradeoff analyses further.

3. **Candidate projects are reviewed with district engineers and program managers.** These reviews are conducted in meetings held by the management team responsible for building the capital program. Items to be reviewed include:

- Realism of estimates of costs, benefits, and other impacts;
- Appropriateness of the project for the route's Level of Development Plan and consistency with relevant preservation, corridor, or other special studies;
- Eligibility for indicated program funding;
- Conformity with guidelines and instructions;
- Degree of local support; and
- Suggested revisions.

As part of these discussions, district and program managers can be asked what their responses would be to shifts in funding for the program being reviewed: i.e., if some percentage change in funding occurred at the margin, either positive or negative, what additional work would they recommend, or what proposed projects would need to be cut or reduced in scope? These discussions provide background information for the tradeoff analyses later.

4. **Projects are scoped and prioritized.** Prioritization methods and criteria should reflect a performance basis, consistent with policy objectives and performance measures as updated in the current LRTP. Prioritization will result in a list of ranked projects that are reviewed and may be adjusted as follows:

- A preliminary "cutoff" is set on the ranked list of projects based upon preliminary funding targets for each program. This constrained list defines a preliminary, baseline, or candidate program.
- Managers may adjust the prioritized list where justified to reflect considerations such as network continuity, local commitments, or factors that are not accounted for in the prioritization criteria. Such adjustments and their justification should be documented.
- The ranked project list may need to conform to geographic equity criteria, which may require further adjustments in the prioritized list and should be documented as such. (See Section 6.3.5 for a discussion of geographic equity.)

Project priorities should not be taken as literal numerical values (i.e., in the sense that "project number 17 is better than project number 21"), but rather as

a way of grouping projects into sets: e.g., highly ranked projects that will be performed in any foreseeable scenario, mid-range projects that are worthwhile and have a good chance of funding, and lower-ranked projects that have merit but for which approval will be sensitive to the results of a tradeoff analysis.

If, subsequently, there are major changes in project scope, cost, or schedule, the project should be reprioritized (discussed below).

5. **Conduct tradeoff analyses between programs.** The purpose of a tradeoff analysis is to assess whether preliminary program funding targets should be adjusted based upon the cost and performance impacts indicated in the tradeoff. It is a way to consider options (in terms of financial targets) at a program, rather than a project, level. An example of the mechanism of tradeoff analyses will be given in Section 6.3.4. Tradeoffs do not have to be conducted among all possible combinations of programs, but rather only where it makes sense to consider potential shifts in funding from one program to another. Tradeoff analyses between programs should be conducted only after the projects within those programs have been prioritized and a preliminary financial target (or cutoff) has been established.

While management systems and other analytic tools can be used to estimate the performance impacts of different alternatives, ultimately the judgment regarding program tradeoffs is a managerial one in which policy objectives must be weighed as a guide to the final decision. Where program tradeoffs are indicated and a shift in program funding is likely, the question of geographic equity may need to be revisited, and adjustments in the proposed funding shift made accordingly.

6. **Finalize program funding targets based upon the tradeoff analyses.** The cumulative set of analyses and adjustments in the preceding step result in a revised funding distribution that can now be finalized. Results of the tradeoff analyses and judgments based on these results should be documented for possible later use in discussions with the Transportation Board and Legislature to justify the recommended program.

Unless there are any further adjustments, this final funding distribution can be submitted, with the adjusted list of prioritized projects in each subprogram, as the recommended capital construction program. If last-minute adjustments do occur:

- Tradeoff analyses would need to be repeated only if there are major changes in specific projects that are included in the recommended program, or in the information regarding particular projects (e.g., costs, benefits, performance impacts).
- If the situation above occurs, the tradeoff analysis should be preceded by a re-estimate of costs, benefits, and performance impacts of affected projects and a re-prioritization of projects in the affected program.

7. **Conclude this programming cycle and prepare for the next cycle.** Concluding activities entail submittal of the recommended program, distribution of the program to stakeholders as appropriate, and any associated updates to program tracking databases. Preparations for the next cycle include updates to the program guidance and instructions, based upon experience of the just-completed exercise.

6.3.4 TRADEOFF ANALYSES

Tradeoff analyses are ways to consider alternative resource allocations at a program level, as compared to the project-to-project evaluations that result from project prioritization. Table 6.1 illustrates the types of tradeoffs that can be considered between different combinations of program investments. Results of an example tradeoff analysis are illustrated in Table 6.2 for Preservation and Improvement. The analysis involves testing what are the consequences of shifting funding from one program to another, and making a judgment as to which resource allocation option is the most favorable. Consequences are gauged by resulting changes in performance measures. The performance measures in Table 6.2 are generalized for purposes of the example; in an actual analysis, it may be helpful to compute one or more performance measures for each subprogram considered (e.g., in Preservation, to consider separate performance measures for pavement, structures, and other features; and for Improvement, to consider measures related to mobility, accessibility, safety, and so forth). For the analysis to work, performance measures must be able to be expressed at a program as well as a project level: i.e., they must be additive (e.g., measures of user costs or benefits that result from economic analyses of projects) or be able to be rolled up as an average or other composite measure (e.g., percentage of facilities that meet a threshold value). An agency's management systems (such as PMS and BMS) can contribute to

tradeoff analyses through their scenario-testing capabilities. Tools such as the FHWA's HERS/ST can assist in tradeoff analyses across programs, since HERS/ST handles both pavement- and capacity-related investments. Analytic tools for subprograms not addressed by existing systems can be developed in simple formats (e.g., as spreadsheet workbooks or database applications) to provide a near-term capability for tradeoff analyses.

Table 6.2 shows two tradeoff cycles for illustration; any number may be conducted as determined by managers in light of results already obtained and whether it is worthwhile to explore additional options. The examples in Table 6.2 show shifts of funds in both directions; other options could investigate different magnitudes of a funding shift. While the analysis shown assumes that total funding remains fixed, this type of analysis also can be used to investigate the consequences of changed levels of funding, whether positive or negative.

Preservation versus Improvement Tradeoffs

The FHWA's Highway Economic Requirements System (HERS) is an example of a tool that supports tradeoffs between preservation and improvement projects. A state version, HERS/ST, is now being promoted. The HERS application is based on the Highway Performance Monitoring System (HPMS) database, and is intended to replace HPMS as the source of biennial federal needs studies submitted to Congress. The HERS algorithms address both highway capacity and pavement preservation needs. Thus, HERS/ST is uniquely suited to asset management studies that are more comprehensive than those addressed by individual management systems (e.g., pavement management and congestion management). For example, HERS/ST could be applied to explore tradeoffs between system preservation and system improvement or expansion.

Table 6.1 Examples of Potential Tradeoffs between Types of Program Investments

	Capital Preservation and Maintenance	System Improvement and Expansion	System Operations
Capital Preservation and Maintenance	➢ Capital-maintenance tradeoffs ➢ Worst-first verses preventive strategies	–	–
System Improvement and Expansion	➢ Tradeoffs between preservation and capacity	➢ Major versus minor capacity and safety improvements	–
System Operations	➢ Tradeoffs among methods of incident response and motorist warnings	➢ Tradeoffs between roadway and technology approaches	➢ Degree of system coordination in corridors and network

6.3.5 GEOGRAPHIC EQUITY

Geographic-based, or "equity-based," funding distributions exist in many agencies and are a political fact of life. The rationale for such distributions may come from several sources:

- Agreements on funding splits with regional and local agencies;
- "Hold harmless" arrangements with regions or districts of a DOT;
- Responses to environmental justice issues regarding the equitable distribution of transportation services to different segments of the population;
- Legislative or transportation board/commission desires for equity statewide; and
- Historical, formula-based arrangements.

Capital-Maintenance Tradeoffs for Pavements

Specialized pavement analysis tools can analyze capital-maintenance tradeoffs and preventive, corrective, and deferred maintenance and rehabilitation strategies as they apply to pavements. The FHWA's EAROMAR system is one such tool. The system is used by the FHWA to conduct pavement life-cycle cost analyses on high-standard roads. EAROMAR has engineering and economic relationships to analyze different types of pavement maintenance, rehabilitation, and reconstruction options and their impacts on both agency costs and user costs. Because it employs a detailed analysis of work zones and their effects on traffic flow and congestion, it also can be used to investigate the staging of projects and the effects of construction or maintenance work packaging, as well as options to limit road occupancy to particular hours of the day or to particular months or seasons of the year.

Reference for additional information: Markow, M.J., and B.D. Brademeyer, ***EAROMAR Version 2, Final Technical Report****, FHWA/RD-82/086, April 1984.*

While geographic distributions and performance-based concepts are different ways of looking at resource allocation, they can be made to work together in a manner that is still consistent with a performance-based approach in asset management. The recommended approach is to maintain a performance-based context for resource allocation and utilization as much as possible, but to acknowledge and articulate the geographic distributions explicitly rather than to "bury" or rationalize them.

Examples of ways to accommodate geographic equity within a performance-based context are as follows:

- Apply a "dual" or "hybrid" method of resource allocation by program. For example, a percentage of funds may be allocated to districts on a geographic basis for district-level prioritization; the remaining program funds may be allocated based upon statewide competition among projects. The district percentages may vary by program.
- Apply performance-based evaluation methods within geographic allocations. While the overall funding split may be geographically based, the evaluation of projects within programs will be according to policy objectives, performance measures, and associated criteria.
- Use selected performance indicators as surrogates for geographic allocation. For example, measures of traffic volume or user benefits could be used in lieu of geographic percentage allocations. The methodology would need to be designed, however, to ensure that rural projects could compete with urban projects fairly (e.g., by calculating an incremental benefit/cost return rather than looking simply at total magnitudes of benefits).

Table 6.2 Illustration of a Tradeoff Analysis

	Proposed Preservation Funding and *Resulting Performance*	**Proposed Improvement Funding and *Resulting Performance***
Baseline	$200 million *80% of facilities rated Good*	$500 million *10% reduction in travel time costs*
First Tradeoff Analysis	($200M less $15M) = $185 million *77% of facilities rated Good*	($500M plus $15M) = $515 million *11% reduction in travel time costs*
Second Tradeoff Analysis	($200M plus $15M) = $215 million *82% of facilities rated Good*	($500M less $15M) = $485 million *8% reduction in travel time costs*

6.4 PROGRAM STRUCTURE AND DEFINITION

The effectiveness of resource allocation can be influenced by the structure of the capital program itself. Typical pitfalls that can arise include the following:

- Programs and subprograms may be too numerous and detailed to clearly see the implications of choices and decisions.
- Programs and subprograms that represent too fine a breakdown of work, overlapping definitions, or outdated transportation needs can distort the resource allocation process, since zero-funding a program is rarely seen as an option, and non-optimal allocations may result.
- Inconsistent methods of defining programs can obscure the linkage between resource allocation decisions and support of policy objectives.

The first two issues relate to program structure and its relative simplicity. The third issue is one of consistent definition.

6.4.1 STREAMLINING PROGRAM STRUCTURE

Flexibility and latitude in resource allocation are increased when the program structure is "streamlined" to focus on key outcomes, however defined (Section 6.4.2). A "streamlined" program structure in this context implies a "pyramid" structure in which high-level programs and subprograms are as few in number and as broad in scope as practicable to manage the capital program effectively. Identification of specific types or categories of work at the lowest level can be as detailed as needed for financial management and accounting; it is the higher-level structure of programs and subprograms that is critical to resource allocation and tradeoff analyses.

Consider the examples presented in Figures 6.3 and 6.4. Assume that Figure 6.3 represents a DOT's current program structure. For clarity, a single program within a capital program structure is shown; in fact, multiple programs will typically exist (e.g., preservation, improvement, safety). Figure 6.4 recommends a new more streamlined program structure for the DOT. Since both structures encompass the same categories of work, shown at the bottom in both figures, they are both capable of addressing the same pool of projects. However, the new structure in Figure 6.4 has fewer subprograms than Figure 6.3, creating different relationships among programs, subprograms, and categories of work. To generalize: Figure 6.4 represents more of a pyramid structure with fewer subprograms but with each subprogram more broadly defined, encompassing multiple categories of work. Figure 6.3 shows a flatter structure in which there are a greater number of subprograms, each more specialized in a narrower category of work.

Figure 6.4 represents a more streamlined program structure that can help in resource allocation. Since this structure does not restrict managers to a narrow category of work within a subprogram, it facilitates their consideration of alternative solutions in each case. It also affords managers greater opportunity to consider resource allocations between multiple categories of work within each subprogram. It enables managers to consider tradeoffs between broadly defined subprograms, clarifying decisions among critical policy choices. While the examples in Figures 6.3 and 6.4 center on subprograms, the same ideas hold for programs within the overall capital program structure.

This comparison should not be misconstrued as arguing against needed distinctions in types of work at the subprogram (or even the program) level. All it implies is that details regarding the many possible types of capital projects should not be pushed up too high in the program structure so as to impede definition of alternatives, tradeoff analyses, and relating investment decisions to broad policy objectives. To cite a couple practical implications of this thought:

- A preservation program could include individual subprograms for pavements and structures, without detracting from resource allocation decisions and estimates of performance impacts. However, treating distinctions between, say, rigid and flexible pavement projects, or Superpave versus conventional pavement projects, at too high a level in the program structure dilutes the impact of pavement investments and complicates tracking of pavement performance as a function of resource allocation decisions.

Figure 6.3 Original Program Structure

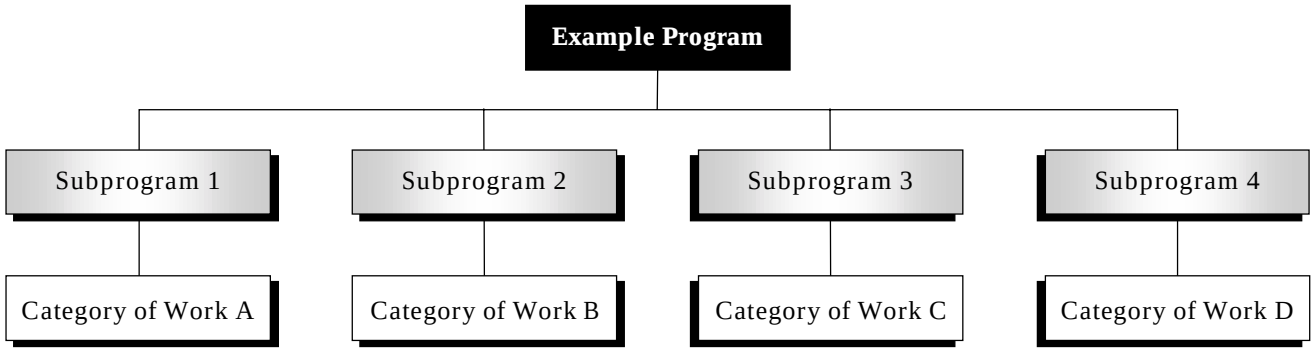
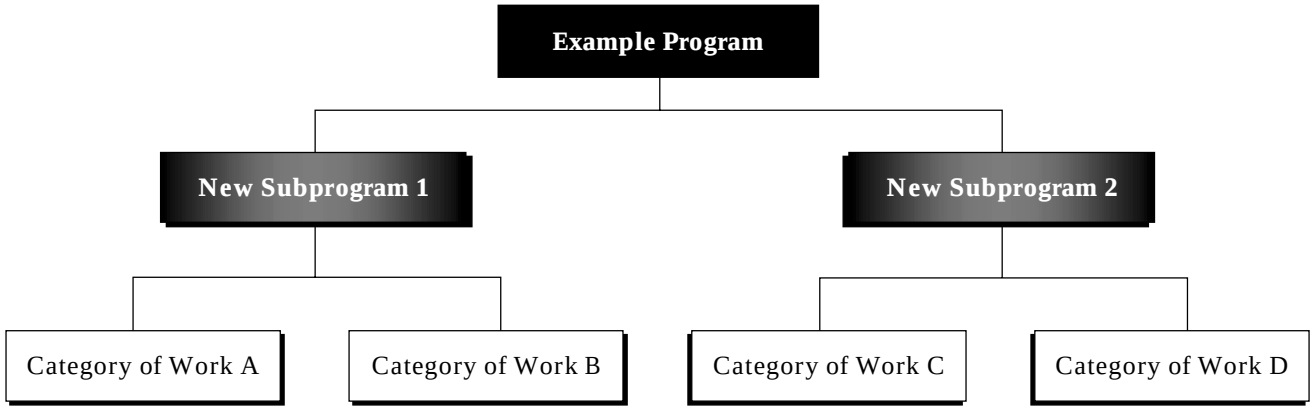


Figure 6.4 New, More Streamlined Program Structure



An improvement program could include individual subprograms for mobility and safety, and even a broad breakdown of mobility-related work at this level. However, treating distinctions among various types of capacity and operations improvements (e.g., turning lanes, climbing lanes, signalization improvements, variable message signs, etc.) at too high a level in the program structure has the same shortcoming as discussed above for preservation.

Figures 6.3 and 6.4 are schematic – they should be interpreted in terms of the different structures they represent, not in the literal number of programs, subprograms, and categories of work shown. Also, they need to be understood in context. If your DOT refers to what are called "programs" in these figures as, say, "capital program categories," and your "programs" correspond to what are labeled "subprograms" in these figures, then the nomenclature in this discussion must be adjusted and interpreted accordingly. While this example is schematic, it nonetheless illustrates the advantages of a streamlined program structure:

- Managers can be more flexible in crafting alternative approaches for solving problems within a broad arena, rather than being unduly constrained by a large number of narrow, predefined subprograms.
- There is less tendency with a streamlined structure to dilute available funding across a large number of subprograms, and there is less risk that these many subprograms will result in non-optimal uses of scarce funds.
- A streamlined program structure facilitates comparison and evaluation of competing solutions, program tradeoffs, and reporting of performance results, but can still accommodate a variety of types of projects.
- A streamlined program structure helps to visualize and communicate the composition and

rationale of the transportation program. Properly structured, it also helps to identify how the transportation program is meeting stated policy objectives by focusing on the outcomes of broad program categories, rather than narrowly defined differences among types of projects.

- Other considerations can be "overlaid" on the program structure used for resource allocation if more detail is needed for other reasons such as the following:
  - Financial management of different "pots" or "colors" of money and related project eligibility requirements;
  - Need for geographic or equity-based distributions; and
  - Statutory or management reports that require a different reporting structure.

6.4.2 CONSISTENCY IN PROGRAM DEFINITION

Program structure can be organized in different ways to provide these advantages, so long as the definition is consistent throughout. Some ways in which a program can be defined include the following:

- By type of asset: e.g., highway, rail, aviation; or roadway, railway, runway, structures, etc.
- By transportation policy or system objectives: e.g., mobility, preservation, safety, etc.
- By type of improvement or solution: e.g., major capacity improvement, minor capacity/system improvement, pavement preservation, safety, operations, etc.

Difficulties can arise in a performance-based approach if the definition of the program structure is not consistent. Consider a program, for example, that is defined in several ways: by policy objective (e.g., roadway preservation, safety), by type of work (e.g., capacity improvement and operations improvement), by asset class (e.g., bridge program), and funding source (e.g., federal congestion mitigation). While it may be possible to manage a capital program that is defined in this way, consider the difficulties of answering basic questions as to what is being accomplished with program investments:

- How much is being devoted to preservation? to mobility? to safety?
- What will it take to improve preservation (or mobility or safety) performance by 10 percent?
- What are the key tradeoffs that need to be investigated?
- Are policy objectives in preservation, mobility, and safety being met? If not, where are increases needed, and by how much?

