FHWA Asset Management Position Paper

white

paper

prepared for

Office of Asset Management
Federal Highway Administration

April 2004

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1.0 Project Overview

BACKGROUND

FHWA has been working with AASHTO, TRB and other partners to develop and advance asset management. The concept of asset management that has emerged is very broad and represents a set of business principles for making more effective resource allocation decisions. While much of the early application of asset management principles focused on infrastructure preservation activities, the principles apply equally to all functions and the entire life cycle of decision-making from defining policy objectives to planning, programming, budgeting, program and project development and design, operations, construction, maintenance, and system monitoring. In discussing this view of asset management with a wide variety of individuals across FHWA's program offices, the terms "total performance management" and "total system management" were used to describe the broad concept of asset management that currently exists. Irrespective of the term used to describe the business principles that are at the heart of asset management, it represents a comprehensive approach to managing resources and the transportation system.

OBJECTIVES

The FHWA Office of Asset Management, as part of its mission to promote asset management, sees significant opportunities for partnering and leveraging resources within FHWA. The purpose of this project is to create a coordinated agencywide asset management strategy by:

- Increasing the understanding of, and support for, asset management throughout FHWA;
- Identifying the relationship of asset management principles to key program offices;
- Identifying ways to leverage resources and develop collaborative efforts supporting asset management; and
- Developing a coordinated action agenda to provide support for implementing asset management with state DOTs and other partners.

To provide a starting point for the development of an agencywide agenda, individual "white papers" were developed for each major program office including Infrastructure, Planning, Operations, Safety, Environment, Right-of-way and Federal Lands. Each white paper describes the principles of asset management, relates these principles to the specific program office's functions, identifies ongoing activities and research that support asset management and suggests some future activities, including coordination with other offices, that might be

useful in the future. A brief summary of each white paper is included as an Appendix to this paper.

This position paper provides a synthesis of issues and observations raised in developing the white papers, and sets the stage for a one-day workshop involving FHWA senior managers to discuss the white papers and define an action agenda for coordinated asset management strategies in the future.

RELATIONSHIP TO FHWA STRATEGIC GOALS AND THE "VITAL FEW"

A stronger and more coordinated focus on asset management will help FHWA realize its goal of improving America's transportation system. Integrating asset management into the agency's ongoing activities will make it a better steward of national highway programs and leader in transportation innovation and public service.

Asset management reflects and supports FHWA's vital few priority areas of Safety, Congestion Mitigation, and Environmental Stewardship and Streamlining. It addresses these areas by identifying capacity expansion or system management alternatives to alleviate congestion and improve mobility, by incorporating the costs of crashes or incidents in evaluating transportation alternatives, and by considering the impacts of projects on the environment.

2.0 Asset Management Principles

Asset management is a set of business principles and best practice methods for improving resource allocation and utilization decisions. It reflects a comprehensive view of system management and performance. The core principles of asset management are:

- **Policy-Driven –** Resource allocation decisions are based on a well-defined set of policy goals and objectives. These objectives reflect desired system condition, level of service, and safety provided to customers, and typically are tied to economic, community and environmental goals as well;
- **Performance-Based –** Policy objectives are translated into system performance measures that are used for both day-to-day and strategic management;
- **Analysis of Options and Tradeoffs –** Decisions on how to allocate funds within and across different types of investments (e.g., preventive maintenance versus rehabilitation, pavements versus bridges; capacity expansion versus operations; different modal mixes, safety, etc.) are based on an analysis of how different allocations will impact achievement of relevant policy objectives. Alternative methods for achieving a desired set of objectives are examined and evaluated.
- **Decisions Based on Quality Information –** The merits of different options with respect to an agency's policy goals are evaluated using credible and current data. Where appropriate, decision-support tools are used to provide easy access to needed information, and to assist with performance tracking and predictions.
- **Monitoring to Provide Clear Accountability and Feedback –** Performance results are monitored and reported for both impacts and effectiveness. Feedback on actual performance may influence agency goals and objectives, as well as resource allocation and utilization decisions.

These principles are not unfamiliar, nor are they radical. Most transportation practitioners would agree that investment decisions should be based on weighing costs against likely outcomes, that a variety of options should be considered and evaluated, and that good information is needed for decision-making. Many agencies are now pursuing performance-based approaches to planning and programming, monitoring system performance, and developing more integrated data and analysis tools to evaluate tradeoffs among capital expansion, operations, and preservation activities. Most agencies recognize that application of asset management principles is critical in times of constrained resources, when all investment and budget decisions are subject to increased public scrutiny.

3.0 Asset Management-Related Activities at FHWA

The white papers developed as part of this project document a wide range of asset management-related activities that are taking place in each of FHWA's major program offices. In addition to documenting existing activities, each white paper identifies a number of potential future activities that might be initiated to further promote asset management throughout the agency. A summary of each white paper is included in an Appendix to this position paper and the complete set of white papers will be provided to all participants in the workshop. The purpose of this section is just to illustrate the types of activities within each office related to asset management.

- **Office of Infrastructure** supports a broad range of activities that are directly related to asset management, including procedural and technical guidelines and research on design, construction, materials, facility preservation and quality assurance for infrastructure. In addition, the Office promotes asset management directly through its Asset Management unit by providing guidelines and best practice material, supporting training, establishing a website and community of practice, and developing and supporting economic analysis-based decision-support tools.
- **Office of Operations** has initiated an asset management program plan that will establish the analytical foundation for the management of operations assets and create linkages with broader transportation asset management activities. The Office has also been involved in a wide variety of efforts to develop decision-support tools that can evaluate system operations strategies and document the benefits of operations investments.
- **Office of Planning** assists states and MPOs in following planning regulations and guidelines that reflect all of the principles of asset management. The Office's Capacity Building program focuses on a wide variety of topics relevant to asset management including performance measurement, multimodal tradeoff analysis, and cost estimation. The Office also supports research and provides guidance on a wide variety of decision-support tools, data integration and management, and data display and communication techniques. In addition, the Office has a number of initiatives aimed at more effectively integrating operations, freight and safety into the system planning process.
- **Office of Safety** is applying asset management principles both in directing the resources of the Office itself and in working with states on defining the most cost-effective methods and strategies to improve system safety. It is actively involved in encouraging the development of strategic safety plans at

the state level and in providing, in association with a broad range of partners, technical and procedural guidance on a wide array of safety strategies. Research activities include the development of number of decision-support tools for evaluating the safety impacts of both facility design considerations and various safety investment strategies. Other research activities focus on improving the safety performance of highway infrastructure and roadside features.

- **Office of Environment** focuses on defining and developing best practice methods for meeting environmental stewardship responsibilities as cost-effectively as possible. Environmental streamlining, support for the use of environmental management systems and the development of best practice maintenance strategies that protect sensitive environmental resources are examples of activities that support asset management. The Office works closely with other offices to integrate environmental considerations into infrastructure design, operations and planning. This facilitates integrated decision-making and the delivery of transportation services that meet environmental goals as well.