Each of these questions entails looking not only at multiple components of the program described above, but in some cases portions of programs (e.g., the bridge program includes new construction as well as preservation). A consistent method of defining a program structure will not eliminate all the calculations that are needed to answer the questions above, but it will put these calculations on a uniform basis and reduce the possibility of double-counting or inadvertently omitting a key contribution.

While effective definition clarifies the program structure, to work the definitions must be enforced. If your agency has both a preservation program and a safety program, then projects that have both kinds of work should be reflected in both programs.[6]

6.4.3 HOW MAY THESE STEPS HELP?

Taken together, a streamlined program structure and consistent definition of that structure will yield a program that:

- Allows greater latitude in identifying options to address problems;
- Is consistent with prioritization procedures that allow candidate projects to compete with their peers;
- Provides flexibility in facilitating tradeoffs among program categories;

[6] It is possible to identify incidental or minor spot safety work that would normally be associated with pavement preservaton projects and to place a limit on the amount of this work that can be funded through preservation. This will avoid unnecessary administrative burdens while maintaining the essential ingredients of a performance-based approach.

- Is clear and enforceable as to the types of projects in each program and subprogram; and
- Is meaningful and easily communicated.

6.5 MAINTENANCE AND OPERATIONS PROGRAMMING

The state-of-the-art in program development for maintenance and operations today is an approach referred to as "maintenance quality assurance," or MQA or simply QA. This approach is likewise performance-based, and is consistent with asset management concepts and principles.

6.5.1 WHAT IS MAINTENANCE QUALITY ASSURANCE?

NCHRP Project 14-12 has described a Maintenance Quality Assurance program as "planned and systematic actions needed to provide adequate confidence that highway facilities meet specified requirements. Such requirements are usually defined by the highway agency but are intended to reflect the needs and expectations of the user."[7] While the NCHRP project report reviews a number of management practices that support this objective, the QA approach that it has developed is fundamentally performance-based and centers on the concept of maintenance "level of service," or LOS. An MQA approach based on levels of service can accomplish a number of purposes:

- To determine the LOS expectations the traveling public supports and is willing to pay for;
- To communicate to the public how the agency is meeting these expectations;
- To seek levels of funding needed to achieve the desired LOS;
- To develop a "priority strategy" to focus on key maintenance activities when funding is less than requested;
- To achieve a more consistent application of LOS throughout the agency (e.g., for highways of a particular class and traffic usage) by identifying locations of excessively high or low maintenance; and
- To identify areas requiring additional employee skills or equipment to accomplish assigned tasks.

6.5.2 MQA FRAMEWORK FOR MAINTENANCE AND OPERATIONS MANAGEMENT

Maintenance QA introduces a performance-based framework for maintenance and operations management as illustrated in Figure 6.5. Several elements of this framework are drawn from traditional approaches to highway maintenance management: e.g., activity performance standards and cost models. The new elements that are added by a QA approach are those related to performance-based management:

- The explicit determination of condition of maintained highway features;
- Levels of maintenance service that are related to highway condition or to the quality of services provided; and
- Impacts of level of service (and associated highway condition) to customers.

Following is a brief discussion of each of the elements of this framework, which will assist in interpreting the different ways in which several states have implemented a QA program for maintenance and operations.

CURRENT CONDITION OF HIGHWAY FEATURES

The current condition of maintained items in the highway system is tracked through periodic inspection surveys. Since complete surveys encompassing all highway features would be difficult and expensive to conduct, DOTs often employ statistical sampling. While legacy maintenance management systems typically have an inventory of maintained highway features, they often have no provision to record feature condition over time. The addition of data on facility condition is one key element of a QA approach, and it is used to establish the current LOS value in each maintenance activity group and district.

[7] M.L. Stivers, K.L. Smith, T.E. Hoerner, and A.R. Romine, **Maintenance QA Program Implementation Manual**, NCHRP Report 422, National Academy Press, Washington, D.C., 1999, p. 9.

TRAFFIC AND ENVIRONMENTAL CONDITIONS

Traffic and environmental classifications can be recorded for each highway segment to help group it for purposes of maintenance management reporting. For example, urban highways may exhibit different demands for maintenance and different unit costs from those on rural highways. Similar distinctions can be made for environmental or geographical zones to reflect the influence of terrain, altitude, local weather conditions, and other factors on maintenance demand, performance, and cost. The classification of each highway segment can be accomplished during initial development of the QA approach and recorded in an inventory file.

APPLICABLE MAINTENANCE LEVEL OF SERVICE

The applicable maintenance LOS is specified by managers as the desired level to which each highway feature should be maintained. It is referred to as the *target LOS* to distinguish it from the *current LOS* that reflects the existing condition observed in the inspection survey. Target LOS values are expressions of maintenance management policy and priority, and play an important role in determining a performance-based budget estimate for the maintenance program, and in influencing the level of maintenance that is perceived by the public. It is for these reasons that LOS values are key ingredients of a maintenance QA program. Individual target LOS values are specified for each maintenance activity (or group of activities) in each district. In setting target LOS values, managers can account for needed adjustments in program priorities, and should reflect a realistic anticipation of maintenance funding. It is important to note, however, that level of service also can be used as an important argument for increases in maintenance funding when the projected benefit is compelling.

DEMAND FOR MAINTENANCE WORK

The combination of items above – the current condition (and LOS) of highway features, their characteristics and location (in terms of traffic and environment), and the target LOS value to which they will be maintained – determine the demand for maintenance work to be provided. In maintenance QA programs, this demand is estimated as a function of LOS.

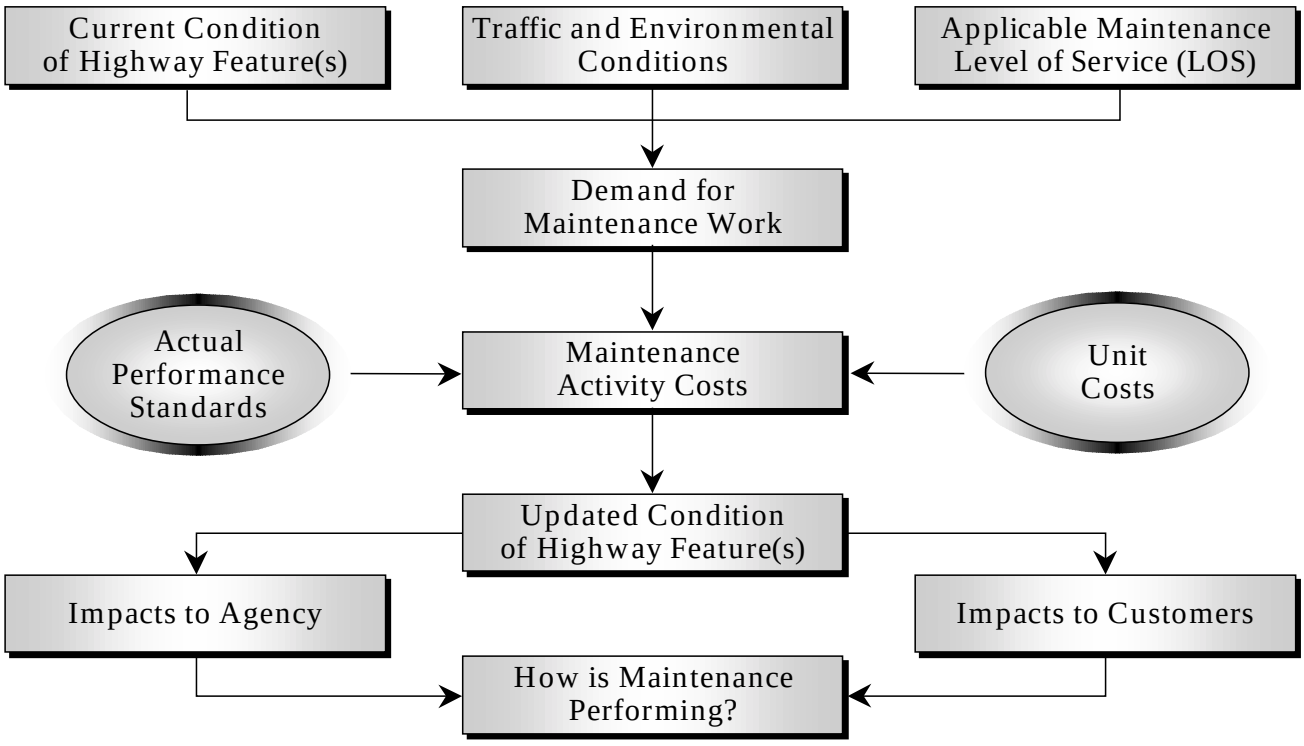
This "demand" for maintenance translates into the estimated work to be performed. It is computed for each activity in each district. The total demand or level of maintenance is recorded in units of work accomplishment, typically the same measures as those used in an existing maintenance management system. Note that this estimated level of maintenance is directly a function of the target LOS specified by managers. If the target LOS is revised, in general the demand for maintenance will likewise adjust.

MAINTENANCE ACTIVITY COSTS

Costs can be estimated for the levels of work computed above, using procedures similar to those employed in existing maintenance management systems. Separate calculations of labor, equipment, and materials can be made, using performance standards and respective unit costs as shown in Figure 6.5. Alternately, an overall activity cost can be computed from the total unit cost per accomplishment unit for labor, equipment, and material combined. The performance standards are referred to as "actual" in Figure 6.5 to denote that it is the actual resource usage rates and crew productivity that should be used in these calculations, not necessarily the "book values" that are listed in the highway maintenance manual.[8] Performance standards (and unit costs) for each activity will in general vary by district, and possibly by the traffic and environmental classifications discussed above. Existing maintenance management systems may not estimate costs to a level of detail sufficient to account for these variations; the QA approach affords an opportunity to do so if warranted. Costs as a function of LOS are computed by the QA analytic procedure.

[8] "Book" values may be used if they reflect up-to-date information for the district, region, or area of interest. Statewide average values that have not been updated recently tend not to be realistic, and more specific, current information should be sought.

Figure 6.5 Maintenance Quality Assurance Framework



UPDATED HIGHWAY CONDITIONS AND IMPACTS

The QA approach considers the benefits or consequences of maintenance as well as its costs. Benefits are reflected by the predicted change in highway conditions that will result from performing maintenance activities to the specified levels of service. These updated conditions have implications for both the highway agency and its customers:

- The agency impacts are in terms of the effect of maintenance on the long-term trend in highway infrastructure condition. By sustaining LOS values at a high level, an agency can avoid building up a "backlog" of maintenance work, and keep maintenance costs at an efficient level over the long term.
- The customer impacts are in terms of highway rideability, safety, comfort, and travel time that are associated with the LOS provided. By sustaining LOS values at a high level, an agency can provide road users with high-quality transportation facilities and services over the long term, cost-effectively.

The current state-of-practice in maintenance QA programs is to use the target LOS value as a surrogate, or proxy, for these specific agency and customer impacts. The data needed for more explicit predictions of the impacts of different maintenance LOS values may become available in the future with additional research.

HOW IS MAINTENANCE PERFORMING?

The QA approach provides a feedback loop by which managers can assess how the maintenance program has performed and adjust the program accordingly. Measures of current performance are the current LOS values; adjustments can then be made through the target LOS values in the next program budget cycle. Level of service thus provides a measure of management accountability, and a means of communicating program accomplishments and customer value provided for dollar spent.

6.5.3 IMPLICATIONS OF AN MQA APPROACH

An MQA approach has several implications for maintenance management:

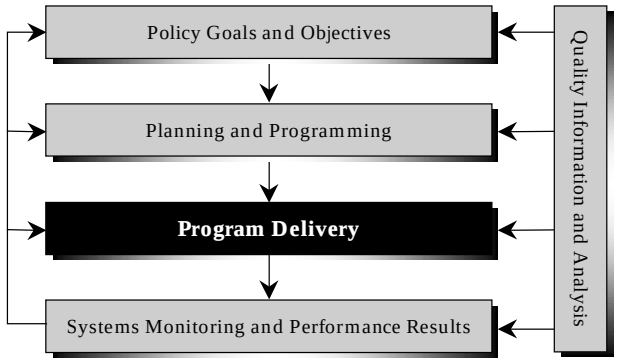
- It is a performance-based approach, in that maintenance levels of effort and cost are based upon current highway condition and proposed LOS targets, and these calculations are implemented within a performance budgeting procedure. Moreover, the target LOS values provide a basis for management accountability for maintenance performance, and the periodic surveys of highway condition establish a quantitative basis for this accountability.
- MQA also is a policy-driven process, as reflected in the setting of target LOS values. To be successful, this process must involve appropriate political decision-makers (e.g., governor's office, legislative committees, the transportation commission or board) as well as DOT executives.
- As a policy-driven, performance-based approach to management, MQA is entirely consistent with a broader set of principles of good practice in transportation asset management.

7. PROGRAM DELIVERY

7.1 OVERVIEW

Resource allocation decisions result in a recommended transportation investment program. Program delivery puts this program "on the ground" through decisions in resource utilization to determine how program work will be accomplished. Its sequence in the asset management framework is shown in Figure 7.1. Key challenges for program delivery include maximizing efficiency and effectiveness of agency resources, meeting customer expectations, minimizing adverse customer impacts, adhering to project scope, schedule and budget, and managing needed changes in projects and programs.

Figure 7.1 Program Delivery within Resource Allocation and Utilization



This chapter illustrates the application of asset management principles to program delivery. It highlights opportunities to optimize the implementation of capital programs, maintenance activities, and operations plans through strategies such as the following:

- **Investigating a range of delivery options**. Assessment of options with consideration of relative costs, benefits and risks, both immediate and long term.
- **Program management**. Close monitoring and management of project and budget status to ensure that desired results are achieved.
- **Cost tracking**. Tracking of actual delivery costs to improve understanding of the true costs of different activities so that this information can be used to enhance future resource allocation decisions.

7.2 ALTERNATIVE DELIVERY METHODS

7.2.1 RANGE OF OPTIONS

Transportation agencies have a range of delivery alternatives available to them. Several non-traditional delivery techniques have been developed and applied by U.S. transportation agencies to reduce time to completion, improve cost-effectiveness, address project complexity, supplement staff skills with specialized expertise, and use in-house resources more effectively. Examples of these techniques include the following:

- Innovative contracting approaches;
- Performance-based bidding;
- Intergovernmental agreements; and
- Outsourcing and managed competition.

When analyzing these and other delivery options, the following issues should be kept in mind:

- Delivery methods should be evaluated on a case-by-case basis. A thorough analysis of project, owner, and market characteristics will help identify legitimate delivery options.[1]
- Although external issues may constrain delivery alternatives (e.g., state or federal procurement laws may prohibit certain procurement approaches), motivated agencies can often customize procurement strategies to meet their specific needs and constraints.
- The methods presented in this chapter may require construction documents, proposal evaluation guidelines, and oversight techniques different from those used in traditional procurement strategies. Care should be taken to structure the procurement to maximize benefits and mitigate potential risks.
- Since alternative delivery strategies give agencies flexibility in terms of project cost, schedule, and the use of in-house resources, these options

[1] Christopher Gordon, "Choosing Appropriate Construction Contracting Method," **ASCE Journal of Construction Engineering and Management**, Vol. 120 No. 1, (Mar 1994).

should be considered early on in the planning and programming processes.[2]

7.2.2 CONTRACTING APPROACHES

State DOTs have developed and implemented innovative contracting approaches in an attempt to improve the cost and time of program delivery or provide needed expertise more efficiently. These mechanisms include assigning responsibility for both design and construction to a single entity, corridor approaches to asset management, and internal adjustments in an agency's pre-construction activities. While such contracting approaches present advantages in certain situations, conventional methods of delivery (i.e., design-bid-build in construction, and performance of maintenance by agency employees) will continue to be used for many projects and activities. Selection of the appropriate delivery method is an example of decisions in "resource utilization" in an asset management context.

Federal Funding for DB Projects

The Transportation Equity Act of the 21st Century (TEA-21) established federal funding eligibility rules for DB projects: ITS projects over $5 million and other projects over $50 million qualify for TEA-21 funds. However, in its proposed guidelines for DB contracting, the FHWA acknowledges the potential benefits of DB contracting for projects of all sizes.[3] The FHWA recommends that agencies opting for DB contracts for projects under the TEA-21 thresholds pursue federal funding through FHWA Special Project No. 14 (SEP-14), Innovative Contracting.

DESIGN-BUILD

Design-build (DB) contracts are one approach to combining design services and construction work into a single contract. Time savings are possible under this arrangement because construction can begin before design is complete. Between 1991 and 2001, 24 DOT's and several local agencies used DB contracts for transportation projects as an alternative to the traditional design-bid-build (DBB) process for 140 projects ranging in size from pavement overlays to freeway construction and reconstruction.[4]

A 1992 study[5] documented the following impacts of DB contracts on project schedule and budget:

- DB projects are completed 21 percent faster than traditional design-bid-build (DBB) projects.
- Initial costs of DB projects are 4.6 percent higher than DBB costs.
- Cost growth due to claims and change orders for DB projects is 4.7 percent less than for DBB projects.

Design Build Example

Utah DOT employed DB on its $1.59 billion reconstruction of a 16-mile length of Interstate 15 in Salt Lake City. This project involved roadway widening from six to 12 lanes, and reconstruction of 142 bridges and other structures, and 12 interchanges. It was estimated that the project would have required eight to ten years to complete utilizing a traditional DBB procurement process. However, in January 1996 the Governor directed the Utah DOT to complete the project in five and one-half years – in time for the 2002 Winter Olympics. The DOT quickly determined that this acceleration would be possible only with a DB contract, which required authorizing state legislation. The DOT selected a program management firm to assist in guidance of the project along with the Department. This firm helped manage the evaluation, selection and award process, leading to a notice to proceed to the selected DB consortium in April 1997.

Early construction starts were accomplished with no design submittals to the Utah DOT, which had oversight/ over-the-shoulder review responsibilities only. ISO 9001 registration required the design-build consortium to establish procedures and standards for quality. Ribbon cutting for the $1.59 billion project occurred on May 14, 2001, five months ahead of the contract completion date, and four to six years ahead of the original procurement estimates.[6]

[2] John B. Miller, **Principles of Public and Private Infrastructure Delivery,** Kluwer Academic Publishers, 2000.

[3] Federal Highway Administration, *Design-Build Contracting; Proposed Rule* (2001). www.transportation.org/committee/design/doc/Federal_Register_NPRM_Design-Build.pdf

[4] Ibid.

[5] Ibid.

[6] Thomas R. Warne and David G. Downs, "All Eyes on I-15", *ASCE Civil Engineering Magazine* (Oct 1999).

CORRIDOR APPROACH

A corridor approach to asset management is another fast-tracking alternative. In this approach, agencies combine several capital projects or maintenance activities along a section of highway into a single project. This approach, which is used to minimize the inconvenience of the traveling public, follows an increasingly popular philosophy to "get in, get out, and stay out."

"Get In, Get Out, and Stay Out"

One "get in, get out, and stay out" approach is to close a length of highway completely so that maintenance or construction crews and utility companies can perform all necessary work simultaneously. Current practices range from closing a highway section overnight or a weekend to more extensive closures of several months for reconstruction. For example, the California and Michigan DOTs have applied a corridor approach to delivering capital projects.[7]

CUSTOMIZED APPROACHES

Transportation agencies also have developed customized contracting and procurement approaches that fit into their specific funding, institutional, and legislative environment, and have adjusted those internal activities that tend to prolong the delivery process.

While revised contracting approaches and internal process adjustments offer significant opportunities to decrease delivery time, they are not always appropriate for every project. For example, state legislation may constrain procurement options and approval processes, or an agency may want design of a project to be 100 percent complete before contractors bid on it. In addition, a faster delivery time for a project increases the share of funding that must be allocated to the project (e.g., completing a mega project in three years instead of five years may require that other projects be scaled back or delayed until year four). Understanding the full costs and benefits of innovative delivery approaches is essential to a meaningful evaluation of this alternative.