- **Office of Real Estate Services** primary focus is administering Federal law and regulations related to relocation assistance and real property acquisition. However, given both the cost and potential project schedule impacts of relocation and right-of-way activities, effective administration of this program can have significant impacts on project and program delivery. Moreover, advance acquisition strategies, where permitted, can plan an important role in preserving future transportation options. The Office provides guidance on the effective management of relocation and right-of-way acquisition activities as well as on property management including disposal of excess land. The Office also works with other partners on joint use and shared use issues related to right-of-way which has become an important source of revenue in some states.

- **Office of Federal Lands Highway** administers a range of funding programs aimed at planning, developing and preserving transportation facilities and services on Federal lands and Indian Reservations. Working closely with its partners including the National Park Service, U.S. Forest Service, U.S. Fish and Wildlife Service and the Bureau of Indian Affairs, the Office provides support and guidance on the development and use of pavement, bridge, safety and congestion management systems. The Office also has provided support for regional and long-range planning and performance-based planning with a number of its partner agencies.

The above summaries provide a brief sampling of the types of activities each office is engaged in that relate to asset management. The amount and range of existing activities that support asset management are impressive and many of these initiatives involve cooperative efforts across offices and with other partner agencies and organizations. By documenting current and potential future activities, the white papers provided a starting point for a more integrated and

coordinated asset management strategy/plan for the whole agency. In addition, the full set of white papers is useful in identifying a number of broad issues or themes that can be included in the action plan. These cross cutting issues are discussed in Section 4.0.

4.0 Applying Asset Management Principles to FHWA Program Areas

As summarized in Section 3.0 and the Appendix, each office in FHWA that participated in this effort is already undertaking a broad array of activities that are very consistent and supportive of asset management principles. In order to build on these existing efforts and provide a vision for how the activities of different offices can be mutually reinforcing, the following objectives are proposed that cut across all areas:

- Support performance-based planning, programming and management processes;
- Strengthen vertical linkages across the transportation facility life cycle: planning, project development, operations and maintenance;
- Strengthen horizontal linkages across program areas to improve capabilities to address multiple objectives in an integrated fashion; and
- Move towards a common and integrated base of information and analysis tools.

PERFORMANCE-BASED PLANNING, PROGRAMMING, AND MANAGEMENT

Establishing business processes that embody the principles of performance-based planning, programming and management is a prerequisite to effective asset management. FHWA's work with state and local transportation agencies should continue to emphasize the key ingredients of performance management including clearly established policies that can be traced to outcomes, and a culture in which options for improving performance are routinely considered. In addition, a comprehensive and consistent approach to performance measurement should integrate all of the key policy issues of concern. Current efforts to integrate safety, freight and operations into the planning process should continue and be extended to programming and overall system management as well.

Many transportation agencies are recognizing the need to embrace a stronger customer service orientation as their focus shifts from one dominated by construction to encompass a broader management and operations role. Accordingly, transportation system performance from the customer perspective is an increasingly important consideration in transportation decisions. FHWA's

research efforts on performance measures across all areas can further strengthen the consideration of user costs and benefits within transportation planning, resource allocation, design, construction, maintenance and operations. Support for multi-jurisdictional approaches is also important in recognition of the fact that travelers perceive performance in terms of their total trip, without regard to facility ownership.

VERTICAL LINKAGES ACROSS THE LIFE CYCLE

The idea that transportation investments should be viewed from a long-term, life-cycle perspective is a central theme of asset management. Economic analysis methods for analyzing highway projects based on their initial construction costs and the continuing stream of maintenance and operations costs are well established. Infrastructure research at FHWA is developing new pavement and bridge designs and construction methods that increase life and reduce ongoing maintenance costs. Research and tool development on work zones is ongoing to help agencies factor in user costs associated with construction into the life-cycle equation. New life-cycle analysis tools developed by FHWA for pavements and bridges incorporate user cost considerations, and employ risk analysis methods to account for uncertainties. Development of new life-cycle cost analysis methods for the operations assets (including the increasingly costly and sophisticated array of ITS equipment) are part of FHWA's Office of Operations' future work plan.

Strengthening linkages across decisions at different stages of the facility life cycle goes beyond application of life-cycle cost analysis. Working towards stronger connections between planning and programming is a crucial element of performance-based planning. Improving the flow of information and experience from relocation and right-of-way, environmental mitigation, construction, operations and maintenance back into planning and programming allows these up-front decisions to be made based on better information. Processes that foster collaboration and communication among planners, designers, construction managers, and maintenance and operations staff result in better decisions at all stages of the life cycle. FHWA is involved in several efforts to integrate safety, operations, and infrastructure issues throughout the planning process and, again, these efforts should be continued and extended.

HORIZONTAL LINKAGES ACROSS PROGRAM AREAS

Integrating decisions across "stovepipe" program areas – such as pavement, bridge, safety, and operations is an important challenge faced by transportation agencies. Asset management principles call for the consideration of tradeoffs across different types of investments based on multiple objectives. There is growing interest in, and use of, corridor approaches to planning and

programming transportation improvements which requires an integrated perspective. Similar approaches are required for system planning and system management. The options and tradeoff analyses implied by comprehensive asset management also require a degree of integration across functional specialties including planning, engineering, operations, maintenance and finance.

Research and technical assistance efforts within FHWA's different program areas can recognize the need for methods of comparing different types of investments and also for using an integrated approach to address multiple program area needs. For example, the Safety Office has supported the development of a tool to help agencies decide on safety features to be implemented in conjunction with resurfacing projects.

Incorporating environmental considerations in project development and maintenance is another example of horizontal linkage. FHWA's Office of Environment is working to encourage the use of context-sensitive approaches to design, which allows for flexibility to address multiple concerns within the design process and moves away from a strictly regulatory compliance-based approach.

Finally, and perhaps most importantly, achieving many key transportation objectives requires working across agencies in a complex institutional environment. The customer perspective on "the trip" irrespective of facility ownership or operating/maintenance responsibility has already been mentioned. The perspective on total performance and system management embodied in asset management principles will require new working relationships and shared responsibilities. In the case of safety, many of FHWA's current initiatives reflect the fact that both transportation and non-transportation organizations will need to work together to achieve desired results. Similarly, the coordination of system planning and operations strategies with land-use, economic development, and environmental programs also requires broad partnerships to be effective.

INFORMATION AND ANALYSIS TOOLS

Data and analytic tools are important building blocks of an asset management approach. There are significant overlaps in data needs, and to some extent, analysis methods and tools across the different FHWA program areas. Multiple offices at FHWA have supported the development of analysis tools for use in planning, evaluation and design – including several tools for life-cycle costing and benefit/cost analysis. There is a need to establish a broader understanding within FHWA of the past, current and planned tool development efforts, and also to work towards a common understanding of where each tool fits within a holistic decision-making framework.

The FHWA's Office of Asset Management has been promoting data integration as a key emphasis area. Data, and the decision-relevant information generated from it, are recognized as a key corporate asset yet many data quality, management, access and cost issues remain as a challenge particularly as performance-based management is implemented more widely. The pending Federal reau-

thorization legislation may include a variety of new data provisions and requirements in recognition of this issue. FHWA can and should continue to play a strong leadership role in the area of data management. For example, the essential role of geographic information systems (GIS) in data integration is widely recognized within the agency, and many research activities are underway which utilize GIS for data visualization or as the base technology for an analysis tool. FHWA can also play an important role working with its partners to promote data standards and interoperability.