7.2.3 PERFORMANCE-BASED BIDDING

Asset management calls for system performance to drive decisions throughout the project life cycle. State DOTs have developed several options for incorporating performance-based concepts into program delivery. Following is a brief description of a few of these techniques.[8]

[7] Federal Highway Administration, *Work Zone Safety Best Practices Guide* (2000). <www.ops.fhwa.dot.gov/wz/wzguidbk/>

[8] Federal Highway Administration, **Initiatives to Encourage Quality through Innovative Contracting Practice -- Special Experimental Project No. 14 – (SEP 14).** <www.fhwa.dot.gov/programadmin/contracts/sep_a.htm>

Customized Approaches to Reducing Delivery Time

Constrained by state legislation that restricted DB contracts, the New Mexico DOT developed a unique delivery approach (design, construction manage, warrant) to reconstruct 120 miles of State Route 44 in three years. Under this approach, a project developer was responsible for overall project management, quality control, bid package preparation, and maintenance during an extended warranty period. The DOT estimated that the project would have taken 27 years with its traditional procurement process.[9]

In another example, the Washington State DOT cut the delivery time for the South Dupont Interchange on Interstate 5 from four to eight months to 26 through a series of internal process improvements:[10]

1. Commencement of the environmental review process earlier in the project, and incorporation of environmental considerations into the design process.

2. Design process enhancements: selection of a "Top Gun" design team, a streamlined design review process, stage submittals in which work proceeded based on engineering estimates rather than waiting for final information, and commencement of bridge design before the interchange plan was approved.

3. Reduction of common third-party delays by including utility work in the construction contract.

4. Inclusion of design alternatives in the contract documents rather than requiring contractors to submit shop drawings for approval.

- **Performance specifications** are an alternative to traditional prescriptive specifications that enable bidders the flexibility to propose innovative solutions. Performance specifications require bidders to meet a defined level of service or quality without stating how to meet these criteria.
- **Cost plus time bidding** (also referred to as A+B bidding) requires bidders to submit a time bid (e.g., number of calendar days until completion) in addition to a traditional cost bid. When evaluating the total cost of the proposals, the owner uses the time bids to estimate the user costs associated with each proposal. This arrangement encourages bidders to minimize time to completion.
- **Best-value bidding** is used to select contractors based on a combination of lowest cost and bidder qualifications or technical merit of a proposal.
- **Lane rental**, like cost plus time bidding, encourages contractors to minimize construction impacts on road users. Contractors are charged a "rental fee per-lane per time" to occupy the roadway throughout the project.
- **Life-cycle cost bidding** is an alternative to traditional lowest cost bidding. In this approach, the owner evaluates bids based on the projected costs over the entire life of a project.
- **Incentive contract clauses** provide contractors with monetary awards for achieving defined performance and schedule benchmarks throughout the course of a project.
- **Warranty periods** enable an owner to guarantee the performance of a new facility for a given time. Warranty provisions on National Highway System projects are limited to specific features (e.g., pavement, structures, etc.) and may not include routine maintenance.

7.2.4 INTERGOVERNMENTAL AGREEMENTS

Intergovernmental agreements can create opportunities to improve the efficiency and cost effectiveness of delivering projects and services. For instance, a state DOT may purchase or exchange maintenance services with a municipality, or expand the capabilities of a county agency through training in exchange for work performed by the county for the DOT.

Intergovernmental agreements have several advantages:[11]

- Cost savings through the sharing of expensive equipment and employee expertise between agencies.

[9] Mesa, PDC, LLC, *A Summary of the New Mexico State Route 44 Project* (2000). <www.nm44.com/pdf/NM%2044%20Project%20Summary.pdf>

[10] Cambridge Systematics, Inc., *Department of Transportation Highways and Rail Program Performance Audit*, prepared for the State of Washington Joint Legislative Audit and Review Committee (1998).

[11] Municipal Research and Services Center of Washington Report No. 27, **Municipal Cooperation Guide** (1993). <www.mrsc.org/pubs/municoop.pdf>

Utah DOT's Performance-Based Procurement

Forced with a very tight schedule for the reconstruction of Interstate 15, the Utah DOT used a variety of performance-oriented requirements. The request for proposal (RFP) included a mixture of performance and traditional prescriptive specifications, best value selection, and stipends (a first for a publicly funded major interstate highway project). Structures, pavements, lighting and several other design elements were governed by performance specifications. For example, the specifications for pavement markings consisted only of a color and retro-reflectivity requirements. Examples of innovations fostered by the performance specifications include the use of polystyrene instead of traditional borrow material to minimize soil settlements and an innovative traffic maintenance strategy that exceeded the Utah DOT's expectations.

Long-term warranty requirements in areas of critical quality (structures, pavements, embankments, drainage) forced life-cycle cost analysis by the DB consortium and up-front quality in design and construction. To give the warranty added force, the contract included an operations and maintenance option under which the consortium would be responsible for these activities for up to 10 years at a fixed price. Although the Utah DOT ultimately did not exercise this option, the consortium's design and construction decisions were always influenced by the knowledge that they might have the maintenance responsibility to correct any long-term problems.

An incentive fee in the maximum amount of $50 million was available to the DB consortium for optimum performance in the areas of schedule, quality, management, and community relations/maintenance of traffic. The Utah DOT evaluated the consortium's performance in these areas in six-month intervals throughout the project, and distributed the award money accordingly.[12]

- Increased efficiency through the elimination of duplicate efforts and economies of scale.
- Access by local agencies to services that they would otherwise be unable to provide.
- Opportunities for state agencies to redirect local resources toward mutually beneficial projects.

[12] Thomas R. Warne and David G. Downs, "All Eyes on I-15," **Civil Engineering** (Oct 1999).

Michigan DOT's Alternate Bidding

In cooperation with representatives of the concrete and asphalt paving industries, the Michigan DOT developed an RFP that enabled bidders to submit bids for one of two "equivalent" pavement designs. The RFP included specifications for both an asphalt and a concrete pavement design. The bids were evaluated based on the lowest life-cycle-cost of the proposed pavement design rather than the traditional lowest initial construction cost. In addition, the RFP included a short-term warranty to cover materials and workmanship, and incentives for extraordinary pavement performance.[13]

Pennsylvania DOT's Win-Win Agreements

Through its Agility Program, the Pennsylvania DOT has developed working relationships with more than 1,500 of its local partners. The program encourages the DOT and local participants to identify win-win opportunities for sharing resources across jurisdictional boundaries. For example, in one agreement, the Pennsylvania DOT widened a township road. In exchange, the local partner agreed to sweep various state roads within the township. In the first four years of the program, the DOT has estimated a total savings for all participants of over $7.7 million.[14]

7.2.5 Outsourcing and Managed Competition

Further opportunities for delivery optimization exist though contracting with the private sector to perform maintenance and operation activities. The potential benefits of outsourcing include lower overall costs, improved service, and opportunities to leverage the expertise of private companies and overcoming in-house staffing constraints. Factors to consider when analyzing the tradeoffs between in-house and outsourced work include:

[13] Michigan DOT, **Alternate Bid Study M-6 South Beltline** (2000). <www.mdot.state.mi.us/projects/retired/m-6/altbids.pdf>

[14] Pennsylvania DOT, **Status of the Agility Program** (2001). <www.dot.state.pa.us/Internet/Agility.nsf>

- Capability of in-house staff capable to improve the quality or cost-effectiveness of services.
- Methods by which to monitor work activities and ensure quality and performance.
- Availability of accurate cost data for comparing in-house versus outsourcing costs (activity-based costs are discussed in later sections).
- Internal costs and experience requited to administer outsourcing contracts (e.g., developing RFP and selection process, cost of transition period, etc.).
- Distribution of project risks between owner and contractor and the impact on costs (e.g., although the private sector may charge a premium to assume all risks during a five-year fixed fee contract, the public agency will know the exact cost of a set of activities over the life of the project).
- Need for a "safety net" if public employees are displaced by a private-sector work force.

In addition to contracting maintenance and operations to the public sector after a facility has been built, outsourcing is possible through the combination of these activities with design and/or construction during the original procurement process. Options for approach include design-build-operate (DBO), design-build-operate-maintain (DBOM), build-operate-transfer (BOT), and design-build-operate-transfer (DBOT) procurement strategies.

An alternative to direct outsourcing is managed competition. This practice has all of the potential advantages of direct outsourcing contracts but also gives the current in-house staff the opportunity and the means to compete against their private sector counterparts in terms of quality and price.

Outsourcing Florida DOT's Program Management

Florida's Turnpike District is one of the Florida DOT's eight districts. It consists of 440 centerline miles of toll roads, approximately 653 bridges, 215 buildings, numerous toll plazas, and communications facilities, spread out over South and Central Florida. For over 10 years, the Florida DOT has managed its Turnpike facilities with consulting contracts for design, construction and maintenance management services.

Nearly 100 percent of the Turnpike's maintenance services are contracted for by the Florida DOT. Overall maintenance program management is provided by a joint DOT/contractor team. Contractor services include annual program and budget planning, road and facilities inspections and needs assessments, emergency operations planning, environmental services, oversize-overweight and access permit management, and procurement and supervision of all routine and specialized maintenance services. At any given time, there are over 100 maintenance and service contracts in effect. The contract involves a staff of approximately 75 people and fees of approximately $5 million per year and is renewed at five-year intervals. The contractor team is composed of highway, bridge and traffic engineers, environmental scientists, contract administrators, and a variety of skilled maintenance technicians and administrative staff members.

The focus of the contract is patron service and safety and protection of bondholder interests. The project is subject to annual quality assurance reviews by the State Maintenance Office.[15]

[15] Wendell C. Lawther, **Privatizing Toll Roads - A Public-Private Partnership**, Praeger Publishers (2000).

Outsourcing Maintenance at the Virginia DOT

In 1995, the Virginia General Assembly enacted the Public-Private Transportation Act (PPTA). This legislation permitted private companies to submit both solicited and unsolicited proposals for constructing, maintaining or operating various facets of Virginia's transportation system. The underlying rationale for the Act was to afford greater opportunity to the private sector to develop innovative and cost-effective solutions to the many transportation issues confronting the Commonwealth.

In 1996, the Virginia DOT received an unsolicited proposal pursuant to the PPTA. This proposal resulted in a negotiated agreement for the private contractor to perform maintenance services for 25 percent of the Commonwealth's interstate highway system. The private contractor was to provide outcome-based routine maintenance services and required restorative work, such as roadway resurfacing and bridge deck replacement, on 1,250 lane miles of roadway on segments of I-95, I-81, I-77 and I-381. The sections of the Virginia interstate system that were covered in this agreement are highlighted in Figure 7.2 (following page).

The agreement addressed the full range of maintenance services, including snow removal and emergency response, required to meet the performance standards established by the Virginia DOT. In December 1996, the Virginia DOT and the private contractor entered into a five and one-half year, $131 million fixed price contract. The DOT preliminarily estimated that the contract represented a savings of $22 million to the Commonwealth.

VDOT Outsourcing

Recognizing that this was an unproven approach, the Virginia DOT designated the maintenance contract as a pilot project intended to address two key questions:

1. Whether privately contracted asset management can provide equivalent or better levels of service in interstate maintenance; and

2. Whether privately contracted asset management can provide such services at lower costs.

Over the course of the contract, the Virginia DOT has worked to develop and modify its evaluation structure to present a fair representation of the contractor's performance. Based upon an evaluation in FY 2000, it appears that the contractor had met or exceeded the DOT's performance targets for 90 percent of the items evaluated on I-95, 89 percent on I-77, 86 percent on I-81 and 86 percent on I-381. The Virginia DOT's evaluations currently are conducted on an annual basis. A legislative commission has suggested that quarterly evaluations would identify problem areas sooner and would be a more effective approach.

Regarding cost, the Virginia DOT contracted with the Virginia Polytechnic Institute and State University (Virginia Tech) to provide an objective assessment of this controversial aspect of the outsourcing contract. The Virginia Tech study utilized a bid item and unit rate comparison of the cost of work performed by the private contractor in calendar year 1999 and corresponding published Virginia DOT bid tabulations. The study concluded that:

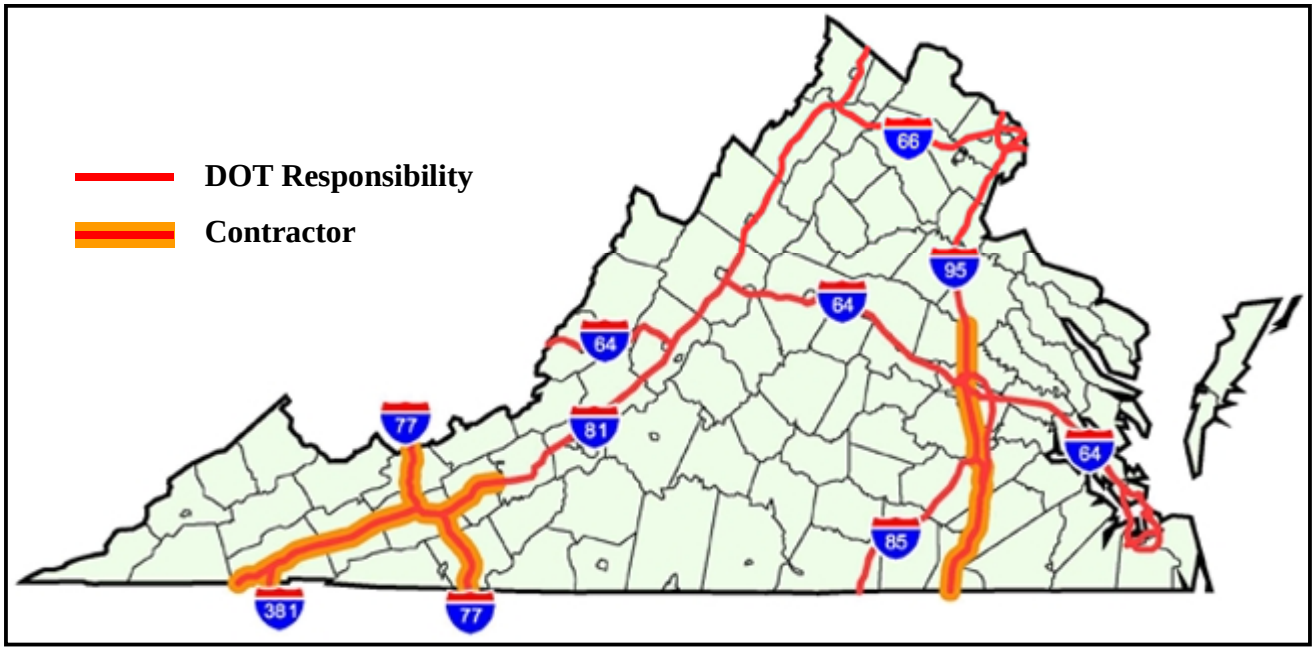
1. Work subcontracted by the contractor was four percent more competitively priced than similar work would have been if it had been let by the DOT.

2. Work self-performed by the contractor was likely to be 6.1 percent cheaper than comparable work if contracted for or self-performed by the DOT.

3. The estimate of total project savings once price escalation was accounted for was likely to be $18.7 million.[16]

[16] Joint Legislative Audit and ReviewCommission of the Virginia General Assembly, **Review of VDOT'S Administration of theInterstate Management Contract**, 2001.

Figure 7.2 Virginia DOT Maintenance Outsourcing Map



Massachusetts Highway Department's Phased Approach to Maintenance Outsourcing

The Massachusetts Highway Department (MHD) began its outsourcing effort by contracting out all routine maintenance in a single county. It has been estimated that after one year, the program saved the MHD between $1.7 million and $2.1 million. Based on this estimate, the MHD expanded the program to two districts and let the state work crews to bid on the projects. (See the discussion on managed competition below.) Further success in this second phase (estimated first year savings of $7.5 million and $10 million in additional maintenance services) gave the MHD confidence to institute the program statewide. In the final phase of the program, MHD employees and private firms each won seven of 14 maintenance contracts. After the initial contracts had expired, the rebidding process received little attention from the media – maintenance outsourcing had become an accepted practice in Massachusetts. In the first eight years of this program, the MHD cut its $40 million annual highway maintenance budget by an ***estimated $15 million,*** *while significantly increasing the amount of work performed.*[17]

A key issue with managed competition is to develop a procurement process in which in-house and public bids compete fairly. Without such a "level playing field," private firms will be unwilling to develop quality bids, and the benefits of bringing the public sector into the process will be greatly diminished. Challenges that must be overcome when developing a level playing field for a managed competition include:[18]

- Separation of government as bidder from government as owner.
- Ability of in-house staff to compute the actual cost of an activity (including overhead, administration, depreciations, and legal costs). Cost tracking techniques are explored further in the last section of this chapter.

[17] Adrian Moore, "Road Work Ahead: Outsourcing Highway Maintenance", **Intellectual Ammunition** (Nov/Dec 2000).<www.heartland.org/ia/novdec00/privatization.htm>

[18] Reason Public Policy Institute (RPPI) Privatization Center, **Avoiding Managed Competition Pitfalls**. <www.privitization.org/collection/PracticesAndStrategies/Avaoiding_Managed_Competition_Pitfalls.htm>

Outsourcing Operations at the OOCEA

The Orlando Orange County Expressway Authority (OOCEA) is the owner of the toll road system in Orange County, Florida. The system consists of 90 miles of toll roads and 11 plazas. In 1994, the OOCEA awarded a five-year contract to a private operator for toll operations services on this system. Previously, the agency had contracted with the Florida DOT to provide these services. Most of the private operator's toll collection staff transferred from the DOT, but new management oriented toward private sector business principles was installed. In 1999, the OOCEA extended the private operator's contract for an additional five years.

The objectives of this outsourcing effort were to reduce operations costs, increase managerial flexibility, and improve service quality and responsiveness. In 2000, an independent study found that the agency was largely successful in achieving these objectives.[19] Increased efficiencies were estimated to produce savings of over $1 million annually, a one-sixth reduction. Improved managerial flexibility was demonstrated by the ease with which the operator was able to quickly adjust the mix of full-time and part-time toll collectors in response to changing conditions – adjustments that would have been difficult for the state DOT to accomplish. The study cautioned that it was not always possible to distinguish between improvements caused by privatization and improvements due to other factors.

- Costs by private bidders to meet bonding and insurance requirements.
- Special privileges and tax exemptions for public agencies (sales tax, corporate income tax, property tax, etc.).
- Private sector costs of developing proposals.
- Difficulty in subjecting in-house staff to performance or cost guarantees.

7.2.6 SUMMARY

- A summary of delivery mechanisms discussed above is given in Table 7.1.

[19] Wendell C. Lawther, **Privatizing Toll Roads – A Public Private Partnership**, Praeger, 2000.

Iowa DOT's Managed Competition

In 1996, the Iowa DOT implemented a pilot managed competition program for two of its activities: paint striping ($2 million annual budget) and sign shop ($1 million annual budget). Program guidelines included the following:

1. Private sector bids competed against activity-based cost (ABC) proposals developed by existing state work crews.

2. Outside consultants were hired to reengineer DOT operations, develop ABCs, and prepare proposals.

3. In-house bids included all direct and indirect costs.

4. A five percent preference was given to the in-house bid.

5. A safety net was developed for displaced state workers.

Iowa DOT employees were the low bidders for paint striping and sign manufacturing, and a private firm was the lowest bidder for graphic display sign work. It is estimated that internal improvements in paint striping operations in response to this program saved the DOT more than $300,000 annually, and the DOT demonstrated that existing sign shop operations were competitive with private sector alternatives.[20]

7.3 PROGRAM MANAGEMENT

Program management is necessary for an agency to implement a capital or maintenance program effectively. By applying asset management principles to its program management approach, and agency can:

- Insure that the approved program is implemented;
- Match available funds and workforce resources to delivery needs;
- Identify opportunities for improvement in its planning and programming processes; and
- Keep all stakeholders up to date on the status of program implementation.