5.0 Recommendations

Many potential future activities that would support asset management have been identified in the seven white papers. The suggested activities have been organized in the areas of policy and regulatory activity, technical assistance and information dissemination, research and technology, and coordination. All of these activities are worthy of consideration and define an ambitious program for each of the respective FHWA offices. There also is value in considering recommendations that cut across issues faced by more than one FHWA office including the cross-cutting themes discussed in Section 4.0. These recommendations are highlighted below.

RESEARCH OPPORTUNITIES

- Asset management implies a comprehensive and integrated approach to managing the transportation system. There are three key areas where further development of approaches and methods, and dissemination of best practice is important.
  - Planning and programming: The Office of Planning is already working with other offices to define planning approaches that integrate consideration of operations, freight, safety, environmental streamlining and context sensitive solutions into traditional long-range system, corridor and project planning activities. Developing practical approaches for more comprehensive planning is a key requirement for asset management and should continue to receive high priority from the offices involved in the effort.
  - System management: Day-to-day system operations require coordination among a wide range of operations, incident response, safety, maintenance and work zone activities.
  - Multi-agency coordination: Managing the system effectively from the customers' point of view, and effective utilization of available resources, will require a much more extensive set of cooperative working relationships among different agencies and jurisdictions than has traditionally been the case. The recent focus on operations and safety has highlighted this issue but it also relates to physical preservation and maintenance activities as well.

    The ongoing work in FHWA on all of these issues is important but additional models of best practice would be useful.
- Systems such as HERS, HPMS, and NBIAS have been invaluable in assisting FHWA and the Congress in identifying highway investment needs nationwide in terms of new construction, reconstruction, and rehabilitation of

pavements and bridges. State DOTs and some MPOs have similar capabilities using pavement and bridge management systems and traditional travel demand models. Corresponding analytic tools in areas such as operations, safety, freight, and environmental mitigation would provide a more complete and balanced picture of investment needs. The Offices of Planning, Operations and Safety are looking at a broad range of analytic tool needs and issues. However, a more comprehensive review of needs and opportunities and a coordinated action plan might be helpful. FHWA should spearhead the development of these new tools in collaboration with state DOTs.

- Improved planning-level estimates of costs and impacts of highway investment options are also needed at the corridor and project development levels. Assessments of options in terms of performance and cost would benefit from estimating methods that can be applied early in the project development cycle, before key decisions on the nature and scope of projects are solidified. These planning-stage capabilities are needed in several areas, including right-of-way costs, environmental impact mitigation, safety features or improvements, and operations installations.

- FHWA has strongly supported economic analysis methods and consideration of user costs and benefits in its analytic tools and research programs. It can leverage this experience using results of complementary research programs in asset management now underway through NCHRP. For example, it can provide assistance to state DOTs in conducting analyses of options and tradeoffs by applying the tools now being developed through NCHRP Project 20-57. Similarly, FHWA's interests in performance measures that strengthen the consideration of user costs and benefits can be combined with results of NCHRP Project 20-60 dealing with performance measures useful for asset management.

- The growing attention to operations and the need for operations-related infrastructure such as ITS systems will introduce a new set of maintenance and rehabilitation requirements to serve these assets. DOTs need to understand how to manage these maintenance and rehabilitation needs. In contrast with more traditional infrastructure (pavements, bridges, roadside appurtenances, drainage facilities, etc.), operations systems entail not only structural needs (posts, masts, signal and sign bridges, etc.), but also system reliability considerations. These require new maintenance planning and scheduling methodologies, including preventive maintenance and scheduled maintenance concepts similar to those used, for example, in tunnel system management and potentially the aircraft industry. Collaboration between the Operations, Infrastructure, and Safety Offices is needed to develop the scope and approach of analytic tools that can be used at a planning stage as well as at a more detailed operational stage.

PARTNERING OPPORTUNITIES

- FHWA should consider establishing an agencywide asset management task force to:
  - Identify and coordinate, where appropriate, the various asset management-related activities occurring in the agency;
  - Identify gaps in research or technical support activities and develop strategies for filling these needs; and
  - Monitor and update a coordinated asset management action plan.
- Essentially this task force would follow up and build on the results of the white papers and workshop included as part of this project. FHWA should engage the Division Offices in an agencywide effort to promote asset management by providing additional training opportunities, communicating the asset management-related activities occurring at Headquarters, and identifying the full set of resources and technical support available to state DOTs. The Office of Infrastructure has taken a positive step in this direction by creating an AM Advisory group consisting of a number of Division Administrators and inviting Division staff to attend the NHI course on asset management now being delivered to individual states on request. The appropriate role for Resource Centers also should be considered as part of this effort.
- FHWA working with AASHTO may want to establish a lead state program focusing on best practice examples. Because the concepts of asset management are very broad, examples of best practice can answer the question "what does good asset management look like?" There may be lead states for various aspects of asset management (e.g., planning, maintenance, program delivery, etc.), as well as examples of more comprehensive approaches.
- FHWA should continue and reinvigorate its cooperative effort on asset management with AASHTO (working with the newly established Subcommittee on Asset Management), TRB, ITE and others. This effort can coordinate research initiatives and target technical assistance and implementation support where it is most needed.
- The planned asset management capacity building effort by the Office of Planning (including an upcoming peer exchange) offers an excellent opportunity to draw on the experience and activities going on across program offices.
- While asset management focuses on more than the condition and preservation of physical assets, FHWA can encourage a consistent approach to managing all physical assets by identifying basic condition data, life-cycle cost parameters, and management systems required for all assets across infrastructure, operations, safety, environment and right-of-way. Best practice

examples, status of research and data management and integration strategies could be part of an information clearinghouse.

Appendix A – White Paper Summaries

Infrastructure
Operations
Planning
Safety
Environment
Right-of-Way
Federal Lands

A. White Paper Summaries

INFRASTRUCTURE

Goals and Performance Measures

- Physical condition (e.g., damage, deterioration, and distress)
- User-oriented performance or serviceability measures (e.g., roughness)
- Indicators of remaining life or value
- Life-cycle costs

Options and Tradeoffs

- Strategic tradeoffs between preservation, operations, and capacity expansion
- Choices of materials, construction methods, and preservation and maintenance approaches (preventative versus reactive)
- Choices of different mechanisms for delivery, such as accelerated bridge deployment or accelerated construction programs

Information

- Infrastructure inventory and condition
- Infrastructure performance over time as a function of environmental factors, traffic loading, design, construction/materials, and maintenance practices
- Infrastructure maintenance, rehabilitation and reconstruction costs

Analysis Methods

- Life-cycle cost analysis
- Deterioration modeling
- Agency and user cost modeling
- Benefit/cost analysis
- Prioritization and optimization
- Investment analysis

Implementation Processes and Practices

- Infrastructure investment analysis as part of long-range planning and needs studies
- Transportation program development reflecting infrastructure strategy selection, prioritization methods, and corridor-based approaches
- Use of life-cycle cost analysis to evaluate alternative designs
- Adoption of design and construction best practices to reduce life-cycle costs

Current FHWA Activities

- Leadership within FHWA on asset management practice, through support of the Transportation Asset Management Guide, the companion NHI course on transportation asset management, and the AASHTO Asset Management web site
- Technical assistance and information dissemination on a broad set of infrastructure management methods, including life-cycle cost analysis, engineering-economic analysis, development and use of infrastructure management systems, design and construction methods, work zone management, and data collection and integration
- Support for development of infrastructure management systems and analysis tools, including the national and state versions of the Highway Economic Requirements System (HERS), structures management (tunnels, culverts), roadway hardware management, and pavement design
- Research and technology activities to improve infrastructure performance, reduce maintenance requirements, reduce user costs (including work zones), develop safer construction methods, and promote context-sensitive design practices that incorporate environmental stewardship considerations, and support long-term infrastructure performance monitoring capabilities

Future FHWA Activities

- Provide technical assistance to help agencies perform tradeoff analysis, address organizational issues, estimate and apply user costs, and provide guidance on methods for developing infrastructure preservation and preventive maintenance strategies
- Continue research and technology activities focused on improving information for decision-making, training and professional development, technology, and deployment
- Work with the Office of Operations to develop technical information on operations asset life, recommended techniques and timing of maintenance, and unit costs of system maintenance, repairs, and replacement

- Work with other FHWA offices (Planning and Environment, Operations, Safety) to support development of new analytic tools for evaluation of options and tradeoffs

OPERATIONS

Goals and Performance Measures

- Mobility (throughput, delay), by class of road user
- Reliability (travel time variability)
- Safety (crashes, injuries, fatalities)
- Security
- Agency-specific output measures are needed to supplement user-oriented outcome measures, since performance in operations-related areas (mobility, travel delay, reliability, safety, etc.) will be affected by many factors outside of the control of an individual transportation agency

Options and Tradeoffs

- Mix and balance across program areas, including Arterials Management, Freeway Management, Emergency Management, Freight Management, Work Zone Management, Incident Management, and Road Weather Management
- Selection of specific strategies within each program area (e.g., for freeways: lane management, ramp metering, electronic toll collection, etc.)
- Mix of physical hardware, systems, and personnel investments
- Allocation of system capacity across user groups (e.g., transit, high-occupancy vehicles, and general purpose traffic; or between freight and passenger travel)
- Consideration of operations strategies as an alternative to capacity expansion

Information

- Inventories of physical and system operations components
- Real-time traffic operations performance: throughput, delay
- Customer input
- Crash records and causal factors
- Operations equipment failure rates
- Life-cycle costs of operations assets
- Personnel requirements of operations programs and strategies

Analysis Methods

- Operations strategy effectiveness analysis
- Benefit/cost analysis
- Life-cycle analysis addressing comparison of strategies with different time horizons
- Traffic simulation/optimization

Implementation Processes and Practices

- Coordinated multi-agency operations programs across state and local agencies
- Consideration of operations strategies in long-range planning

Current FHWA Activities

- Development of operations asset management framework
- Pilot investigation of traffic signals asset management subsystem

Future FHWA Activities

- Continue developing operations asset management framework and tools, including:
  - Operations performance measures
  - Life-cycle costing methodologies and tools for different operations areas
  - Development of an operations need identification and costing tool to estimate national-level operations improvement needs and costs
  - Development of management systems for Traffic Signals, Data and Information, Traffic Management and Control, Freeway Management, and Roadway Management
  - Development of an umbrella Operations Asset Management system with linkages to support broader Transportation Asset Management analysis
  - Outreach activities with AASHTO, TRB, and ITE committees on operations asset management, including presentations and workshops, preparation and distribution of guidance materials, and tool development and training

PLANNING

Goals and Performance Measures

- Planning goals include preservation, mobility, accessibility, safety, security, congestion relief, economic development, environmental protection, and cost-effectiveness
- Performance measures include level of service; travel time reliability; condition of physical assets; crash, fatality and injury rates; incident response time; mobile source emissions; wetland acreage; community cohesion; life-cycle costs; and user costs

Options and Tradeoffs

- Tradeoffs among preservation, operations and capacity expansion expenditures
- Tradeoffs between passenger and freight mobility
- Tradeoffs among modal and intermodal options
- Tradeoffs among different geographic areas or functional systems
- Balancing safety, mobility, environmental, and equity objectives

Information

- Socioeconomic data, including growth projections
- Current traffic volumes and trip patterns
- Transportation supply characteristics (capacity, speed, type of service, pricing, etc.)
- Facility inventory, condition and performance
- Crash data
- Congestion/travel time
- Environmental data
- Vehicle fleet characteristics

Analysis Methods

- Travel demand modeling and traffic simulation
- Infrastructure management methods
- Strategy impact assessment

- Benefit/cost analysis
- Air quality modeling

Implementation Processes and Practices

- Long-range plan development and updates
- Corridor and regional planning
- Performance measurement and monitoring
- Transportation improvement program development
- Linkages among planning, programming and budgeting

Current FHWA Activities

- Reviews at the state and metropolitan levels to assess current efforts in following planning guidelines and regulations, and offer suggestions
- Encouragement and support of the broader use of data, modeling, and analytic tools
- Research on scenario analysis techniques and visualization tools for planning
- Best practices and case studies on strengthening performance-based planning practice
- Work with the Office of Safety on the safety conscious planning initiative, and with the Office of Freight Management and Operations to better integrate freight planning

Future FHWA Activities

- Work with the Office of Asset Management to develop a more consistent message that performance-based planning is a key building block of good asset management
- Include a focus on asset management and performance measurement in the Transportation Planning Capacity Building Program
- Identify data and analysis tool gaps in areas required for more integrated planning (operations, safety, freight) and define research programs to develop these gaps
- Continue to identify and promote the use of tools such as management systems as part of long-range planning, programming and budgeting efforts
- Document case studies at the state and MPO levels illustrating best practice with respect to asset management and planning (e.g., use of HERS-ST for planning)

SAFETY

Goals and Performance Measures

- Reduce fatalities, injuries, and crashes
- U.S. DOT target: 1.0 fatalities per 100 million VMT by 2008
- FHWA fatality reduction targets for roadway departure, intersection, and pedestrian crashes

Options and Tradeoffs

- Balance of investments in engineering, enforcement, education, and emergency response
- Balance of programs targeted at drivers, vulnerable users, vehicles, and highways
- Balance of programs targeted at work zones, intersections, vehicle-train crashes, head-on crashes, road departure crashes, and truck crashes
- Sustained versus spot safety activities
- Inclusion of safety design features in preservation, operations and capacity projects

Information

- Crash records and causal factors
- Highway design characteristics that relate to safety
- Safety hardware inventory

Analysis Methods

- Strategy effectiveness analysis to assess the likely reduction in crashes, injuries and fatalities from different strategies
- Economic benefit/cost analysis
- Prioritization and optimization analysis to most effectively allocate limited resources to maximize reductions in injuries and fatalities

Implementation Processes and Practices

- Integration of safety considerations into long-range transportation plans
- Integration of safety considerations into program development processes within safety programs and across all program categories

- Development of state-level safety plans with participation from broad set of partners
- Adoption of design and construction best practices reflecting safety considerations