[20] Jim Chrisinger, **Managed Competition Pilot Projects: Iowa Department of Transportation**, a National Academy of Public Administration report (1996). <www.alliance.napawash.org/ALLIANCE/Picases.nsf/e24ffc586e80044a852564ed006eb5be/0091ca9c8412ad788525656a00752035? OpenDocument>

Table 7.1 Delivery Method Summary

Delivery Method	Advantages	Challenges	Implementation Examples
Fast Tracking			
Design-build, DBO, DBOM, BOT, DBOT, and other non-traditional procurement strategies	Shorter delivery period, single point of responsibility for owner to oversee, decrease in cost growth due to change orders	TEA-21 thresholds, state statutes, lack of experience managing DB contracts	Utah I-15 DB, New Mexico SR 44 design-construction manage-warranty, Massachusetts Route 3, DBOM examples from 24 state DOTs
Corridor approach	Shorter delivery time, minimal inconvenience to traveling public	Contractor bonding limits, limitations in the size of the local work force	Michigan DOT corridor planning and weekend closures, Caltrans nighttime closures
Performance-Based Bidding			
Performance specifications	Flexibility for contractor to propose innovative solutions	All of the performance-based bidding techniques require construction documents, proposal evaluation guidelines, and construction oversight techniques that vary significantly from those of a traditional procurement process	Utah I-15 design-build, Florida I-75 asset management,
Cost plus time bidding	Shorter construction times encouraged, decreased user costs		South Caroline, Oregon, New York, Michigan, Maryland, and Missouri actively use this technique
Best-value bidding	Consideration of both price and quality of proposals		Utah 1-15 design-build, Oregon I-15 lift span bridge
Lane rental	Shorter construction times encouraged, decreased user costs		Indiana I-70, Maine I-295, Oregon U.S. 26
Life-cycle cost bidding	Lowest life-cycle cost of proposals considered instead of lowest construction cost		Michigan M-6, Missouri's seismic isolation system
Incentive contract clauses	Contractors encouraged to meet performance and schedule benchmarks		Michigan M-6 South Beltline
Warranty periods	Encourage quality design and construction, transfer of financial risks to the public sector		Michigan I-75 and M-28 concrete pavement repairs, examples from 24 states DOTs
Intergovernmental Agreements	Resource sharing among agencies, increased efficiency, alignment of local forces with state objectives	Establishing relationships across agencies, identifying win-win opportunities	PennDOT Agility Program
Outsourcing	Lower operational costs, improved quality of services, transfer of risks to private sector, supplement in-house work capacity	Difficulty monitoring performance, availability of accurate data to compare in-house versus outsource costs, labor org. concerns for displaced public employees	MassHighway Maintenance, Virginia DOT Interstate Maintenance, Florida Toll Ways Operations, Florida DOT Turnpike Maintenance Engineering Management, South Carolina Program Management Services
Managed Competition	Same as outsourcing with added opportunity for current work force to improve operations and compete with private sector	Same as outsourcing with added challenge of maintaining a level playing field during procurement	Iowa DOT paint striping and sign shop activities, MassHighway maintenance

7.3.1 MANAGING CHANGES IN THE PROGRAM

If an agency is practicing good asset management, its approved programs support its policy goals and are realistic in light of funding projections. Defined procedures to approve changes in projects and to manage resulting adjustments in programs enable an agency to systematically address unforeseen issues that arise during program delivery and make adjustments accordingly. Managing changes in programs entails:

- Clear guidelines and assigned responsibilities for reviewing and approving project and program-changes.
- Current and accurate project and program data to identify potential problems and anticipate needed adjustments in areas such as the following:
  - Project scope, cost, and schedule;
  - Potential impacts on agency staffing;
  - Availability and sources of funding to cover needed adjustments; and
  - An expenditure plan to analyze impacts on cash flows and to balance revised expenditures to available funds.
- Coordination between project and program managers and between their respective management systems.

7.3.2 DELIVERY TRACKING

Asset management calls for system monitoring and performance results to be applied throughout the resource allocation process. Program delivery performance can be tracked in terms of schedule, cost, scope, and quality. Table 7.2 identifies potential project and program level delivery measures for each of these items. Please see Chapter 5 for a more detailed look at developing performance measures – those concepts also apply to defining and using delivery measures.

Washington State DOT's Management of Program Changes

The Washington State DOT has developed a comprehensive approach to manage program changes during capital program delivery. Highlights include:

***Clear guidelines and responsibilities**: The DOT has documented its protocol and staff responsibilities in a program management manual. The manual defines four project change levels (minor, moderate, significant, and major) and approval requirements for each level. Major changes must be approved by a project screening board, which consists of the Deputy Secretary of Transportation and several assistant secretaries from across the DOT.*

***Current and accurate data**: The Washington State DOT uses a Capital Program Management System (CPMS) to track the status of its capital projects (e.g., start date, planned expenditures, overruns, etc.). Several offices throughout the DOT provide input for the CPMS. The Program Management Office helps these offices understand the importance of their contributions to the process and to submit timely, reliable data.*

***Coordination**: Regional DOT offices enter project-level change requests in to the CPMS. Each night, the CPMS automatically generates a report of these changes. Program managers use this report to review changes and evaluate their subprogram and program impacts. The results of change requests are traced by the CPMS and by the Washington State DOT's Transportation Executive Information System (TEIS).*[21]

Problems with program delivery can often be traced back to one or more of the following shortcomings:

- Poor scoping process (e.g., limited review and scope creep problems).
- Poor costing process (e.g., outdated estimates, oversights).
- Poor scheduling process (e.g., single-project viewpoint, done in isolation, impacts on other projects not considered).
- Poor pre-construction processes (e.g., lengthy environmental permitting requirements, delayed right-of-way acquisitions).

[21] Washington State DOT, **Programming and Operations Manual** (2001). <www.wsdot.wa.gov/FASC/EngineeringPublications/Manuals/P_OManual.pdf>

Measures that are tracked during delivery help agencies quantify performance in these areas and identify opportunities for improvement. For example, final construction costs that consistently surpass initial budgets may indicate a need for estimation techniques to be reevaluated or schedule overruns may indicate the need for improvements in the environmental permitting process. In addition to this diagnostic function, delivery measures provide a means for communicating program delivery status to all stakeholders.

Table 7.2 Examples of Program Delivery Performance Measures

Category	Example Measures
Schedule	Contract milestones (e.g., completion date)
	Project on schedule (yes / no)
	Percent schedule overrun
Cost	Project within budget (yes / no)
	Activity unit cost
	Percent cost increase / decrease
Scope	Number of change orders
	Activities performed versus planned (e.g., lane miles paved)
	Value of projects programmed versus delivered
	Number of projects programmed versus delivered
Quality	Performance specifications for capital improvements
	Levels of service (LOS) for maintenance and operations activities

7.3.3 COMMUNICATING PROGRAM STATUS

The asset management framework presented in Chapter 2 identifies the importance of performance monitoring and constant feedback. The performance measures described above are only effective if they are communicated to decision-makers throughout an agency.

Arizona DOT's Program Status Reports

Effective and timely program delivery is a major priority for the Arizona DOT. Therefore, it establishes 20 milestones for each of its capital projects at the beginning of the pre-construction delivery process. These milestones include anticipated finish dates for various stages of design, completion of technical tasks (e.g., surveying), and obtaining right-of-way clearances. The Arizona DOT incorporates these milestones into a monthly Active Projects Status Reports. This report is used to manage project schedules among DOT staff, design consultants, and other stakeholders. The report is available on the Arizona DOT's web site. Statistics on the pace of program implementation also are submitted monthly to the Governor's offices as one the DOT's key measures of performance.[22]

Effective asset management also requires agencies to be customer-focused. In addition to evaluating the impacts on system users of various delivery strategies, an agency can maintain a customer-oriented approach to program delivery through external reporting. Structuring public reporting requires an agency to identify those aspects of program delivery in which the traveling public has an interest. In addition, communicating delivery status and achievements to the public, legislative bodies, and other stakeholders also will strengthen an agency's credibility and accountability.

Pennsylvania DOT's Agency Report Cards

An example of an effective external communication tool is the Secretary's Report Card, which the Pennsylvania DOT uses to report its accomplishments to the public on a regular basis. Each month, the DOT issues a one page report that explains the importance of a single performance measure and graphically represents its accomplishments in that area. Past reports have included information on the International Roughness Index (IRI), tons of pothole patching material used, and snow removal.[23]

[22] Arizona DOT, **ADOT Project Time Management Guidelines, What's New – Highlights** (2000). <www.dot.state.az.us/about/ppms/guide/GUUIDEREV0.pdf>

[23] Cambridge Systematics, Inc., **Synthesis of Transportation Asset Management Practice**, NCHRP 20-24(11) Task 1 Report (2001). <gulliver.trb.org/publications/nchrp/nchrp_w41_task1.pdf>

7.4 COST TRACKING

It virtually impossible to overstate the importance of valid and reliable costing – both original estimates and monitoring through the course of a program or project. It is difficult to conceive of a major agency decision or initiative that does not include costing as part of its foundation. If the costing turns out to be unreliable, the decision or initiative is often undermined, with potentially disastrous results.

This section describes the types of cost data required to support asset management, identifies common gaps in cost data, and proposes strategies for bridging these gaps. It is assumed that an agency has financial management mechanisms in place (e.g., financial management system able to track expenditures by accounts, manage cash balances and accounts payable and receivable, monitor funds by source and issue required reports, etc.). The following sections focus on how these data relate to the program delivery stage of asset management.

7.4.1 CURRENT SOURCES OF COST DATA

An appropriate suite of infrastructure management systems, complete with accurate and current cost data, would enable an agency to answer the types of questions presented in Table 7.3 with confidence. However, cost data stored in financial management systems (FMS), infrastructure management systems, maintenance management systems (MMS), and bid tabulations are not consistent and not easily integrated. For example, infrastructure management systems track and calculate costs by output (e.g., square yard of asphalt overlay). In contrast, FMS track costs are based on input (e.g., number of labor hours, equipment hours, units of material used, etc.). Therefore, using FMS data to populate infrastructure management system databases is not always straightforward.

Several potential issues arise even when the fundamental basis of cost tracking is consistent between systems. For example, even though FMS's and MMS's both track output-based costs, they track closely related but different aspects of costs. Table 7.4 identifies examples of these differences. The result of these inconsistencies is that comparing projected future maintenance costs generated by a MMS to actual maintenance cost records from a FMS is not an "apples to apples" comparison.

Table 7.3 Cost Data Types and Uses

Application of Cost Data	Example Questions
Relate cost to outcome	What is the impact on overall network performance if we increase or decrease the annual pavement budget by 10 percent?
Identify cost by asset class and / or group of assets (e.g., route, district)	How much do we spend on bridges in Greengrass County? In District 5? How much do we spend annually to maintain I-1?
Estimate costs of project, maintenance activity, or contract alternatives	Is it more cost-effective to relive congestion on a state highway by adding a lane or enhancing operations with an ITS project? What is the cost of using a DB contract compared to our traditional procurement method? How much does it cost to us to maintain our signs? How does this compare to outsourcing alternatives?
Estimate costs of investment strategies)	What is the life-cycle cost of a deferred maintenance strategy compared to that of a preventive maintenance strategy?
Estimate program-level costs	How does the final cost of delivery a program compare to our initial estimates?

Another common gap in cost tracking is the inability to calculate full costs that capture both direct and indirect costs.

- **Direct Costs** – Infrastructure management system cost totals may not account for the direct costs of additional items included in typical project work. For example, pavement project estimates generated by a PMS may not include additional costs for work on ancillary drainage items, guardrail, roadsides, signs, pavement markings, and so forth.
- **Indirect Costs** – Management system costs may not account for indirect work. This work would include, for example, design, construction management and inspection, traffic management and control, and project administration.

Unknowingly underestimating full costs leads to distorted decision-making throughout the entire resource allocation and utilization process.

Table 7.4 FMS versus MMS Cost Tracking Comparisons

	FMS	MMS
Labor	Time sheets	Time sheets or maintenance cards
Wage rate	By employee with all adjustments (e.g., benefits, bonuses, etc.)	Estimated wage rate by employee class or statewide average rate
Equipment	Lump sum at purchase, depreciated over life	As though equipment was rented (e.g., cost/hour)
Materials	Detailed calculations of stockpile costs	Average unit cost

7.4.2 BRIDGING THE GAPS

Improving cost data is often complicated, agency-specific, expensive, and technically challenging. However, the potential benefits of current and accurate cost data far outweigh these impediments. This section presents three general strategies to bridge the gaps in your agency's cost data.

- Populating an infrastructure management system with activity-specific costs based on data from a FMS, MMS, and bid tabulation records.
- Applying an adjustment factor to MMS results so that they are consistent with FMS reports.
- Developing activity-based costs.

The approach that your agency takes to enhance its cost data should be customized based on its specific data needs and the status of its current financial records and systems.

POPULATING MANAGEMENT SYSTEMS

Future cost projections can be improved by populating management systems with data from a FMS, MMS, or bid tabulation records. This approach may require the following steps:[24]

- Identify existing sources of cost data and compile data.
- Identify activity costs required in your infrastructure management systems.
- Map existing data to these data items. Challenges that may arise during this step include:
  - Activities used by your infrastructure management systems may not correlate directly to the pay item codes used in your other systems.
  - Your FMS and bid tabulation records may express costs in different units of measure than your infrastructure management systems.
  - The activity costs in your MMS may not include overhead and indirect costs.
  - An inflation factor may be required to convert historic records to present-day costs.
- Perform a statistical analysis to determine the reliability of the data (this step may include an analysis of cost variation by district).
- Create an expert panel to review the data and make final adjustments.
- Document this procedure and develop guidelines for future updates.

ADJUSTING MANAGEMENT SYSTEM OUTPUT

An alternative to calculating individual activity costs (i.e., management system *inputs*) is to develop an overall adjustment factor that can be applied to system *outputs*. For example, bringing MMS projections in line with actual data tracked in a FMS may require the following steps:

- Define number of adjustment factors. For example, an agency may opt to calculate one statewide factor, urban and rural factors, or a factor for each district. (The remainder of this section describes an approach for calculating a factor for each district.)

[24] John O. Sobanjo and Paul D. Thompson, **Development of Agency Maintenance, Repair & Rehabilitation (MR&R) Cost Data for Florida's Bridge Management System** (2001).

- Calculate total maintenance cost for each district for a given time period using the MMS.
- Calculate the same costs using the FMS.
- Develop an adjustment factor for each district by calculating the percentage of the FMS figure over the MMS figure (it is a general rule of thumb that FMS costs will exceed MMS costs for highway maintenance).
- Identify large discrepancies and investigate possible causes in the agency's business processes.
- Rely on a panel of experts to review factors and make final adjustments.
- Apply the factors to MMS output during future analyses.
- Develop and institutionalize procedures for updating the adjustment factors regularly.

ACTIVITY-BASED COSTING

Activity-based costing (ABC) is an accounting approach common in the private sector that significantly enhances asset management in the public sector. ABC enables agencies to calculate the full costs of its maintenance and operations activities. Knowing these costs, an agency can:

- Accurately evaluate capital, maintenance, and operation alternatives to address a system deficiency;
- Practice activity-based management (ABM) by highlighting activities with specific opportunities for cost savings and operations enhancements; and
- Compare the cost of performing a task in-house to that available through the private sector.

Following is a summary of the process that the Iowa DOT used to develop activity-based costs.[25]

- Define a set of activities that when taken as a whole, encompass the entire scope of work performed by the division.
- Calculate the ***direct labor*** costs required for each activity. This information may be available from timesheets and must be adjusted for time "borrowed" by other divisions and time spent on non-work activities.
- Calculate the ***material costs*** for each activity.
- Calculate the ***facility costs*** for each activity. First, estimate the facility costs for the entire division (e.g., based on the percentage of floor space of a large DOT facility occupied by the division). Secondly, allocate this total among the activities. Facility costs should include a depreciation expense.
- Calculate the ***vehicle and equipment cost*** for each activity. These costs include original cost, maintenance, operating costs, depreciation, and salvage value.
- Calculating the ***overhead costs*** of each activity. Overhead costs include operations, finance, administrative, and oversight costs.
- Determine ***unit cost*** for each activity by combining all of these costs into a full activity cost and dividing by the number of output units.

[25] Mark D. Abrahams and Mary Noss Reavely, "Activity Based Costing: Illustrations from the State of Iowa", **Government Finance Review** (April 1998). <www.state.ia.us/government/ dom/pubs_ presentations/abc_article_pdf.PDF>

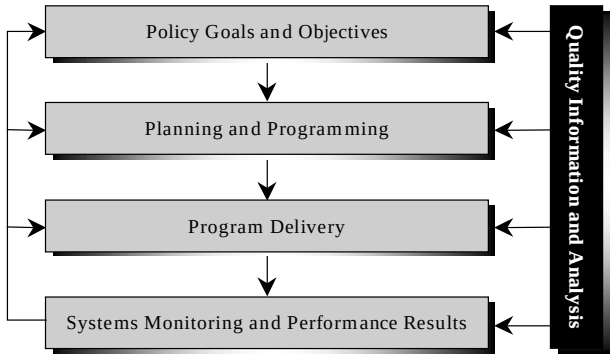
8. INFORMATION AND ANALYSIS

8.1 OVERVIEW

A sound asset management approach requires objective, high-quality data, presented to decision-makers and other stakeholders as understandable, useful information. It is a systems analysis challenge to catalog the many stakeholders and their information requirements, find the simplest analytical and presentation methods that meet as many stakeholder needs as possible, and design data collection processes that efficiently feed the analyses with an acceptable level of quality. In this context, information technology (IT) is a tool to support asset management, not an end in itself.

This chapter provides a management-level overview of the process design issues involved in delivering sound information to decision-makers. IT support of asset management in the broadest sense draws upon wide-ranging expertise in planning, finance, various technical disciplines (e.g., pavements, bridges, traffic, safety) and functions (design, construction, maintenance, operations), business process and work-flow re-engineering, economics, statistics, systems analysis, database management and data integration, software development, and communications. Transportation agencies may already have this expertise in-house or have the ability to procure needed experts from outside. A large body of literature exists in each subject area, of which selected samples are cited in this chapter.

Figure 8.1 Information and Analysis within Resource Allocation and Utilization



There are no comprehensive asset management systems that can satisfy all stakeholder needs off-the-shelf, though there do exist entire competitive industries having effective solutions to parts of the problem (e.g., data collection equipment, pavement and bridge management systems, geographic information systems, and asset inventory systems). Each agency has to decide which commercial systems to buy, which required capabilities should be developed in-house or by consultants, and which capabilities can be used as they already exist. Each agency also has to decide which initiatives to undertake right away and which to defer or to implement in a staged development.

8.2 INFORMATION NEEDS AND DATA QUALITY

Figure 8.2 presents a model for improving an agency's data resources. As with many of the processes discussed in this ***Guide***, this data improvement approach represents a cyclic process enabled by a feedback loop. However, for simplicity, the process is discussed as if it were a linear process starting at the top-right of Figure 8.2, performing an Audit of the Current Situation. Section 8.2 discusses all of the steps through Ensure Data Quality. Improvements to data integration and accessibility are addressed in Section 8.3.