Current FHWA Activities

- Safety conscious planning effort to integrate safety considerations throughout transportation planning and programming processes
- Active participation in AASHTO Strategic Highway Safety Plan development and implementation efforts
- Technical assistance to states on implementation of safety programs
- Research and education on safety best practices and effectiveness
- Support for information system and analysis tool development, including the Interactive Highway Safety Design Module (IHSDM), Roadside Safety Analysis Program (RSAP), Resurfacing Safety Resource Allocation Program (RSRAP), Traffic and Criminal Software package (TrACS), AASHTO Roadway Hardware and Safety Management Systems effort, and AASHTO Transportation Safety Information Management Systems (TSIMS) effort

Future FHWA Activities

- Continue existing research, technical assistance, and outreach activities to support a performance-based approach to transportation safety
- Use asset management principles to increase focus and accountability for safety with decision-makers. Relate results to actions using analytic capabilities available today to estimate impacts of safety programs and demonstrate predicted benefits of safety investments

ENVIRONMENT

Goals and Performance Measures

- Goals include environmental protection and stewardship, improved quality of environmental decision-making, and environmental streamlining
- Performance measures include mobile source emissions, water quality, noise levels, wetlands acreage, ecosystem preservation and enhancement, process efficiencies, and number of States implementing environmental best practices in planning

Options and Tradeoffs

- Location, design, and environmental mitigation features of transportation projects
- Integration of environmental best practices into highway rehabilitation projects
- Tradeoffs between construction and maintenance options (materials and techniques) and environmental impacts
- Choices among transportation control strategies for air quality improvement

Information

- Air and water quality data
- Ecological data, including wetlands, critical habitat areas, habitat connectivity
- Model projection data of emissions levels, land use, climate variability, etc.
- Cost data on various environmental mitigation strategies and alternative materials
- Process data, including time to fulfill regulatory requirements and project delays

Analysis Methods

- Air quality conformity analysis
- Benefit/cost analysis
- Geospatial analysis integrating multiple environmental and infrastructure data
- Tracking and assessment of environmental performance indicators

Implementation Processes and Practices

- NEPA process and compliance with state and Federal regulations
- Development of environmental policies, procedures and commitments with partners
- Preparation, implementation, and monitoring of environmental mitigation plans
- Use of environmental management systems to track environmental planning processes, project-level requirements, environmental performance
- Integration of environmental planning with transportation planning, programming and budgeting

Current FHWA Activities

- Support for transportation agencies in complying with environmental regulations
- Technical assistance to transportation agencies for meeting their environmental responsibilities and advancing environmental stewardship, including promotion of integrated planning approaches, research on transportation and climate change, support of environmental management systems, and dissemination of best practices
- Research to build knowledge and develop models and tools, including ecosystem – and watershed-level management strategies, emissions from mobile sources, maintenance best practices for water quality, and hazardous materials management

Future FHWA Activities

- Support to transportation agencies in integrating environmental data and performance objectives into existing asset management systems, including the application of geospatial tools
- Conduct research on costs and performance of environmentally sound technologies and practices for transportation construction, preservation, and maintenance
- Conduct research to develop, test and disseminate information about management techniques to improve environmental performance, including use of programmatic agreements and advanced mitigation strategies
- Increase focus on environmental issues of regional or national scale
- Continue development and promotion of interjurisdictional and collaborative project planning and decision-making, including work to integrate transportation environmental planning with other environmental planning processes
- Continue work to integrate environmental metrics with other key measures during the NEPA process, including economic, community, mobility, and safety effects

RIGHT-OF-WAY

Goals and Performance Measures

- Timeliness and cost-effectiveness of providing right-of-way for projects
- Minimizing costs and risks of right-of-way acquisition
- Compliance with Federal and state law, including full compensation for all property acquired and satisfaction of all relocation assistance requirements

- Cost-effectiveness of property management while ensuring safety and environmental protection
- Managing access to highway facilities to maintain mobility and safety

Options and Tradeoffs

- Transportation alternatives analysis: corridor location and alignments
- Timing of property acquisition and disposal
- Incorporation of right-of-way activities within design-build contracts
- Access management provisions
- Corridor management preservation techniques
- Property management options (maintenance responsibilities, joint development, shared-use agreements) and practices (maintenance and upkeep)

Information

- Complete, accurate, current information on property holdings
- Real property and relocation costs by category of parcel, project type, and location
- Time requirements for different project phases by project type and location
- Environmental characteristics of parcels, and mitigation needed
- Project experience: success and risk factors actually encountered, and recommendations for addressing similar situations in the future.

Analysis Methods

- Scheduling
- Property acquisition cost estimation
- Revenue estimation
- Land valuation
- Geographic Information Systems analysis

Implementation Processes and Practices

- Analysis of corridor development, preservation options, and joint development opportunities in long-range planning
- Estimation and updates of right-of-way needs, costs, and mitigation requirements

- Planning and scheduling of right-of-way acquisition to allow sufficient time for completion before construction
- Operations and maintenance of the right-of-way

Current FHWA Activities

- Technical assistance to agencies throughout the entire cycle of project delivery and encouraging the use of property inventory and maintenance systems
- Sponsorship of research on right-of-way topics, including performance measures, advanced acquisition, corridor preservation, and procedures to support innovative contracting practices and streamlined transportation development
- Development of technology to support right-of-way management, including web-based statistics and GIS and data management applications for local agencies

Future FHWA Activities

- Continue to encourage use of comprehensive right-of-way inventory databases
- Develop tools to assist agencies in determining how much property is needed, how much to dispose, and how far in advance to begin the acquisition process
- Develop tools to better integrate right-of-way in long-range planning by helping decision-makers to anticipate long-range property needs and evaluate impacts
- Conduct education activities emphasizing right-of-way asset management options
- Improve right-of-way cost estimation methods

FEDERAL LANDS

Goals and Performance Measures

- Mission is to improve transportation access to and within Federal and tribal lands, support recreational travel and tourism, protect and enhance natural resources, and support economic development in rural areas
- Business improvement goals (consistent with FHWA's Vital Few) are:
  - Improve the safety of transportation on Federal and tribal lands;
  - Streamline the environmental process;

  - Work with partners to ensure that transportation planning is an integral part of their planning processes; and
  - Improve the accountability of all parties involved in project management.
- Specific performance measures include minimizing project delivery costs, maximizing capital improvement with public funds, improving stability of the multi-year program, improving environmental compliance services, and improving infrastructure condition.

Options and Tradeoffs

- Balancing preservation, operations, and capacity expansion programs
- Decisions between modal and intermodal options, where appropriate
- Balancing access and mobility objectives with environmental and cultural protection

Information

- Condition data for transportation facilities, including pavement, bridge, and transit
- Inventory data
- Safety data on crashes, injuries, and fatalities
- Traffic data
- Transit system performance
- Customer satisfaction with respect to access, road and bridge condition, safety, traffic, views, natural resource preservation, directional signs, and transit services

Analysis Methods

- Infrastructure management methods (life-cycle analysis, deterioration modeling, etc.)
- Traffic and safety analysis
- Project prioritization

Implementation Processes and Practices

- Development of transportation plans defining goals, performance measures and strategies; development of regional plans in coordination with partner agencies
- Development of transportation improvement programs based on established goals, performance targets and prioritization criteria

- Development and use of safety, bridge, pavement, and congestion management systems to analyze needs, identify and analyze project candidates, and relate investment levels to performance results

Current FHWA Activities

- Publication of final rules for the partners (National Park Service, U.S. Forest Service, U.S. Fish and Wildlife, and the Bureau of Indian Affairs) to develop and implement safety, bridge, pavement, and congestion management systems
- Work with the National Park Service and the U.S. Forest Service on nationwide implementation of regional and systemwide long-term transportation planning; work with the U.S. Fish and Wildlife Service to develop a draft 20-year transportation plan; publication of tribal "Transportation Planning Procedures and Guidelines"
- Collection and management of infrastructure inventory and condition data
- Maintenance of a safety database and work towards greater consistency of crash data

Future FHWA Activities

- Assist FLH partners with implementing and using the new management systems; coordinate with the FHWA Office of Asset Management for support
- Improve data collection and performance monitoring for all transportation facilities covered by the FLHP, particularly for facilities not owned by the Federal government
- Publicize the successful tri-party partnerships between FLH, the U.S. Forest Service and 41 state DOTs, and extend this concept to improve coordination with all partners
- Develop a program to strengthen transportation asset management for tribal lands

FHWA White Paper: *Infrastructure and Asset Management*

The purpose of this paper is to define the relationship between transportation asset management and transportation system planning and to describe the current, and potential future, activities of the FHWA Office of Infrastructure that support the implementation of asset management. The paper is one of a set of seven papers exploring the relationship of asset management to each of FHWA's major program areas including planning, right-of-way, environment, infrastructure, safety, operations, and Federal lands.

Section 1.0 provides a general overview of asset management relevant to all program areas. Section 2.0 defines the relationship between planning and asset management. Section 3.0 describes current, and potential future, activities of the Office of Infrastructure that support asset management.

1.0 Overview of Transportation Asset Management

1.1 Definition of Asset Management

Transportation asset management is a set of guiding principles and best practice methods for making informed transportation resource allocation decisions, and improving accountability for these decisions. The term "resource allocation" covers not only allocation of money to program areas, projects, and activities but also covers deployment of other resources that add value (staff, equipment, materials, information, real estate, etc.). While several of these principles and practices were initially developed and applied within the domain of infrastructure preservation, most established definitions of asset management are considerably broader. The **Asset Management Guide**,[1] recently adopted by AASHTO defines asset management as:

[1] *Transportation Asset Management Guide*, prepared for the National Cooperative Highway Research Program (NCHRP) Project 20-24(11) by Cambridge Systematics, Inc. with Parsons Brinckerhoff Quade & Douglas, Inc., Roy Jorgensen Associates, Inc. and Paul D. Thompson, November 2002, AASHTO Publication RP-TAMG-1.

> *"… a strategic approach to managing transportation infrastructure. It focuses on…business processes for resource allocation and utilization with the objective of better decision-making based upon quality information and well-defined objectives."*

As Mary Peters, FHWA Administrator has frequently put it:

> *"If I have one additional dollar to spend on the transportation system, what is the most effective way to spend it?"*

The essence of asset management is answering that question.

Asset management is concerned with the entire life cycle of transportation decisions, including planning, programming, construction, maintenance, and operations. It emphasizes integration across these functions, reinforcing the fact that actions taken across this life cycle are interrelated. It also recognizes that investments in transportation assets must be made considering a broad set of objectives, including physical preservation, congestion relief, safety, security, economic productivity, and environmental stewardship.

1.2 Asset Management Principles

The core principles of asset management are:

- **Policy-Driven –** Resource allocation decisions are based on a well-defined and explicitly stated set of policy goals and objectives. These objectives reflect desired system condition, level of service, and safety provided to customers, and typically are tied to economic, community and environmental goals as well;

- **Performance-Based –** Policy objectives are translated into system performance measures that are used for both day-to-day and strategic management;

- **Analysis of Options and Tradeoffs –** Decisions on how to allocate resources within and across different types of investments (e.g., preventive maintenance, rehabilitation, pavements, bridges, capacity expansion, operations, different modal mixes, safety, etc.) are based on an analysis of how different allocations will impact achievement of relevant policy objectives. Alternative methods for achieving a desired set of objectives are examined and evaluated. These options are not constrained by established organizational unit boundaries – for example solving a congestion problem could involve a capacity expansion or an operational improvement (e.g., signal coordination). The best method is selected considering the cost (both initial and long-term) and likely impacts on established performance measures. The limitations posed by realistic funding constraints must be reflected in the range of options and tradeoffs considered;

- **Decisions Based on Quality Information –** The merits of different options with respect to an agency's policy goals are evaluated using credible and current data. These data may apply to specific functions (e.g., pavement and bridge management,

traffic monitoring) or reflect a more integrated, corporate view. [2] Where appropriate, decision support tools are used to provide easy access to needed information, to assist with performance tracking and predictions, and to perform specialized analysis (e.g., optimization, real-time simulation, scenario analysis, life-cycle cost analysis, benefit/cost analysis); and

- **Monitoring to Provide Clear Accountability and Feedback –** Performance results are monitored and reported for both impacts and effectiveness. Feedback on actual performance may influence agency goals and objectives, as well as resource allocation and utilization decisions.

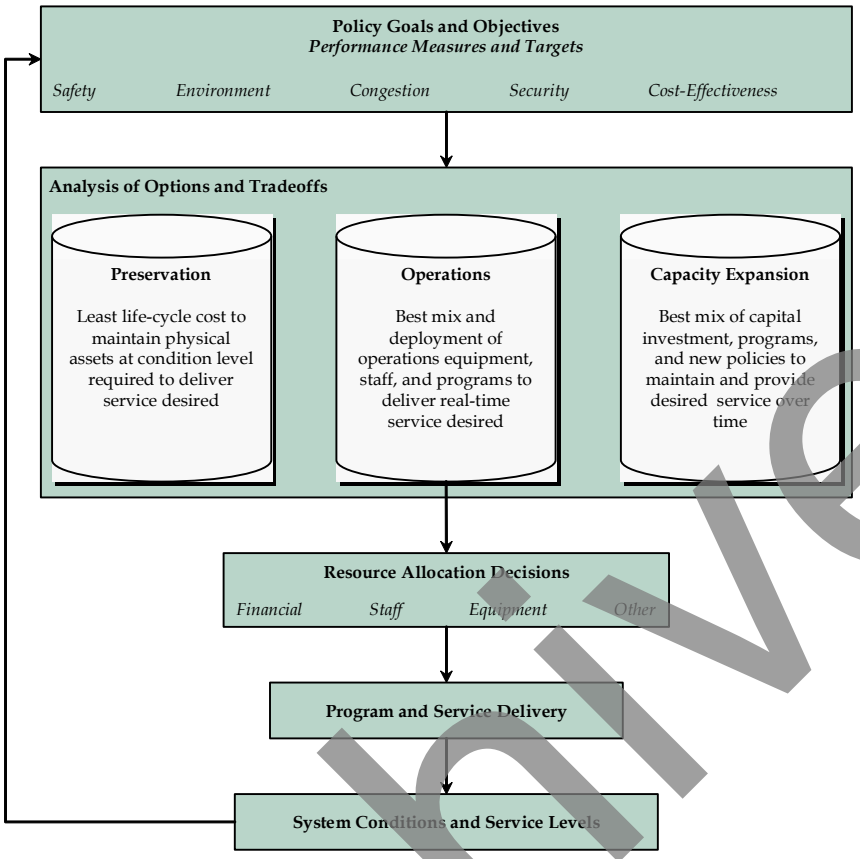
These principles are not unfamiliar, nor are they radical. Most transportation practitioners would agree that investment decisions should be based on weighing costs against likely outcomes, that a variety of options should be considered and evaluated, and that quality information is needed for decision-making. Many agencies are now pursuing performance-based approaches to planning and programming, monitoring system performance, and developing more integrated data and analysis tools to evaluate tradeoffs among capital expansion, operations, and preservation activities. Most agencies recognize that application of asset management principles is critical in times of constrained resources, when all investment and budget decisions are subject to increased public scrutiny.