8.2.1 DEVELOPING A DATA STRATEGY

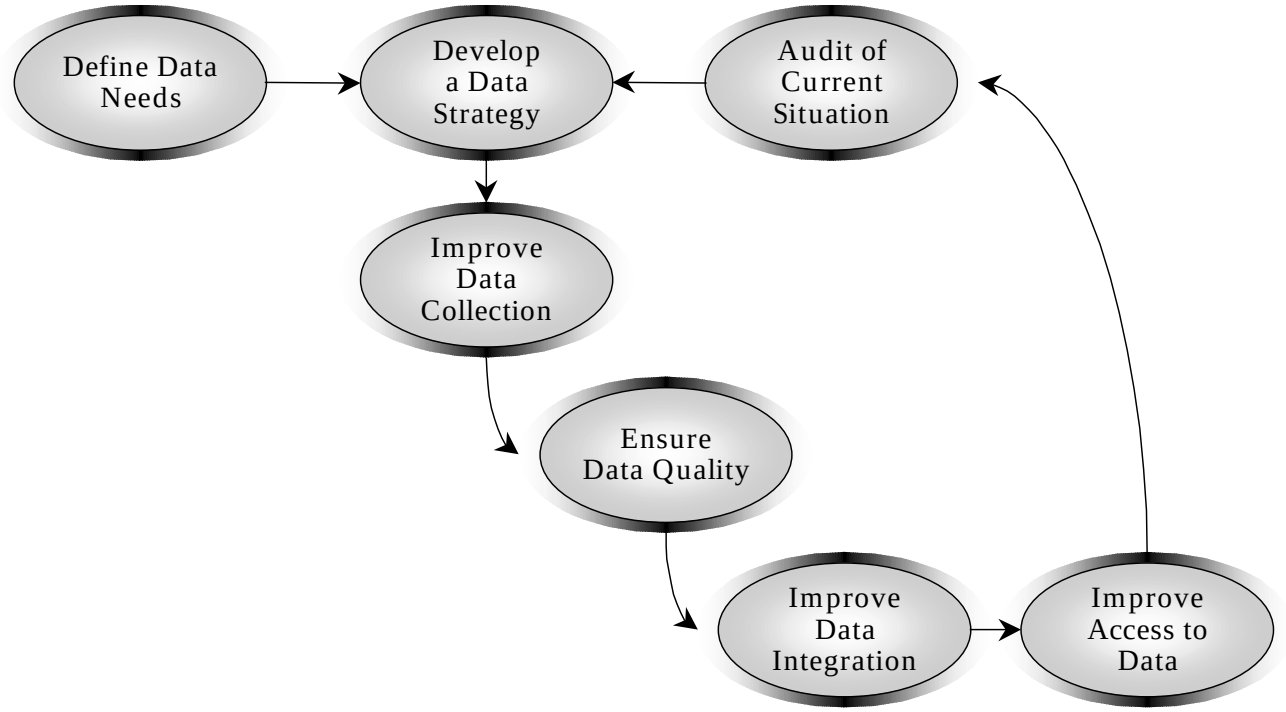
Developing a data strategy requires performing a performance audit of the current IT environment and practices at an agency and defining data needs. The audit will help identify key IT issues that need to be addressed by the data strategy. Areas to consider during this audit include:

- Data that currently is available throughout the agency;
- Data requirements of existing and planned management systems and decision-support tools;
- Data collection and maintenance costs; and
- The value (real and perceived) of data for decision-making.

The results of the IT audit will feed into the identification of data required to implement and support an agency's transportation asset management functions. These decisions depend upon the scope of asset management and the particular business processes conducted by the agency, as discussed in Chapter 4. The example requirements below

provide guidelines for identifying data items required to support asset management. Individual agencies should tailor these examples to their particular practices and system objectives, and may choose to develop requirements in more detail to relate to specific business process, system, and data characteristics.

Figure 8.2 Data Improvement Model



ASSET INVENTORIES

- Inventories for different asset classes should be based on a common location-referencing scheme. This standard allows for queries of which assets are present in a given location or network segment, and provides a unified basis for data input, display, and reporting.
- A common set of geographic descriptors and classification categories for summarizing information should be supported across asset types – e.g., districts, corridors, functional classes, responsible agency for ownership and operation, climatic or topographic zones, and so forth.
- The coverage and detail of inventory data for each asset class and type[1] should be established at a level that is appropriate to the scale of investment required for that class, business process requirements, and data collection costs. Choices include, for example, use of a sampling approach versus 100 percent coverage; annual updates versus less frequent surveys; and identification of specific items at individual locations versus aggregate counts within intervals or segments.
- The inventory should include sufficient information on asset characteristics and classifications to support the full range of asset management business processes, including condition assessment, GASB financial

[1]For example, if "pavements" and "hardware" are asset classes; "flexible pavement" and "signs" would be asset types.

reporting of infrastructure assets,[2] needs analysis, and project prioritization. A strategic overview of transportation assets is needed to define an inventory of appropriate structure and detail, with standards of precision, accuracy, and timeliness of data collection that meet these varied needs.

- While there may be separate inventories for each class of asset, commonly used data (such as functional classification and AADT) should not be collected more than once. If individual systems require the same kind of information, but in different formats, or at different levels of detail, then automated methods should be established for deriving the necessary information from the primary source.

CURRENT ASSET CONDITION AND PERFORMANCE

- For each type of asset, at least one objective measure of condition should be collected and stored.
- Ideally, historical condition data (possibly in aggregated form) should be maintained and made accessible to support trend reporting and analysis.
- In addition to purely technical condition indicators (e.g., pavement roughness, sign visibility or reflectivity, and percent items deficient), other measures that are useful for policy-making and reflect customer perspectives should be collected and stored. Examples include composite condition or serviceability indexes, customer satisfaction ratings, and measures of user cost or benefit are useful for policy-making and reflect customer perspective.

COST DATA

- Cost data should account for the full costs of an activity; accounting for indirect as well as direct activities. Construction and maintenance cost information should be compiled so that a time-series of costs can be derived: e.g., by work type, asset type or asset class, location and network classification.

PROGRAM DELIVERY INFORMATION

- Maintain records of actual costs and time of completed projects, including significant changes
- Program outcomes in terms of established performance measures

8.2.2 MAXIMIZING DATA COLLECTION AND DATA MANAGEMENT EFFICIENCY

EXISTING TECHNICAL CAPABILITIES

A major source of simplification and economy is to take advantage of existing data collection processes, systems, and standards. A transportation agency has many opportunities to do this. Here are just a few examples:

- Agencies can take advantage of commercial off-the-shelf systems for storing and managing asset data (e.g., commercial database applications, querying and reporting applications). Bridge, pavement, and maintenance management systems are now used by most transportation agencies for this purpose.
- Several firms offer to sell, lease, or operate automated data collection equipment, including pavement survey vehicles, truck weight and dimension measuring equipment, and bridge monitoring devices. Taking advantage of this technology is often less expensive than performing similar functions manually.
- Often data collection equipment or procedures can be applied to multiple purposes. For example, pavement management survey vehicles can inventory and videotape roadside features, measure obstructions, and record information about capacity and access. These data can be used by other units in a DOT: e.g., for safety, geometric design, maintenance, etc. Bridge inspection processes can record traffic safety features and speed restrictions at bridge sites. Crash data can be mined to analyze vehicle occupancy.

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[2] GASB refers to the financial accounting and reporting standards issued by the Governmental Accounting Standards Board. Many of the references to GASB in the system requirements listed in this section will apply only if the modified approach is used for financial reporting.

Virginia Inventory and Condition Assessment

The Virginia DOT has developed a comprehensive Inventory and Condition Assessment System (ICAS) to facilitate the management of the extensive assets associated with the Commonwealth's highway and road networks. The system employs state-of-the-art automated data collection and precise global positioning technologies. The purpose of the system is to provide an accurate inventory of transportation system assets, determine and record their condition, and locate them geographically using global positioning satellites. This information is loaded into a relational database to provide tools for decision makers to get a near real-time picture of the state of their transportation network and assist in effective, responsive planning and the most efficient allocation of scarce resources. ICAS provides the foundation for the statewide asset management system.

When ICAS is fully implemented, VDOT can use this system to immediately access information about any asset, including lighting, signs, guardrails, traffic control devices, and drainage, to determine exact location and condition to ensure effective and efficient maintenance and safe operation of the roadway network. The capability to access spatial information also allows decision makers to visualize the situation and take appropriate actions in case of natural disasters or damage by vehicles to the roadway network. Since the requirements can be identified quickly, work efforts can be prioritized efficiently to ensure the most critical requirements can be satisfied first, gaining the most effective results from constrained resources and workforce to meet the public's transportation and safety needs. This system also provides ready access to vital information for long range planning, budgeting, and resource allocation. In addition, the database provides an efficient storage medium for historical information that might have been lost in the past as experienced personnel relocate or retire, ensuring continuity of operations.

The data collection system employed in the initial three-county pilot effort consists of three key elements: 1) field collection using inspectors with backpack-mounted computers, voice recognition software, and global positioning equipment; 2) van mounted data and digital image collection systems; and 3) asset collection from digital and orthographic images. The data collected are then used to build an asset inventory and develop roadway centerlines (geometric data).

Field collection using backpacks and a voice recognition system was highly innovative and effective. It allowed inspectors to establish accurate geo-referenced location, compile a detailed inventory, and assess condition. All of this information was collected and entered into the database "hands-free," allowing effective and safe data input. This method also allowed collection and assessment of highway assets such as pipes and drainage that are not visible in ground-based imagery or digital orthophotography.

In areas where it was not safe or impractical to accomplish field collection, inspectors used the van collected digital images to obtain and record asset data/information. Lastly, some information, such as ramps and loops, was collected directly from orthophotographic images. All of this asset information was merged with the field data and entered into the central database.

In conjunction with this effort, VDOT contracted the collection of right-of-way images and development of roadway network centerlines. This was a significant element of the project because it develops roadway centerlines for the entire statewide network, including interstate, primary, and secondary roads. this information will also be entered into the database.

The central database employed in this project is a relational database that allows VDOT to access needed linear-referenced inventory and condition assessment information to enhance effective and timely planning, decision-making, and resource allocation by the various offices and districts in VDOT responsible for the effective, efficient, and safe operation and maintenance of the state's highway and road network.

- Global Positioning System (GPS) equipment is becoming widely used to pinpoint the locations of road segments, structures, and roadside features. A single GPS survey should be able to satisfy the needs of all types of assets, as well as recording speed limits, traffic direction, number of lanes, route connectivity, and other geographic network information about the infrastructure.
- Maintenance crews typically have to fill out timesheets, and contractors have to report work they have accomplished. These activities can be augmented to record data necessary for estimating quantities and costs to improve planning models. GPS equipment on maintenance vehicles can help to ensure the accuracy of this information.
- Data collection processes done by in-house staff require training and standardization. Agencies can take advantage of industry standards, which help improve the quality and lower the cost of data collection. For example, AASHTO has new standards for pavement management data collection. In addition, pooled efforts can be used to spread the cost of

developing training and quality control procedures.

There may be a disadvantage of using existing procedures and equipment for a new data collection need, in that the existing method may not be fully adaptable to the new requirements. For example, when an agency decides to adopt an off-the-shelf pavement management system, it typically has to choose between living with the existing database architecture even if it is not an exact fit to the agency's needs, or foregoing compatibility with future enhancements that may be provided by the vendor. It may be possible to build a software "shell" or "adapter" around an off-the-shelf system that tailors the system more closely to the agency's requirements.

SAMPLING TECHNIQUES

Another way to economize in data collection is to use sampling. Sampling is a powerful tool for certain applications, but it also has distinct limitations. In an inventory where each individual facility is significant and failure of any one could be catastrophic – bridges, for example – sampling may not be appropriate in certain applications. Even in bridges, however, sampling can play a role: for example, estimating the severity of chloride contamination of bridge decks is done by taking samples scattered over the deck surface.

Effective Use of Sampling

Sampling is often used when the data are representative and where the consequences of not observing every facility are not catastrophic, or where a backup process is in place to detect serious problems. One common example is the measurement of sign cleanliness and reflectivity. Many agencies check a random sample of signs periodically to gain a statistical indication of sign condition. The backup process is the watchfulness of local maintenance supervisors, who are expected to report individual cases of missing or obscured signs.

Sampling also may be used to exploit a cause-and-effect relationship to estimate a difficult-to-measure variable from sampled data, using one or more variables that are easier to measure and have larger or exhaustive samples. For example, a strategy to predict costs in pavement or bridge management systems might involve three stages:

1. Start with an exhaustive sample of condition data from ongoing data collection processes, showing the extent of deterioration on each facility.
2. From a relatively large sample of work accomplishment data, estimate the quantities of various kinds of work required (e.g., pay items or bid items) as a function of the deterioration quantities and other relevant variables.
3. From a smaller sample of work records, estimate the unit costs of the pay items and bid items.

This three-level approach recognizes the fact that the extent of deterioration is readily available for all facilities, but quantities of work are less accessible, and accurate costs are less accessible still. Recent work in developing unit costs for bridge management systems uses approaches like this.[3]

8.2.3 ENSURING DATA QUALITY

Quality assurance is an ongoing process, using system design, statistical methods, training, and auditing to maximize various attributes of data that together we know as quality. Quality is not free, but the expense of quality assurance does tend to pay for itself later.[4] For example, increased quality of bridge inspection saves the expense of sending crews to a bridge site for repairs that turn out not to be needed, or setting up emergency repairs on a bridge where an existing problem had not been detected.

Measurement of quality begins by identifying several important attributes, and determining their importance to the end result.

- **Accuracy.** Data are accurate when repeated measurements cluster around the "true" value of what is being measured. Accuracy is determined by performing occasional check

[3] Sobanjo, John O., and Paul D. Thompson, *Development of Agency Maintenance, Repair, and Rehabilitation Cost Data for Florida's Bridge Management System*, Final Report, Florida Department of Transportation , 2001 (available on www.pdth.com/images/fdotagcy.pdf).

[4] Crosby, Philip B., *Quality is Free: The Art of Making Quality Certain*, McGraw-Hill, 1979.

measurements using a more accurate (but probably more expensive or scarce) tool.

- **Precision.** Data are precise when repeated measurements are tightly clustered around the same value, whether or not it is the "true" value. GPS measurements, for example, are more precise than locating an object on a map.
- **Coverage.** The extent of coverage of a data set is a key design decision and a key limitation on its usefulness. An inventory of state highways, for example, is of no help to project-level needs identification for local roads.
- **Timeliness.** Timeliness refers to the age of data at the time they are used. Timeliness must balance several competing requirements: e.g., the appropriate point or season of the year in which to conduct inspection surveys; the need to process data for use in management system(s); and the need for the resulting information by one or more organizational units in assessing current condition, comparing actual to planned accomplishments, identifying work needs, developing a program budget, and so forth.
- **Detail.** Appropriate level of detail is an application-specific requirement that is often a matter of definition. PMS and BMS need unit cost data at a level of detail that matches the definitions of treatments that their models can analyze.
- **Accessibility.** This attribute of data quality refers to the ease with which the data can be put to use. Weigh-in-motion data, for example, are an excellent resource for truck weights, but are often useless unless processed to the needed level of detail.
- **Assumptions and Definitions.** Data sources may have definitional differences or inherent assumptions that make them more or less useful for asset management applications. For instance, definition and interpretation of pavement condition data may differ between an agency's PMS and MMS.

QUALITY STANDARDS

When two or more information systems share the same data source, it is important to have a formal, documented quality standard, describing minimum and maximum requirements along all the dimensions noted above, that meet the needs of the stakeholders using the systems. This serves as a multi-way agreement among the end-users, data collectors, and system developers, an agreement that should not be modified without again involving all these stakeholders. Upper managers do not have to be involved in developing these standards, but they do need to insist that the standards are developed.

Data quality standards are an essential management tool: they are directly connected to budgetary requirements for data collection, and they provide a streamlined way for upper management to ensure that conflicts regarding data quality are resolved. With this tool, a manager responsible for a data collection budget can express the impacts of budgetary increases or decreases in terms of changes to the data quality standard, and their effect on specific end-users.

QUALITY ASSURANCE

Quality assurance (QA) processes require a context of documented standards, and they are the mechanism by which adherence to standards is measured. Senior managers are not typically involved in quality assurance personally, but the existence of QA processes, and periodic effectiveness measures, are what provide managers the needed control and assurance. The first point of quality assurance is the training of data collectors and equipment operators.

Data Collection Training

Bridge inspectors have at least two weeks of formal training, often much more, including classroom and field work. They are then tested and certified. To maintain certification, they must take refresher courses and be re-tested periodically. Although it is possible to create training courses in-house, it is often far more cost-effective to use externally-developed courses, even though this may mean changes or limitations on data quality standards. The National Highway Institute offers a variety of courses, including bridge inspection, and manufacturers of data collection equipment often offer training.

Quality assurance with respect to use of fully automated data collection equipment includes defining standards for measurement, planned equipment testing and certification, and applying calibration procedures prior to surveys and verification of calibration following surveys.

After data are collected, a number of methods are available to measure adherence to the quality standards. These include re-inspection strategies, consistency checks, stakeholder surveys, and formal data audits.

RE-INSPECTION

It is a standard procedure in any sizeable data collection process to devote a portion of the resource, often five to 20 percent depending on the consequences of error, to re-collect a sample of data using similar or better equipment and/or personnel. For example, after a section of road is completed with a pavement survey vehicle, an agency might use an alternative vehicle, a different crew, or even profile measurements made by land surveying equipment, to double-check the initial data. Locations for the re-check are typically chosen by random sampling, and statistical methods are available for deciding how many locations to check[5]. The results of these checks are tracked over time as a performance measure. Sometimes crews compete and are rewarded according to the results of the process.

CONSISTENCY CHECKS

Often data sets have built-in redundancy. For example, a roadway inventory may have the number of lanes, lane and shoulder widths, and traveled way width. An automated process could easily identify discrepancies needing evaluation. A well-designed information system should be able to perform these checks automatically, and flag potential problems for later resolution. The ability to resolve such problems at a later time is important, since it may have to wait until the next data collection cycle or until someone can be dispatched to visit the facility. After resolving the issue, it should be possible to record an explanation and turn off the flag even if no correction is warranted. The number of such errors in newly collected data, and their resolution status, should be tracked as a quality measure.

STAKEHOLDER SURVEYS

For certain attributes of quality, it is efficient to ask stakeholders to report the level of quality they perceive in the information they receive, including their level of satisfaction. Although stakeholders generally can not easily measure accuracy (except anecdotally) or precision, they can often uncover problems with coverage, timeliness, detail, accessibility, and definitions.

DATA AUDITS

Occasionally it is useful to employ an outside agency or consultant for an independent review of data quality, especially if the consequences of incorrect information are dire. In bridge inspection, for example, it is common for districts within a state to swap inspectors periodically to give a fresh perspective. The FHWA, an important user of bridge data, conducts regular audits of states' bridge inspection practices.

It is very important for senior managers to recognize that data quality for asset management is relatively easy to define using the approach described here, and is highly measurable at reasonable cost. For each data item (or group of items) in an asset management database, it is reasonable to identify, along with the source of the data, the quality control process that ensures that the data will be sufficiently accurate for its intended use, according to all relevant quality dimensions. Doing this in an organized way is less expensive and more effective than an ad hoc approach, and certainly less expensive than the consequences of poor decisions that could result from incorrect or insufficient data.

8.3 DATA INTEGRATION AND ACCESSIBILITY

Data integration is a set of processes and systems to share data from one source among multiple applications, or to merge data from multiple sources for use by a single application.[6] As agencies have applied several maturing information systems related to asset management over the past 20 years, they have come to recognize more widely the importance of data integration. However, competing philosophies and technologies have led to a wide range of alternative approaches. For those wishing a more detailed description of data integration approaches,

[5] Cochran, William G., *Sampling Techniques*, Wiley, 1977.

[6] Management System Integration Committee (MSIC), *The Integration of Transportation Planning Information*, Federal Highway Administration, 1998.

the FHWA has published a *Data Integration Primer*.[7] In addition, the FHWA is sponsoring an in-depth review of current data integration practices and their application to transportation asset management. This project is scheduled for completion in 2003.[8]

8.3.1 BENEFITS OF INTEGRATION

The benefits of integration are clear:[9]

- Provide more thorough information that yields a more accurate picture of what a manager is managing. Effective integration matches available data to each user's responsibilities.
- Help coordinate management functions across departmental units (e.g., among construction, maintenance, and operations regarding proposed road closures).
- Allow existing data collection processes and information systems to serve new applications they were not originally intended for. For example, the outputs of several asset management systems can be brought together for integrated programming and budgeting applications.
- Make data more understandable by having standardized definitions and measurement techniques and units across the agency.
- Reduce data collection cost by avoiding duplication of effort and making more efficient use of expensive data collection equipment and technical personnel. Data collection and associated database management can have significant economies of scale.
- Make systems and results consistent by using the same data sources.
- Make quality assurance processes as manageable as possible.
- Make multiple data sets accessible for comparative, analytical, and reporting purposes by linking the data electronically.
- Enable applications that may be important but have too narrow an audience to justify their own data collection processes.
- Improve communications by making data presentations more intuitive and complete.

8.3.2 APPROACHES TO INTEGRATION

While current infrastructure management systems provide many useful capabilities, they are not widely integrated, and may not meet all of the analytic and reporting needs of an agency's desired asset management approach. Areas where better integration may be considered are as follows:

- **Data collection, processing, and storage –** Efficiency can be gained by using data collection techniques that serve multiple business areas and associated IT applications: e.g., customer satisfaction surveys that cover a wide range of topics, collection and processing of a single set of traffic statistics, and use of pavement survey vehicles that collect data for pavement, traffic, safety, and maintenance management. Analyzing and storing data in an integrated fashion avoids data duplication or conflict, provides a consistent basis for analyzing infrastructure usage, condition, performance, and related user benefits, and promotes data integrity.
- **Queries of asset conditions, needs, and planned projects** – The capability to access information – e.g., on infrastructure characteristics, conditions, deficiencies or needs, and planned projects – using a flexible, easy-to-use query feature allows for custom reports and rapid responses to management questions. Combining this feature with a map display provides a useful visual tool to identify problem locations and proposed solutions.
- **Consistent evaluation framework in analyzing projects and programs** – Even though different types of projects and classes of assets may need to be analyzed using specific engineering and economic methods, a common framework provides a basis for evaluation and investigation of tradeoffs. This framework

[7] FHWA, *Data Integration Primer*, Office of Asset Management, August 2001.

[8] Contract DTFH61-01-C-00181, managed through FHWA's Office of Asset Management.

[9] Several of the following benefits and drawbacks of data intergration were discussed in NCHRP Report 363, *Role of Highway Maintenance in Integrated Management Systems*, Chapter 3, 1994.

might entail, for example, use of a life-cycle cost approach to project evaluation where appropriate, and common measures of cost, benefit, and performance that allow for comparisons across project types and asset classes. The framework also should promote consistency in technical assumptions such as discount factors, value of time, accident cost, and so forth.

- **Improved *decision support* in the following areas**:
  - **Executive Information –** System capabilities and tools that are specifically designed to provide policy-level information are needed to better support executives and managers needing a "big picture" view.
  - **Tradeoff Analysis** – Methods are needed to assist with tradeoff analysis across asset classes, program categories, and types of investment, making use of comparative analyses of costs, benefits, and performance measures.
  - **Benefit/Cost Analysis** – Benefit/cost analysis provides a useful, commensurate basis to evaluate different categories of candidate projects. When structured in a life-cycle cost context, it provides an economic framework for analyzing capital-maintenance and capital-operational tradeoffs.

GIS as a Platform for Integration

New York State DOT now integrates its pavement management and bridge management information on a GIS platform as part of its asset management development. A typical display shows a map with the highway system, on which are superimposed color-coded symbols indicating pavement or bridge projects, respectively. Double-clicking on a project symbol opens a window displaying detailed information on the project. An analogous approach is now under development in Michigan DOT and Arizona DOT, and is proposed in CDOT. MDOT has compiled a unified data repository, ADOT is designing and developing a data warehouse, and an extension of CDOT's data warehouse to asset management is now proposed. These data warehouses will consolidate asset inventory information and potential project information from asset management systems, communicate with a GIS to display asset information spatially, and generate management reports efficiently, including reports designed and formatted for higher-level management.

The best model to use for improving data integration can vary by agency and therefore should be considered on a case-by-case basis. Similarly, the actual cost of each strategy will depend upon the specific situation at hand. It is possible to stage the migration of data to provide near-term improvement while planning for longer-term redevelopment.

8.3.3 IMPROVING ACCESS TO INFORMATION

Most states employ asset management systems: particularly for pavements and bridges, but also for safety, public transit, intermodal facilities, other system features and appurtenances, construction projects, maintenance, and traffic operations. Surveys conducted by NCHRP[10] and the FHWA[11] indicate that these systems are widely used for technical and research purposes, including detailed program

[10]Lance A. Neumann, *Methods for Capital Programming and Project Selection*, NCHRP Synthesis 243 (1997).

[11]Edgar P. Small, Terry Philbin, Michael Fraher, and George P. Romack, *The Current Status of Bridge Management System Implementation in the United States*, International Bridge Management Conference, IBMC-043, Transportation Research Board and Federal Highway Administration, Denver CO (April 1999).

development. However, their use by higher-level or executive management for decisions such as resource allocation and program tradeoffs is much less frequent. Initiatives in asset management and compliance with GASB Statement 34 will likely change this outlook. Several state DOTs have already made efforts to provide wider access to the information required to support their business processes. For example, WSDOT has for several years successfully employed an executive information system that provides high-level programmatic and financial information to WSDOT managers, legislators, commission members, and staff. WSDOT's maintenance levels of service are likewise implemented in this executive-level system, complete with color photographs illustrating each level of service within a maintenance program area. Users can apply the system to explore budget implications of changes in level of service within each program area. Michigan DOT has been contemplating to build such a system upon its existing asset management applications. NYSDOT's maps of its high-level program performance measures (discussed above) also are an effective illustration of information tailored to executives.

8.4 DECISION SUPPORT

8.4.1 OVERVIEW

At any level of maturity, a transportation agency with a bona fide asset management process uses the data it collects in some productive way to make better-informed decisions. As the process improves over time, decision-makers and other stakeholders gain increased trust in data quality, and garner more usable and capable tools for accessing and presenting information. At some point, decision-makers reach the limits of utility that presentation tools can offer, and need more sophisticated tools in order to exploit their valuable data resources to further improve decision-making. Decision-support tools serve several important purposes:

- They digest a large amount of input data into a much smaller and more focused set of information needing immediate attention;
- They convert data collected according to the definitions and norms of engineers and data collection staff, into terms and concepts more familiar and useful to managers;
- They provide an economic perspective on facility conditions, and calculate performance measures in a form compatible with the agency's objectives, uniformly across all asset types;
- They predict the future outcomes of decisions under consideration; and
- They express decisions and predicted outcomes at the level of detail and coverage appropriate to each specific decision-maker.

Agencies already have considerable IT capabilities supporting transportation asset management. All states have, at a minimum, two basic pools of data: one associated with FHWA's Highway Performance Monitoring System (HPMS), which provides information on geometric, structural, and operational condition for a sample of roads; and the second required by FHWA's National Bridge Inspection (NBI) Program. Most DOTs, however, have more extensive highway inventories and periodic inspection and condition assessment programs. Inspection survey data for assessing the physical condition of infrastructure are obtained through a variety of techniques, including drive-by visual observation, detailed site inspections, non-destructive testing, automated vehicle measurements, and photo- and video-logging. Operational data describing real-time conditions of the transportation system are likewise obtained through a number of technologies, including cable or loop detectors and cameras for monitoring traffic flow, speed, and vehicle characteristics, and sensors for monitoring road surface temperature and precipitation. These data are used in systems to manage infrastructure, as described in Figure 8.3, and traffic operations and safety, as listed in Figure 8.4. Figures 8.5 and 8.6 identify systems that, while not addressing infrastructure specifically, play important roles supporting asset management.

Figure 8.3 Typical Infrastructure Management Systems

Infrastructure Management Systems
Pavement Management – Nearly all states have pavement management systems (PMS). Experience with these systems over several decades has led to a high degree of refinement regarding information organization and content and decision-support procedures. These systems generally have capabilities for maintaining and reporting the status of the pavement inventory, current and historical condition, forecasts of performance for assessing future needs, guidance on project and program development, and actual performance of pavement parameters (e.g., materials, structural design, mix design, etc.) in such applications as Superpave and the new AASHTO 2002 mechanistic design.
Management of Bridges and Other Structures – Bridge management systems (BMS) have well-developed data, analytic, and reporting capabilities for bridge structural and operational condition. Some states have employed BMS to represent other structures such as high-mast light fixtures, sign bridges, and minor tunnels. However, this practice is not standardized, and additional systems development may take place to address these and additional structures (e.g., retaining walls, ITS installations) more specifically. The FHWA, in partnership with the Federal Transit Administration (FTA), recently completed the development of a Tunnel Management System for highway and transit tunnels.
Maintenance Management – Many states have a maintenance management system (MMS) in place. The original uses of these systems were to record information on maintainable highway features, plan and schedule maintenance activities, and estimate budgets and resource requirements based upon standardized, statewide work-requirement factors. Recently several DOTs have enhanced their analytic approach to maintenance management to develop level-of-service or performance-based methods for maintenance budgeting, bringing MMS closer to the concepts used in PMS and BMS. More integrated MMS are on the horizon that will link maintenance management with other DOT functions in transportation asset management, financial management, resource management, and construction project management.
Other DOT-Maintained Facilities and Features – While many agencies employ their maintenance management systems to monitor condition of facilities (e.g., rest areas) and features (e.g., guardrail, signs, and signals), some agencies have developed individual management systems to maintain more detailed information on these items.
Other Modal Facilities – The application of IT to assets of other modes is more varied among DOTs, due to different program responsibilities and levels of budget that DOTs exercise among transit facilities, aviation and maritime facilities, pedestrian ways and bicycle paths, and intermodal facilities such as park-and-ride lots and stations. Transit routes, pedestrian ways, and bikeways that are part of the highway network may be designated within a highway database or maintained in a separate system or database, while individual modal and intermodal facilities may be addressed by a separate IT application. A complicating factor is that modal responsibilities may be vested in more than one agency, in which case the DOT's role is associated, for example, more with program funding and monitoring than with line management responsibility. In many cases a DOT's role in these other modes, and consequently its IT applications, may focus more on operational rather than infrastructure concerns.

Figure 8.4 Typical Management Systems in Transportation Operations, Safety, and Customer Service

Transportation Usage and Customer Services
Highway Usage, Operations and Safety – All states maintain data on traffic (at a minimum, annual average daily traffic or AADT), and accidents by location, though the level of detail and sampling strategy varies. Some states have capabilities in place such as traffic operations centers to track more detailed operational characteristics (e.g., congestion patterns, speeds) for particular facilities.
Congestion, Safety, Public Transit and Intermodal Management Systems – The degrees of implementation and the operating characteristics and scope of these systems vary among agencies. The most sophisticated treatments of these topics occurs in traffic operations centers, which monitor traffic speed and congestion in real time, and with ITS installations, which, among other technologies, employ real-time monitoring and information feedback to the traffic stream (e.g., through variable message signs).
Transportation Network Planning Models – Most transportation agencies have basic trip generation, modal split, and traffic assignment modeling capabilities in place to forecast future transportation movements, with associated data: e.g., trip origin-destination tables and network characteristics (distance, speed, travel time, cost). These models are used primarily at the regional level, though a number of statewide models also are in use. DOTs also may track demographic data that influence demand for, and impacts of, transportation: e.g., population, employment, socioeconomic characteristics, and travel patterns. Some states have freight as well as passenger travel information.
Customer Information – Some states maintain data on customer perceptions of service quality that are obtained via surveys. Event tracking systems also are used by some DOTs to log customer questions and comments, initiate any needed work orders, and manage the closure of each item.
Real-Time Weather Information – DOTs in winter climates that may lead to freezing temperatures on pavements and snow and ice precipitation may monitor weather conditions in real time. These systems employ sensors that report air and pavement temperature and precipitation on the road surface as they occur. These monitoring systems may be combined with weather forecasting capabilities that apply data on local site conditions within area meteorological models to forecast weather conditions affecting roads.

Figure 8.5 Typical Systems to Manage Agency Resources

Agency Resources

Accounting and Financial Management – DOT systems for comprehensive accounting and financial management are central to tracking and reporting departmental funding and expenditures by program. They document funds expended by program, organizational unit, work task, and type of expenditure, supporting asset management in several ways: e.g.,

- They enable tracking of historical trends in revenues and expenditures, which can be correlated with major program changes and influencing factors.
- They enable agencies to identify the full costs of building, operating, maintaining, and rehabilitating transportation infrastructure, and to compare the costs of different methods of program delivery.
- They define the "ground truth" for dollars received and spent as a reference for other management systems. Program costs calculated by other systems (e.g., PMS, BMS, MMS, equipment or materials management, construction project management) can be reconciled against financial system data.
- They can identify the costs of responding to extraordinary or non-typical situations (e.g., emergency and disaster response, major interdistrict transfers of resources, and special applications of program funds).

Human Resource and Payroll Management – Agencies have systems to manage employee information and payrolls. Human resource data back-up line managers' assessments of the availability and cost of in-house staff to deliver products and services, influencing decisions on feasible methods of program delivery. Information on labor skills and costs by organizational unit can be applied within integrated maintenance management systems to provide more precise tracking of activity accomplishment as well as single-source input of labor time reporting.

Maintenance Resources – MMS are the primary tool for scheduling and managing maintenance resources across organizational units and for comparing methods of delivery (e.g., in-house labor forces versus outsourcing). They do not, however, track labor usage and costs to the same precision as that employed in human resource systems, payroll systems, and financial management and accounting systems. Moreover, their costing of equipment in terms of simple "rental" rates based on usage (e.g., by hour or mile) and of materials in terms of essentially a unit cost may only approximate the more precise calculations used in other systems.

Equipment and Materials Data – Agencies may track information on heavy equipment (as for construction and maintenance) and materials through financial system modules or via specialized equipment and materials management systems designed specifically to reflect agency purchasing and accounting conventions. These systems incorporate algorithms that meet an agency's specific approaches to cost assignment and accounting: e.g., depreciation or estimation of rental charges for equipment, and stockpile or inventory calculations for materials.

Real Estate and Property Data – Agencies may employ specialized systems to manage right-of-way holdings and acquisitions, as well as buildings and properties ancillary to the transportation network (e.g., maintenance yards, garages for DOT equipment).

Figure 8.6 Typical Systems to Manage Programs and Projects

Programs and Projects
Planning and Programming Information – Agencies often support planning and programming procedures and STIP development with IT applications identifying the status and characteristics of candidate projects. These systems organize project information within a time horizon, typically 10 to 20 years for planning, six to 10 years for mid-range investment plans, and three to six years for programming. Data usually include project identification by program, proposing agency or division, estimated cost (total or by phase: preliminary engineering, right-of-way acquisition, and construction), planned years of phased implementation, and funding sources. This information may be printed and incorporated as part of a DOT's long-range plan, its statewide transportation improvement program (STIP), and other agency planning and programming documents.
Project Pipeline and Construction Management – Agencies also may maintain information on construction projects in various phases from preliminary engineering to completion. Project pipeline systems address project status following approval of the STIP and the annual/biennial construction program, as projects move into design, right-of-way acquisition, environmental evaluations, and permitting prior to advertisement of bids ("ad date"). Construction management systems address project implementation following opening of bids and construction contract award, through to project completion and closeout. Project milestones, critical events affecting progress, and payments to contractors are tracked. Approved changes in the scope, cost, and schedule of each project also are recorded.
Bid Costs – Many agencies track the cost of construction projects in terms of a standardized list of bid items and associated unit costs. Each advertised project that includes a particular bid item contributes a paired data point in terms of the unit cost submitted by the winning bidder and the specified quantity of the bid item. At the end of the year the weighted-average unit cost of each bid item is computed from these accumulated data pairs; the unit costs of all bid items are published or maintained in a database. Data may be computed statewide or by geographic unit such as district or county. These data provide guidance to engineers on current bid prices, reflecting trends in labor, equipment, materials, and subcontractor costs and the local bidding climate.

8.4.2 SAMPLE INFORMATION SYSTEM REQUIREMENTS

INFORMATION SYSTEM REQUIREMENTS

This section provides several examples of information system capabilities that support the resource allocation and utilization process illustrated in Figure 8.1. The organization of these examples is consistent with the organization of the data needs presented in Section 8.2. Individual agencies should view these examples in the context of their individual practices and system objectives, and may choose to further investigate capabilities that are highly relevant to their business processes and inline with their existing suite of management systems.

CURRENT ASSET CONDITION AND PERFORMANCE

- Systems or analytic tools should be able to derive values of established agency performance measures from raw condition data in an unambiguous and replicable way (e.g., to compute a cracking index as a function of type, severity, and extent of cracking). If the condition measures or indexes are used in the financial reports of infrastructure, they should conform to GASB 34 standards.
- Systems should support queries of individual asset condition and of aggregate condition measures, composite measures, and combinations of measures, by location and asset class or type.

PROJECTED ASSET CONDITION AND PERFORMANCE

- Systems should provide the capability to project future asset condition: e.g., using asset deterioration models. Ideally, the system will be able to apply actual data from condition monitoring to automatically update these deterioration models.
- Systems should provide the capability to project future values of established agency goals, objectives, or target performance measures.
- Systems should project condition in relation to a target condition level, also referred to as scenario testing (refer to the example on the following page).

COST ESTIMATION AND REPORTING

- Systems should utilize models to estimate costs of key activities in transportation asset management, particularly for projects to build, repair, rehabilitate, and reconstruct infrastructure, and for preventive and routine maintenance. To the degree possible and appropriate, these models should try to achieve the following criteria: accounting for the full costs of an activity (refer to Chapter 7 for more details on cost tracking); distinguishing between constant- and current-dollar estimates; clarifying the basis of the cost estimate (e.g., operating costs of equipment in maintenance management systems; depreciation of equipment in equipment management systems); using actual unit costs in lieu of statewide averages; conforming to GASB standards on cost reporting, even if the modified approach is not planned for use; and providing an option to account for ancillary costs (e.g., benefits on labor costs; costs of construction inspection and management as adjustments to project costs; replacement of appurtenances as part of a construction project).
- In addressing critical assets such as bridges, systems should consider a "failure-cost" approach that reflects an effective penalty borne by the agency and by transportation customers due to closure of a severely deteriorated facility. Such a penalty effectively provides a criterion to undertake needed work before the infrastructure reaches a failed state.
- Systems should include budget constraints in cost estimates performed at a network, system, or program level. They also should provide the capability to forecast the annual needed to maintain assets at established condition levels; or, conversely, the condition level that will be attained as a function of constrained budget level.