1.3 Asset Management Practice

Figure 1 illustrates the strategic resource allocation process that embodies the asset management principles presented above.

[2] The FHWA plays a key role in standardizing the content and format of data that are mandated by federal law: e.g., the National Bridge Inventory (NBI) data that are reported by state DOTs.

Figure 1. Strategic Resource Allocation Process



The diagram includes the following elements:

- **Policy Goals and Objectives,** supported by performance measures are established through the policy and system planning process and used to guide the overall resource allocation process.

- **Analysis of Options and Tradeoffs** includes examination of options *within* each investment area, as well as tradeoffs *across* different investment areas. The definition of investment areas is flexible and can be tailored to how an individual agency does business. For example, an agency may have a separate safety investment area and also incorporate consideration of safety within system preservation, operations, and capacity expansion expenditures. Each option and tradeoff is evaluated with respect to established agency goals and performance objectives.

- **Resource Allocation Decisions** are based on the results of tradeoff analyses These decisions involve allocations of financial, staff, equipment, and other resources to the different investment areas and/or to different strategies, programs, projects, or asset classes within an individual investment area.

- **Program and Service Delivery** is accomplished in the most cost-effective manner which again involves consideration of different delivery options (e.g., use of contractors, interagency agreements), as well as a delivery tracking process involving recording of actions taken, costs, effectiveness, and lessons learned to guide future activity.

- **System Conditions and Service Levels** are tracked to see the extent to which established performance objectives are being addressed. This information is used to refine policy goals and priorities (e.g., put more emphasis on safety in response to an increase in crash rates).

1.4 Transportation Investment Categories

In Figure 1, the box labeled "Analysis of Options and Tradeoffs" shows three types of investment categories – preservation, operations, and capacity expansion. These are defined as follows:

1. **Preservation** encompasses work to extend the life of existing facilities (and associated hardware and equipment), or to repair damage that impedes mobility or safety. The purpose of system preservation is to retain the existing value of an asset and its ability to perform as designed. System preservation counters the wear and tear of physical infrastructure that occurs over time due to traffic loading, climate, crashes, and aging. It is accomplished through both capital projects and maintenance actions.

2. **Operations** focuses on the real-time service and operational efficiency provided by the transportation system for both people and freight movement on a day-to-day basis. Examples of operations actions include real-time traffic surveillance, monitoring, control, and response; intelligent transportation systems (ITS); signal phasing and real-time signal controllers at intersections; HOV lane monitoring and control; ramp metering; weigh-in-motion; road weather management; and traveler information systems. Although operations focuses on system management, the infrastructure needed to provide this capability may be substantial (e.g., traffic control centers; ITS hardware; environmental sensors and fire control systems in tunnels). Thus, an operations strategy requires capital and operating budget as well as substantial staff resources.

3. **Capacity expansion** focuses on the actions needed to expand the service provided by the existing system for both people and freight. Capacity expansion can be achieved either by adding physical capacity to an existing asset, or acquiring/constructing a new facility.

These three categories are defined in order to show that:

- Asset management is not just about preservation of highway network assets; it is about making investment decisions that address a wide range of policy goals.

- The three categories provide a simple, useful way for decision-makers to align program investment categories and priorities with key policy objectives. For example, many agencies establish a "preservation first" policy or favor maximizing efficiency of operations prior to investing in new capacity.

- The categories may present alternative ways of meeting a policy goal. For example, it may be appropriate to consider operational improvements to address a congestion problem as an alternative to adding a new lane.

- Decisions about the resources allocated to each category cannot be made independently. Meeting many policy goals (e.g., safety) may require a mix of investments across these categories. Similarly, an increase in capacity expansion investments may require increased operations and preservation expenditures at some point in time.

As noted above, tradeoff analysis may be done across *investment categories* as well as within them. An agency might wish to define investment areas coincident with the three categories discussed above (preservation, operations, capacity), or they may define a different set of categories. For example, a safety program could be defined as an investment category, with subareas for operational activities (e.g., signs, markings, signalization, channelization, etc.), preservation (replacement of guardrails), and capacity (project design features supporting safety, e.g., wide shoulders). This would provide the framework for understanding the best mix of complementary actions within the safety area as well as tradeoffs between safety and other objectives.

1.5 Asset Management and the Transportation Planning Process

A common reaction to the broad description of asset management is "how is this different from the overall planning and programming process in an agency?" The response is that asset management is not a new kind of business process that replaces planning and programming. Rather, it should be viewed as a set of best practices to be employed within the established planning and programming framework. Existing regulations pertaining to the planning process, together with statutes related to specific funding programs and their allocation criteria, and the body of environmental regulations affecting transportation planning – provide the context within which asset management practice occurs. In terms of Figure 1, transportation regulations and statutes impact establishment of policy objectives, the manner in which options are generated and evaluated, and they also provide certain constraints on resource allocation (based on Federal and state funding eligibility restrictions). Many of the core principles of asset management are embodied in the existing planning regulations (e.g., consideration of alternatives). Examining the planning process using the lens of asset management

provides an opportunity to explore ways to continue to strengthen the mission of transportation planning – for example:

- How to improve connections between long-range planning and resource allocation;
- How to strengthen agency and public consideration of preservation and operations investments within the long-range planning process;
- How to better integrate environmental considerations throughout the transportation planning and decision-making process – across capacity, operational and preservation investments; and
- How to provide a common information resource base to serve multiple activities across the transportation asset life cycle – long-range planning, corridor studies, safety studies, environmental assessments, multi-year capital programming, project development, preventive maintenance and system operations.

While asset management is closely associated with planning and programming activities, asset management best practices are also integral to design, construction, routine and preventive maintenance and operations activities. For example:

- Application of life-cycle cost analysis in the facility design process;
- Analysis of alternative construction materials and methods;
- Tradeoffs across different maintenance activities based on level of service and extended facility life provided to customers;
- Developing an appropriate mix of operations expenditures on technology upgrades, hardware/infrastructure maintenance and replacement, and skilled personnel;
- Evaluation of delivery options (e.g., design-build, use of private contractors for maintenance and operations, inter-agency agreements, etc.).