Scenario Testing Example

Scenario testing can be used to investigate the funds required to achieve a performance target or, conversely, the condition that can be achieved with a given budget level. Figure 8.7 illustrates an example comprising a set of three scenarios that have been analyzed for an example network of 500 bridges using the Pontis® 4.0 bridge management system. Each scenario tests a particular budget level (high, moderate, and none) to preserve the bridge network through a 10-year analysis period. Figure 8.7 plots the condition of the bridge network versus time in years. The network-average bridge condition is gauged by the percent of bridges with Health Index (HI), a measure of bridge structural condition, greater than 75 percent. Plotting the condition level at the end of 10 years versus the corresponding annual budget (the end points in Figure 8.7) results in the relationship between condition and expenditure as shown in Figure 8.8. This graph captures the tradeoff between constant expenditure level and resulting long-term condition. This relationship can be used directly as a guide identifying the expenditure level to meet a specified target condition level. Moreover, Figure 8.8 provides a basis for tradeoffs analyses with other programs (as described in Chapter 6).

Figure 8.7 Example of Budget Scenarios and Effects on Infrastructure Condition

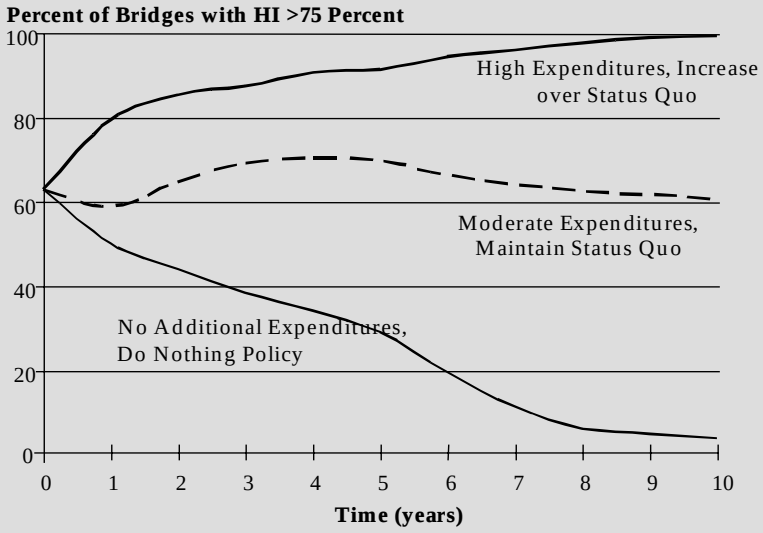
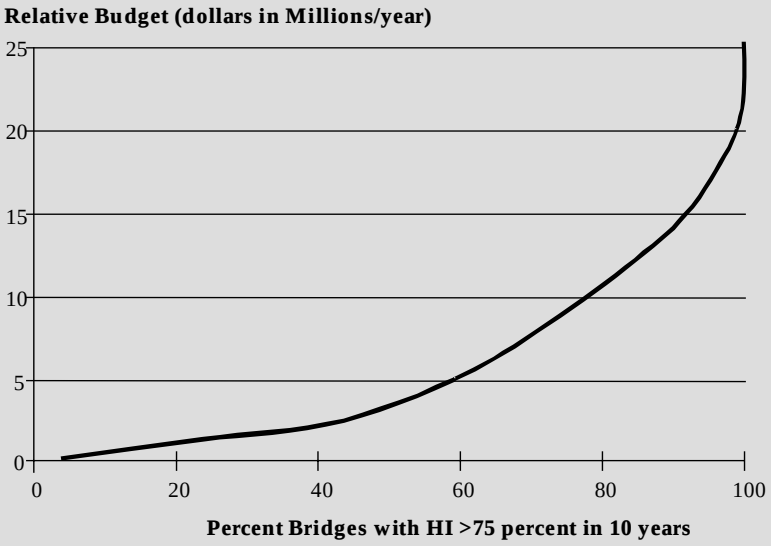


Figure 8.8 Resulting Relationship Between Infrastructure Condition and Needed Expenditure



NEEDS IDENTIFICATION

- Systems should provide the capability to flag the specific locations of assets or individual facilities that do not (or will not) meet one or more minimum standards.
- Systems should provide the capability to identify multiple types of needs occurring in a given location (e.g., deficiencies due to congestion and to pavement condition).
- Systems should provide the capability to estimate the costs of addressing the identified needs using decision rules or automated evaluation and selection of alternative actions.
- Systems should provide the capability to summarize these costs across a variety of dimensions (by type of action, location, type of asset, etc.).
- Systems should provide the capability to easily locate and retrieve information on planned, programmed and pipeline projects in selected locations.

PROJECT, PROGRAM, AND NETWORK-LEVEL EVALUATION OF PROPOSED WORK

- Given a list of candidate projects (which may include a mix of assets and project types), systems should provide the capability to prioritize candidates according to a consistent methodology: e.g., benefit/cost ratio, cost-effectiveness criterion, or other agency criteria, to assist in planning and programming.
- Agencies should develop project evaluation tools that have a consistent set of outputs and outcome measures across project types to allow for evaluation of wide range of alternative approaches.
- Systems should provide the capability to evaluate the life-cycle costs and benefits of a given type of project. In asset preservation, provide the capability to estimate the life-cycle costs associated with different capital/maintenance strategies.
- Systems should provide the capability to calculate performance measures associated with a range of investment levels and distributions (e.g., to support tradeoff analyses).

PROGRAM DELIVERY

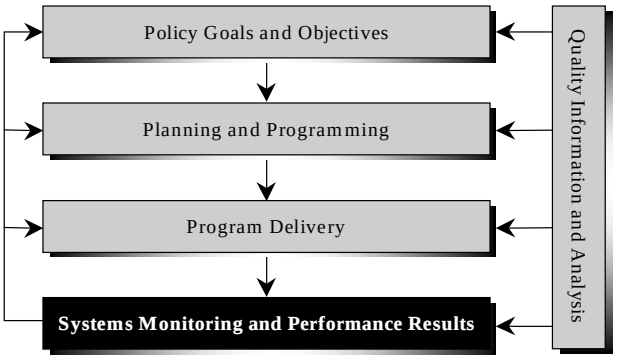
- The systems should summarize information on overall program delivery in terms of cost and time parameters, number of proposed projects completed, and reasons for significant changes.
- Systems should provide the capability to derive or update unit costs and cost models based on actual project or contract cost data.

8.5 SYSTEM MONITORING AND FEEDBACK

8.5.1 OVERVIEW

A critical aspect of information support for asset management occurs in the scheduled monitoring of the transportation system to gather data on how the transportation network infrastructure is performing, compare performance results to intended targets or policy objectives, and provide feedback to individual stages of resource allocation and utilization to identify needed adjustments in policy, procedures, and criteria for future management cycles. Monitoring the performance of the transportation network infrastructure within the asset management framework is illustrated in Figure 8.9.

Figure 8.9 Feedback Loops within Resource Allocation and Utilization



In the context of asset management, system monitoring refers to gathering information on the impact of preservation, improvement, maintenance, and operations programs on the characteristics and behavior of the transportation network. The synonymous terms "system performance monitoring,"

"program performance monitoring," and "performance monitoring" all refer to the same management activity: to determine and report the impacts of transportation programs on the transportation network and the service it provides to its users. These impacts may be in several areas: e.g., the physical condition and integrity of the system, the transportation service provided (which in turn affects the level of mobility and support for economic opportunity), and the effects of system usage on other public policy objectives such as environmental protection, social cohesion, and energy conservation.

There is a corresponding set of measures that can be applied at the same stage in Figure 8.9 to monitor the delivery of the transportation construction, maintenance, and operations programs themselves. These measures, which are discussed in Chapter 7, provide accountability for program accomplishment and communicate program status and progress. These measures can be referred to as "program delivery measures" to distinguish them from measures of transportation system performance. Both sets of measures are relevant to an asset management perspective.

8.5.2 Performance and Delivery Measures

Performance measures are measurable or observable indicators used in system monitoring. They help to communicate system status, impacts of recent program investments, short-term and long-term trends affecting the transportation system, and emerging needs for new investment or updates in policy. They provide a critical linkage between policy goals and planning and programming decisions, and the means to gauge the implications of shifting funds among programs in tradeoffs. The preferred approach is to have quantifiable performance measures, although qualitative measures can serve in certain situations (e.g., in gauging visual appeal of roadsides or facilities, or in characterizing network connectivity or degree of intermodal connections). Delivery measures provide accountability for program accomplishment.

Useful characteristics of performance and delivery measures are as follows:

- A set of measures should track system performance and program delivery in each major program area, and in certain cases by class or type of asset.
- Performance measures should be related to:
  - Policy objectives;
  - Physical condition and system performance; and
  - User benefits and perceptions of system and service quality.
- Performance measures collectively should help explain reasons for changes in transportation system performance, and whether due to program investments and agency services or to other factors (e.g., shifts in transportation demand).Performance measures should reflect transportation impacts that are an integral part of a performance-based budgeting framework.
- Performance and delivery measures should be tracked regularly through inspections, customer surveys, and program status reports, and should be reported regularly to internal and external stakeholders as accomplishments.
- Monitoring of trends over time should help identify needed adjustments in policy and/or planning and programming.

Performance measures are an important element of making an asset management approach work in practical terms. They provide important linkages among the functions shown in Figure 8.9. NCHRP Project 20-60, due to start in 2003, is intended to identify more specifically how performance measures should be selected and applied to meet asset management benchmarks for improved practice.

Performance Measures in a Statewide Transportation Plan

Since 1992, the Oregon DOT's transportation plan has used a set of performance measures based on earlier work by a citizen's group. Examples of these performance measures are "percent of pavements in fair or better condition" and "percent of mileage that experiences low or moderate congestion during peak hours." Each update of the plan includes a set of specific benchmarks against which the implementation of the plan is measured. Progress toward the benchmark criteria is tracked each year using data from the agency's management systems.[12]

8.5.3 FEEDBACK MECHANISMS

Figure 8.9 identifies a number of feedback mechanisms that need to be served by performance and delivery measures. These feedback loops are part of the principle of asset management relating to informed decisions based on objective information. The nature of the information provided by the several feedback loops in Figure 8.9 is as follows:

- **Feedback to Policy Goals and Objectives**. Comparisons of system performance trends to performance targets provides information on the impacts of program investments and the degree to which program objectives have been attained. They also may identify emerging trends that need to be accounted for in future policies and investment priorities. This information can influence future policy formulation and redirect priorities toward emerging needs.
- **Feedback to Planning and Programming**. System performance monitoring helps to quantify the outcomes of recent investment decisions and establish baseline data on system usage and performance for future decisions. This information may influence adjustments or updates to project prioritization criteria. Monitoring and data collection by an agency also can update information on current asset inventory, condition, and performance, and the cost and effectiveness of project treatments and service delivery methods for use in future programming and program delivery decisions. Customer surveys can gauge the public response to construction and maintenance work and the impacts of these investments on system performance. Customer perceptions of the priority of needed improvements and services, and the quality and timeliness by which the DOT accomplishes these efforts, also can be assessed.
- **Feedback to Program Delivery**. Program delivery monitoring and feedback documents whether projects and services have been delivered on time and budget and to the requisite quality. It also can identify problems that require remedy.

8.5.4 ROLE OF INFORMATION TECHNOLOGY

System performance and program delivery measures ideally should be able to be predicted by your agency's management systems or analytic tools, as well as be measurable or observable in the field. This dual capability provides closure in the following aspects of an asset management approach:

- It enables management systems to be used during policy formulation to assess the costs of achieving different levels or targets in performance, and to inform decisions on realistic policy objectives and performance targets.
- It enables the evaluation of alternatives by applying the same performance measures as those that will be used to monitor the impact of the completed project.
- It enables management systems and other analytic tools to inform planning and priority programming decisions, since these processes need to be compatible with policy objectives and associated performance measures and targets.
- It enables management system and other analytic support of program tradeoff analyses.
- It enables IT support of program delivery, including examination of "what if" scenarios regarding project and program adjustments.
- In general, it promotes the integration and fullest use of your agency's considerable

[12] Oregon DOT, Oregon Highway Plan, http://www.odot.state.or.us/tdb/planning/highway, 2002

investment in IT with your day-to-day business processes in all of these areas.

8.6 REPORTING AND DOCUMENTATION

While reporting and documentation are related to information and analytic capabilities and are an element of system performance monitoring and feedback, they are important enough to warrant additional emphasis. The audiences for performance-based information are both external and internal. Internal audiences include agency managers and staff with responsibilities for functions or meeting targets related to asset management. External audiences include public officials, customers, other stakeholders, and the public at large. The scope and detail of reports will vary with the intended audience, but collectively, these reports are an important part of sustaining good infrastructure management practice within the agency, informing stakeholders and the public as to the status and direction of infrastructure management, providing the feedback information needed for effective updating of policy, planning, and programming, and establishing the basis for accountability.

Practices in reporting results and providing accountability are maturing, particularly among agencies that have adopted performance-based concepts in their management approach. Many states provide reports externally (e.g., annually or quarterly), and several are developing semi-automated internal reports in the form of monthly summaries and "dashboards" for executive briefings and decision-making. Examples of "report cards" and other types of status reports for program delivery are given in Chapter 7, and many of the elements discussed in Chapters 5 and 6 (e.g., policy objectives, performance targets, prioritization procedures, tradeoff analyses, the LRTP, and the STIP) are potentially the subjects of reports.

One of the key needs identified in asset management is the strengthening of information and analytic capabilities to support decisions by executives and other senior managers. One mechanism that agencies have undertaken in this regard is the use of "dashboards." Dashboards provide an overview of key indicators and potential problems in transportation system performance. They are built up from the relationship between the strategic objectives that focus on core business areas and the respective performance measures and targets and their organizational "owners." The indicators that are tracked may vary from period to period, reflecting executive priorities, and they are usually on an "exception" basis, using dials or colors to indicate a problem. They rely on readily measurable data (e.g., infrastructure condition).

More generally, asset management encourages more effective reporting from bottom-up to inform high-level decisions more completely and effectively (e.g., using what-if capabilities of management systems), and more effective communication of policy objectives and associated targets from top-down (Figure 2.2). Documentation of key information (whether electronically or in hard copy) establishes an historical record, maintains the time-series data that are used to establish trends, and provides the foundation of objective information that is needed to analyze the consequences of investments, and to identify fundamental changes in infrastructure condition, use, performance, or cost over time. Within this context, asset management encourages the following considerations when updating information and analytic capabilities to support more effective reporting and documentation:

- To update existing analytic systems and tools, and develop of new capabilities, that:
  - Incorporate performance measures and performance targets in decision-support procedures and reports, if they do not already do so;
  - Aggregate or "roll up" network information in a form that is useful to high-level management decisions; and
  - Design reports that clearly indicate the consequences as well as the cost of investment, and give a sense of the relative standings of alternatives that have been considered.
- To incorporate more comprehensive and timely data in reports:
  - Comprehensive data to support identification and evaluation of alternatives and analysis of tradeoffs; and

  - Timely data to be able to collect, compile, and analyze data on the timetable dictated by executive decision-making.

- To indicate more clearly the basis of management accountability for results by delineating the portion of results for which the agency exercises responsibility versus results due to aspects of performance beyond the agency's control; and
- To provide reports that foster communication and coordination with other government agencies, and that inform other key stakeholders and the public.

9. IMPLEMENTATION

9.1 INTRODUCTION

Previous chapters have built the foundation for understanding how asset management can become part of your agency's "way of doing business":

- Chapter 3 enabled your agency to complete a self-assessment of its current situation.
- Chapter 4 outlined how to develop an asset management strategy.
- Chapters 5 through 8 provided guidance in several areas on how asset management can help your agency build a stronger focus on results in resource allocation and utilization.

This chapter looks at some practical aspects of asset management implementation.

- **Section 9.2** presents examples of "entry mechanisms" that DOTs have taken to begin understanding and getting involved in asset management.
- **Section 9.3** looks longer term to sustaining the asset management implementation through effective leadership and tracking progress. Principles of change management and communication are discussed as they relate to asset management implementation.
- **Section 9.4** presents concluding thoughts on transportation asset management.

9.2 EXAMPLE FIRST STEPS

Several agencies have already taken a proactive stance in asset management. The diversity among these efforts reinforces a point made in Chapter 4: there is no single, "correct" approach to getting started. If your agency has not yet begun to think about asset management, or is looking for a entry mechanism by which it can begin getting managers thinking about potential advantages, examples provided in this section may serve as a point of departure for discussions within your agency.

9.2.1 INTERNAL VISION WORKSHOP

Buy-in from all units of the agency is critical to a successful asset management effort. A department-wide vision workshop is a mechanism for achieving this shared view and an understanding of what asset management implementation will mean to each unit. A vision workshop can provide an opportunity for both knowledge-building and team-building. It can be used to define the vision of asset management within an agency, present initial recommendations to representatives from across an agency, and foster discussions across departmental units on priority areas and specific improvements required for successful asset management implementation. A vision workshop also may serve as a platform for bringing parties together to participate in the self-assessment process described in Chapter 3.

9.2.2 ASSET MANAGEMENT "MARKETING" PACKAGE

Another mechanism for developing buy-in for an asset management initiative is to create and distribute an asset management "marketing" package. For example, the Michigan DOT developed a number of "fact sheets" that summarize key asset management topics and activities. Individual sheets cover topics such as a primer on asset management, descriptions of key management systems, an overview of the agency's asset management process, and other related information. Michigan DOT has printed hard copies of these materials and posted them on its web site. The communication package helps to educate employees and external stakeholders and create buy-in for future efforts. This material is available on an MDOT web site.[1]

9.2.3 SUPPORT LEGISLATIVE PROPOSALS

Another approach to getting started is to support legislative proposals that will institutionalize asset management in state transportation. This practice can help establish legislative policies that provide continuity in long-term implementation, overcoming problems introduced by leadership turnover. Michigan DOT, working with local agencies and other stakeholders, recently played a pivotal role in drafting and securing passage of such legislation. This state statute calls for the use of asset management principles and processes for transportation resource allocation decisions statewide. Highlights of the bill, passed in the summer of 2002, include:

[1] www.michigan.gov/mdot/0,1607,7-151-9621_15757---,00.html

- Establishment of an Asset Management Council charged with developing a statewide asset management process;
- Requirement that state and local agencies use this process in developing multi-year programs based on long-range plans; and
- Requirement that all agencies report annually their roadway and bridge inventory, condition, work activities, expenditures, and activities proposed for the following year.

This legislation is available on a state web site.[2]

9.2.4 PROJECT-LEVEL ASSET MANAGEMENT AS A PROTOTYPE

Utah DOT has taken an incremental approach to asset management implementation. The agency is developing and implementing an asset management system that focuses initially on assets in the newly reconstructed I-15 Corridor in Salt Lake City. After implementation of the prototype system is reviewed, the agency intends to extend the program statewide.

9.2.5 COMPREHENSIVE ASSET MANAGEMENT PROJECTS AND PLANS

A comprehensive approach to asset management reviews an agency's full range of infrastructure assets and business processes, and often results in an implementation plan as discussed earlier and in Chapter 4. Various catalysts may encourage DOTs to consider comprehensive asset management reviews:

- In 2001 the Vermont legislature passed a bill requiring the Vermont Agency of Transportation (VTrans) to develop an asset management implementation plan. The legislation defined specific items for inclusion in the plan: e.g., asset inventory, condition, deterioration rates, estimation of the long-term funding necessary to maintain target performance levels, and so forth. In response to these requirements, VTrans initiated a project to review its current practices, processes, and IT tools in the context of both legislative compliance and the state-of-the-art in asset management. The project resulted in a report documenting recommended steps for moving forward with the agency's asset management efforts.
  - This legislation is available on a web site.[3]
  - The resulting report, The VTrans Asset Management Vision and Work Plan, is available on a web site.[4]
- In another state, the impetus for an asset management project was in part the development of a data warehouse designed to compile information required by GASB 34. With the understanding that its new data warehouse could provide information beyond GASB 34 and could support more broadly based activities in asset management, the DOT established a project to review the current state-of-practice nationwide, identify the agency's current business processes and IT capabilities, and recommend improvements to enhance its asset management practices.

9.2.6 NHI TRAINING COURSE

An FHWA-sponsored National Highway Institute (NHI) ***Training Course in Transportation Asset Management*** has been developed to complement this ***Guide***. This course provides an opportunity to bring together key managers from one or more agencies, review and discuss with them the material in this ***Guide***, involve them in hands-on exercises demonstrating asset management principles and techniques, and enable them to begin thinking about how to implement an asset management improvement process within their respective agencies. Parties interested in this course should contact the NHI.[5]

[2] www.michiganlegislature.org/documents/2001-2002/billenrolled/house/pdf/2001-HNB-5396.pdf

[3] www.leg.state.vt.us/docs/2002/acts/act064.htm

[4] http://www.aot.state.vt.us/lanning/Documents/VTrans%20Asset%20Mgmnt%20VW.pdf

[5] The NHI may be contacted at 1-877-558-6873 or through its web site, www.nhi.fhwa.dot.gov

9.3 LOOKING TO THE LONG TERM

9.3.1 MAINTAINING A PROPER COORDINATION ROLE

Regardless of how comprehensive or how tailored your agency chooses to implement asset management, ultimately implementation represents a number of individual efforts in which agency units are charged with improving their specific practices, use of information from management systems, and decision criteria. Despite this specialized work of implementation, it is important that the agency also maintain an overall view of the process. Coordination will continue to be needed to ensure that the individual efforts support overall objectives, and that they are aligned with one another and with support activities.

During implementation, coordination is the key responsibility of the asset management "owner" and supporting committees described in Chapter 4. A fine line must be maintained, however – asset management concepts, principles and techniques need to drive improvement in existing agency functions, but "asset management" itself should not be misunderstood at the front lines as a separate, new, or competing business process. ***It is the role of the asset management "owner" and supporting committees to "bring asset management home" to each organizational unit affected.***

Some agencies that have already dealt with issues like this have found that by focusing on specific improvements or tasks with each group – e.g., developing a life-cycle-cost capability, researching methods to analyze preventive maintenance, identifying specific policy objectives, updating planning and priority programming processes, defining performance measures, strengthening controls on program delivery, building new information processing capabilities, and so forth – the process is better understood by the respective units that are responsible for carrying out these improvements than would be the case if all of the implementation efforts were dealt with solely by the abstract explanation of "asset management." At the executive level, however, and in the coordination by the asset management "owner" and committee, the overarching principles of asset management and how they relate to each business function and organizational unit do need to be understood.

Additional responsibilities of your agency's "owner" and implementation committee include tracking implementation progress, communicating the status to key stakeholders, and making adjustments in the implementation plan (objectives, activities, timing information, etc.) as needed to address fundamental political, institutional, and technological changes over the long term.

9.3.2 TRACKING PROGRESS

There are a number of ways to track progress in asset management implementation. A couple examples are described below. However, your agency should feel free to tailor these or to define others, depending upon the types of improvements you envision and the level of detail of your implementation plan.

TRACKING PROGRESS TOWARD IMPLEMENTATION PLAN COMPLETION

One approach is well suited to situations where a detailed implementation plan has been developed, with specific tasks, schedules, and levels of effort. This monitoring approach tracks the completion and level of effort of each task against the estimates documented in the implementation plan. It also assesses whether the intended coordination between tasks has been accomplished, accompanied by communication between affected organizational units. Adjustments in schedule, sequencing of tasks, and mid-course corrections are reflected in periodic updates to the implementation plan. These updates are communicated in periodic status reports to internal and external stakeholders.

TRACKING PROGRESS TOWARD ATTAINING A CAPABILITY

Another approach is to track progress toward a defined business process improvement. This option may be useful, for example, where an agency limits or tailors its asset management effort to a specific function or capability, and where achieving this end may require proceeding in stages. Earlier sections of this ***Guide*** can help identify what are some appropriate development stages to track. An example will help illustrate this option.

Assume that an agency wishes to develop the capability to conduct program tradeoffs. The self-assessment exercise (Chapter 3) indicates that the agency has little capability today to conduct tradeoffs in the manner suggested by best practice. Relevant sections of the ***Guide*** that discuss a tradeoff capability conforming to good asset management practice include the following:

- **Management Framework**. The planning and programming management matrix (Table 2.3) includes tradeoffs as part of Item 4: "Resource allocations and program tradeoffs are based on relative merit and an understanding of comparative costs and consequences." The best practices associated with program tradeoffs in the matrix include a life-cycle analysis of benefits and costs and the application of performance measures. Other principles and practices in the matrix include consistency with program objectives and basing of program development on consideration of alternatives.
- **Self-Assessment**. The planning and programming portion of the self-assessment exercise (Section 3.2.2) includes several suggestions of specific capabilities relevant to tradeoffs: e.g., knowledge of program objectives and realistic estimates of program costs, benefits, and performance impacts.
- **Descriptions and Examples**. Chapter 6 of this ***Guide*** provides descriptions and examples of program tradeoffs and how they can fit into an agency's resource allocation process.

From this material the agency identifies key elements that it needs for tradeoffs. These include the following:

- A defined set of performance measures that relate to policy objectives;
- Life-cycle estimates of costs, benefits, and performance impacts associated with different types of investments; and
- Management systems or other analytic tools that can compute realistic estimates of cost, benefit, and performance needed above, and that have the credibility to provide information that can be incorporated in program development and tradeoff analyses.

The agency recognizes that these items will take time to develop fully. It therefore organizes the development and application of these elements within a series of steps that it will undertake in a staged process to develop the capability to do tradeoff analyses:

- First it will review performance measures for all key types of program investments, to ensure that they are consistent with policy objectives for those programs, and are practical and suitable for use in tradeoffs. Trial use will allow for adjustment or addition of further measures if needed.
- Estimates of life-cycle costs and benefits for a range of investment options will be done initially using either the agency's existing management systems (if these systems already deal in life-cycle analyses of costs, benefits, and performance) or simple analytic tools that are developed specifically for particular types of investments where the agency does not now have suitable management systems. This approach will allow refinement of methods relatively quickly and inexpensively, and will allow managers and staff to get used to these estimates and suggest refinements where needed. Another option is to use available tools that are well suited to tradeoff analyses: e.g., HERS/ST. Regardless of the option used, estimates of costs and benefits, combined with estimates of performance measures above, provide the economic and technical basis for an initial set of tradeoff analyses.
- A separate management system or analytic tool also will be developed to frame and report the tradeoff analysis itself – i.e., to automatically test different investment scenarios, obtain information on cost, benefit, and performance from the tools and systems discussed above, conduct the tradeoff analysis between the specified programs, and report results and recommendations.
- The agency's business processes will be modified to include tradeoff analyses, supported by information provided by the management systems and tools developed above.

This approach defines four stages by which the agency can undertake development of a tradeoff capability. As it proceeds, it will keep abreast of ongoing research in methods and performance measures, and communicate with peer agencies what they are doing in tradeoffs. They can explain:

- What they did;
- How they did it;
- Why they did it that way; and
- How well it works.

Again, this is an example, and you may find that a somewhat different staged approach better meets your agency's needs and situation. The point is that you can work with input from the ***Guide*** plus knowledge of your agency to chart a path toward asset management improvement, and then monitor progress in key milestones.

9.3.3 ASSET MANAGEMENT REPRESENTS "CHANGE"

While all DOTs today follow asset management principles to a degree, implementing further improvement in asset management often represents more than a change in technical procedures. It requires a transformation in agency culture based upon a change in philosophy about institutional objectives, the measurement of success, and how agency units relate to one another. The responsibilities and authority of existing organizational units may be subject to a re-examination.

Asset management may be perceived by many agency managers, staff and external stakeholders as threatening to their sense of competence, independence, status, and even employment. It is therefore essential that the case for asset management be presented in a manner that generates acceptance and support to the maximum extent possible. Buy-in of this type can be best achieved through a comprehensive change management strategy and an effective communications plan to address the people-related aspects of asset management implementation.

CHANGE MANAGEMENT

OVERVIEW

Change management involves engaging individuals and groups to take responsibility for realizing the new vision of their organization and to develop their own potential. It is characterized by continuous assessment, actions and communications. Change management may be arrayed across four dimensions:

- Culture – Belief systems regarding personal, professional and organizational values, roles and relationships, including key external perceptions and accountability.
- Cooperation among and within agency units – Functional relationships, reporting hierarchies, independence / dependence among agency units.
- Competencies – The technical capabilities needed at various unit levels participating in asset management.
- Communications – An increase in horizontal communications and shared tactical and strategic vision.

OBJECTIVES

The key objectives of the change management strategy are to measure and actively build commitment to the asset management initiative. This work engages those internal and external stakeholders involved in, or affected by, the implementation during its life by:

- Ensuring a basis for common understanding and coordination around change activities and events;
- Anticipating, identifying and planning for behavioral outcomes that are expected of stakeholders during significant change;
- Inviting stakeholders to participate in the design of the change regarding how they will perform their new responsibilities; and
- Building an atmosphere in which change is viewed in a positive way.

A comprehensive change management program consists of a wide range of activities, including input to training and skills assessment activities and, most visibly, a Communications Plan.

FRAMEWORK

The change management framework relies on two-way communication and the establishment of feedback mechanisms to promote and monitor the effectiveness of change activities. A key initial activity is an assessment of the agency's readiness for change. The objective is to assess, at a high level, the degree to which the organization is ready to adopt changes to its business practices. This provides an appreciation of the issues up-front which

could potentially thwart the successful implementation of asset management. Typical obstacles to change include a lack of understanding and awareness of the asset management initiative, regionalism and partisanship, and skepticism and lack of commitment from all organizational levels.

READINESS ASSESSMENT

A readiness assessment provides an analysis that can serve as the basis for the design of all other change management activities. The analysis determines which activities are best suited to different audiences and which strategies are required to mitigate the resistance to change and other implementation risks. This analysis is particularly useful in the design of the communications strategy for asset management implementation.

The analysis identifies the winning strategies/principles that stakeholders believe must be in place for a successful project. A typical list would include the following:

- Brand the implementation project to create clear, consistent project identity and awareness;
- Demonstrate and communicate value and shared vision;
- Communicate key milestones;
- Use a number of methods/formats to repeat and reinforce messages;
- Communicate the impact that the project will have on the individual and the way they do business;
- Quick wins – Show tangible achievements along the way;
- Provide a consistent message to the organization;
- Demonstrate senior executive involvement, support and direction – these are crucial;
- Involve operations level personnel, regions – wide consultation;
- Be clear on roles, time lines and deliverables;
- Conduct effective training;
- Promote change management as an agency-wide initiative with no room for individual tailoring;
- Commit to evaluating progress mid-way and adjusting where necessary; and
- Identify credible champions – Enroll managers in delivering messages.

The findings from this activity will identify where change management efforts can best be focused to effect change acceptance, by resolving or mitigating the impacts of the issues identified above, and by understanding how best to structure the change strategy.

TYPES OF CHANGE

It is important to understand the types of change, which will occur as a result of asset management implementation. The types of change may be categorized as follows:

- Changes in organizational culture, values, beliefs and attitudes (for example, from an individual-unit to a shared-effort mind-set, from a technical to a business focus, from a regional to a strategic focus).
- Changes in the policies, practices and guidelines or criteria that govern the way that asset investment decisions are made.
- Changes to finance and business planning, and other decision-making functions.
- Introduction of new methodologies, and integrated tools and systems.
- Changes to processes (e.g., changes in the sequence, nature and number of activities required to provide a service). This could include the elimination of some activities, and the creation of others.
- Changes in reporting relationships, opening or broadening horizontal lines of communication and interaction (refer to Figure 2.2).
- Changes in roles and responsibilities, job profiles/skills, knowledge gaps, resource requirements, and delegated authorities.
- Changes in mechanisms and procedures to instill and report accountability, and use of performance-based contracts as a tool to strengthen accountability.
- Changes to performance targets and measures, and greater ability to report and market these.

- Changes to program and project justification reporting.
- Changes to formal program and project monitoring and reporting.

COMMUNICATIONS PLAN

A Communications Plan addresses the communication requirements, objectives and the key messages tailored to different stakeholders for the duration of the initiative in asset management implementation and associated change management. The plan prepares a framework for instituting effective communications about asset management to those people whose acceptance and commitment is needed for a successful effort.

ELEMENTS

The Communications Plan should draw upon an assessment of change readiness and a stakeholder analysis, including the following elements:

- A matrix of stakeholders, events / activities, communication objectives, key messages, appropriate supporting media, timing of communication and feedback channels;
- Common and repeatable themes to be used to sell the initiative; and
- Communication roles identified and assigned.

OBJECTIVES

The objectives of the communications strategy should include the following:

- Facilitate the change acceptance process;
- Stimulate staff and upper management participation in asset management implementation;
- Clarify intent – What the implementation effort is and is not, and what impacts to the agency can be anticipated;
- Educate stakeholders on the approach, planning, and asset management content for the implementation; and
- Provide background on the implementation, and an understanding of asset management objectives, benefits, scope, and customer value.

KEY CHARACTERISTICS

To build credibility and understanding for asset management, communications should exhibit the following characteristics:

- Be regular and consistent throughout asset management implementation;
- Be content rich;
- Be expressed in plain language;
- Adopt common terminology, which is consistently understood;
- Have consistently applied messaging and visuals throughout all materials; and
- Have appropriate agency coverage.

TYPES OF MESSAGES

Some common content and methods will apply to all audiences and key messages, repeated in several ways. Strategies for specific audiences may differ in timing, positioning and tailoring of information. The depth of content communicated will vary, depending on the given audience's degree of involvement in asset management implementation.

The following message types provide a framework for developing the content included in the different communication events:

- Asset management project objectives, benefits, scope, asset management definition / drivers and background – includes communication about the project vision, scope, objectives, timeline, benefits and overall impacts to the agency. This information should not be overly time-specific so that when new team members or stakeholder groups require communication, the material will require only minor updates.
- Business and technical content – includes communication events coordinated with the implementation plan timelines directed towards stakeholder groups. Content includes discussion and demonstration of deliverables, new tools, systems, case studies, training, and so forth.
- Success stories / quick wins – includes sharing success stories about a new solution in the implementation effort (quick wins), and other items that will generate positive employee

excitement about enhancements to their jobs. Communicating quick wins will demonstrate tangible progress in implementation.

9.4 FINAL THOUGHTS

This ***Guide*** presents transportation asset management as a framework within which you can assess your agency's current business practices, identify opportunities for improvement, and develop a comprehensive implementation plan to fill these gaps. When considering the applicability of this framework to your agency, think about the answers to the following questions:

- Can your agency defend not being strategic – not being comprehensive, long-term, policy-driven, performance-based?
- Can it defend not considering options and tradeoffs?
- Can it defend not setting performance goals and not measuring results?
- Can it defend not being in the strongest position to justify its requests for resources?

Applying this framework and coordinating subsequent improvement efforts requires a broad perspective of an agency's organizational, institutional, and technological environments. Implementing the essential individual pieces requires "bringing asset management home" to the front lines by focusing on the responsibilities of individual units and on the specific benefits of these activities. Eventually, a comprehensive transportation asset management program can be institutionalized throughout an agency as an improved "way of doing business". Achieving this environment requires strong executive support and a sustained and consistent commitment. This ***Guide*** provides guidance on the initial steps required to tailor a systematic asset management improvement initiative for your agency. Many of these activities can be performed with the resources that you currently have, and all of them will help you build momentum for this support.

GLOSSARY

This section defines key terms and acronyms as used in this ***Guide***. The objective is to explain these terms in the context of transportation asset management. Some of these terms also may be used in other contexts and may therefore be applied and interpreted differently among state DOTs and other transportation agencies.

AADT – Annual average daily traffic.

AASHTO – Association of American State Highway and Transportation Officials.

ABC – Activity-based Costing – Method of tracking costs that accounts for the full costs (direct plus indirect) of performing an activity.

ADT – Average daily traffic.

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.

Application – Software product that performs a useful function or provides information; can be a management system, database procedure, spreadsheet workbook, automated computation, web-based procedure, etc.

Asset – As used in this Guide: 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, characterized by the concepts and principles explained in Chapter 2 of this Guide.

Benchmarks – Best practices as related to asset management; see "evaluation matrices."

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.

BMS – Bridge management system.

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.

Corridor approach – An approach to work packaging that attempts to perform anticipated construction projects, scheduled maintenance, and utility work in segments of a transportation corridor at the same time or in coordination fashion to minimize road closures and traffic delays.

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.

DB – Design-Build – Project approach combining design services and construction in one contract.

DBB – Design-Bid-Build – Project approach entailing separate design and construction contracts, with construction award based on the most favorable (generally

the lowest cost) bid; conventional approach to much transportation project construction.

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.

DRIP – "data rich, information poor" – Situation in which an agency is unable to translate its large quantities of data into meaningful information on current status or for decision support.

EIS – Executive Information System – Information and decision-support application intended for executives, senior managers, and political leaders.

Evaluation matrices – Formulized management framework that presents asset management evaluation criteria, basic characteristics of asset management best practice, and state-of-the-art benchmarks; also referred to as "management matrices."

FMS – Financial Management System.

GASB – Governmental Accounting Standards Board – Professional, non-governmental 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.

Geographic equity – Geographic-based funding distributions (e.g., percentage or formula-based splits among districts).

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.

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.

Indirect cost – Cost that cannot be precisely assigned to a given project or activity: e.g., administrative costs, cost of overall program management, rent on buildings, training costs, etc.

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.

Intergovernmental agreements – Agreements between agencies or levels of government to purchase or exchange services, often with the aim of greater efficiency and cost-effectiveness.

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.

ISTEA – Intermodal Surface Transportation Efficiency Act, Public Law 102-240, signed into law in December 1991.

IT – Information Technology – General term for an agency's systems applications and its capabilities in automated data processing and reporting.

ITS – Intelligent Transportation System.

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.

LOS – Levels of Service – 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.**LRS** – Linear Referencing System – Protocol for locating features on a highway system; enables mapping and location of asset

condition and performance measures, traffic characteristics, crashes, performance of work activities, etc.

LRTP – Long-Range Transportation Plan – Federally mandated, 20-year statewide transportation plan.

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.

Managed competition – Procurement approach in which an agency's existing work force competes with other public-sector or private-sector organizations to provide specified services (e.g., in maintenance).

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).

MMS – Maintenance management system.

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.

MPO – Metropolitan Planning Organization.

NBI – National Bridge Inspection – A program mandated by the Code of Federal Regulations to conduct safety inspections of bridges according to specified standards at least every two years.

NCHRP – National Cooperative Highway Research Program.

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.

PMS – Pavement management system.

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; provides value-added to these processes; may include labor knowledge and skills, financial capacity, real estate, corporate information, equipment and materials.

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 PMS, BMS, and MMS.

STIP – Statewide Transportation Improvement Program.

Strategic – A view of assets that is policy-based, performance-driven, long-term, and comprehensive.

TEA-21 – Transportation Equity Act for the 21st Century, Public Law 105-178, signed into law in June 1998.

Tradeoffs – Comparisons between alternative solutions, particularly involving consequences of reallocating funds between programs.

TRB – Transportation Research Board.

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, financial, information, and other resources to implement projects and services for the transportation system.

"What-if" analysis – See scenario analysis.