1.6 Key Opportunities

Despite the support for taking an asset management approach, many agencies face very real organizational, institutional, and technical challenges to making further progress in asset management. Each one of these challenges represents a potential opportunity for FHWA to work with its partners to encourage broader implementation of asset management principles. For example:

- Top management needs to set an organization-wide direction and framework for decision-making and to ensure that all parts of the organization are working together in a coordinated fashion. Maintaining continuity in leadership direction and understanding of key asset management principles can be particularly challenging with frequent turnover in agency executives;

- Clear roles for each organizational unit must be established to solve common problems or meet common objectives. Differences in perspectives and approaches, lack of established procedures, or turf battles must be reconciled;

- Established resource allocation methods, often constrained by externally imposed restrictions, historical allocations or formulas, or delicate and difficult political negotiations may restrict the range of options and tradeoffs that can be considered;

- Staff resource constraints together with a constant "fire-fighting" mode of operation also may restrict the amount of time and effort that can be spent on analyzing options;

- Developing a comprehensive set of reliable methods, data and tools to evaluate performance tradeoffs among the full set of investment options will take a sustained, multi-year effort;

- Establishing a causal link between an investment or action and a performance indicator of interest, due to the presence of external factors influencing performance (e.g., gas prices, vehicle fleet changes, growth patterns, etc.) may require additional research in some cases;

- Coordination among multiple agencies to achieve established objectives in areas such as operations and safety adds complexity to the decision-making process and program implementation efforts; and

- External and internal agency culture based on "bottom-up" decision-making, with a focus on specific projects rather than on broader system performance and outcomes.

While it is relatively straightforward to implement asset management within a well-defined area of the agency (a pavement management unit, for example), the issues identified above illustrate why it is much more challenging to implement it more fully within an agency, or across multiple agencies.

However, the need to allocate scarce resources as effectively as possible and demonstrate results and performance to the customers of the transportation system provides strong motivation and support for overcoming these challenges. A comprehensive, performance-based approach to transportation investment decisions will be essential to meeting the increasingly complex set of transportation needs of the 21st century.

2.0 Infrastructure and Transportation Asset Management

This section looks at the relationship between asset management and highway infrastructure. It is written from the perspective of an operating agency (e.g., a state DOT).

2.1 Overview of Highway Network Infrastructure

Highway infrastructure encompasses the physical assets that form a road network. While there are many features in a highway system, pavements and structures are the most important from a program funding perspective, and are the most critical in delivering transportation performance. Many agencies regard the knowledge and understanding of pavements and structures, and the decisions they must make regarding this infrastructure, as central to their asset management program. Other features (such as signs and signals) are also included in infrastructure and will be mentioned below where relevant.

The activities, supporting information, and decisions related to infrastructure are pervasive throughout a transportation organization. They range from technical matters such as establishment of standards, materials specification and selection, and engineering design, to managerial concerns about performance and effective maintenance, to issues of funding, resource allocation, and strategic planning. Using the principles of transportation asset management, these important topics are viewed together, rather than separately. The following sections build a framework of asset management within which actions addressing highway infrastructure can be understood, integrated, and improved.

The sections below develop the asset management approach from three perspectives that build on the asset management concepts and principles in Section 1:

- Infrastructure activities related to each of the transportation investment areas of system preservation, operations, and capacity expansion;
- Infrastructure considerations throughout the transportation facility life-cycle; and
- A summary of key asset management principles as they apply to infrastructure.

2.2 Relationship to Transportation Investment Areas

Infrastructure investments are an important component in transportation agency programs. Each of the major investment areas of system preservation, operations, and capacity expansion presents decision-makers with numerous options, and requires quality information with which to evaluate the options.

System Preservation

Pavements and structures (primarily bridges and tunnels) are valuable assets that must be preserved to maintain their integrity, provide safe, economical, and efficient serviceability to motorists, and meet design expectations cost-effectively. Agencies typically address system preservation needs across several areas and organizational units.

Engineering and Technical

- Engineering design and materials specifications that are put in place during new construction affect infrastructure performance and future system preservation needs. Performance impacts include structural behavior and service life; serviceability to road users in terms of a safe, comfortable, and efficient ride; and reliability of performance throughout the network.

- Preservation treatments reduce future problems or correct existing ones, helping to extend life and performance cost-effectively, while being compatible with materials in the existing structure. Key decisions involve what treatments to perform, when to perform them optimally, and where to perform them in the network. These decisions must take into account technical, economic, and financial constraints.

- The technology of the preservation treatments themselves is an important consideration. Materials used in pavements and structures must perform over many years under the demands of traffic loads, weather, seasonal changes, and variable ground conditions. The ability to achieve acceptable quality of treatment throughout an extensive network must be maintained even when performed under widely varying conditions. Ensuring materials quality and correct technique during placement depend on proper specification, testing, and training, backed by research programs to keep up to date on the latest methods and products.

Life-Cycle Analyses, Tradeoffs, and Supporting Analytic Tools

- The analysis of system preservation options is conducted within an economic framework, using life-cycle cost techniques. A life-cycle approach provides objective comparisons of different preservation actions and approaches that may have different service life extensions, costs, and performance benefits to road users, including reductions in vehicle operating costs and travel time costs. An economic life-cycle analysis can demonstrate the benefits of a preventive maintenance approach, the consequences of a deferred maintenance approach, and the results of capital-maintenance tradeoffs.

- Agency managers have choices in the types of treatments they can apply (e.g., relatively minor treatments conducted through maintenance programs, or major repairs or rehabilitation that are done as capital construction projects), as well as the strategies within which these treatments will be applied. For example, a preventive maintenance strategy may emphasize actions taken before significant distress occurs, while a more reactive strategy may emphasize preservation treatments in response to observed deterioration in condition or performance. Life-cycle cost analyses can also be used to analyze the potential benefits and costs of new materials, and to assess the additional system preservation-related costs of changes in vehicle sizes and weights.

- Agencies have embodied life-cycle analyses in management systems for decision support. Individual systems have been developed for pavements and bridges (and very recently by FHWA and FTA for tunnels) to account for the specific engineering details, rates of deterioration, appropriate treatments, and costs associated with each

of these types of infrastructure. With recent advances that have been pursued by state DOTs, these management systems enable agencies to conduct several analyses important to asset management, including needs identification and prioritization, capital-maintenance tradeoffs, optimization of investment programs subject to budget constraints, and what-if analyses of the tradeoffs between budget level and performance.

- Management systems can provide a benchmark for performance monitoring, and house the information on system inventory and periodic condition inspections performed for pavements and structures. Systems have been developed for both capital preservation and routine maintenance (using a level-of-service approach.) Agencies are now devoting significant efforts to understanding how the data and analytic capabilities of these and other systems need to be integrated to provide stronger asset management support (e.g., in the analysis of cross-program tradeoffs) and better information to agency executives and stakeholders.

Organizational Capabilities and Procedures

- System preservation services are delivered through an agency's construction and maintenance organization, either by agency employees or through outsourcing to public-sector or private-sector contractors. Important delivery support is provided by agency units ranging from the materials and testing laboratory to the information technology, planning, or other staff that support geographic information systems (GIS).

- Since preservation is performed on actively operational facilities, the issues of work zone layout, operation, and safety are critical. Training is also important in infrastructure preservation, to help employees understand and apply correct techniques, and to inform them about potentially hazardous materials.

Operations

Infrastructure affects operations through the serviceability it provides to motorists in terms of an unimpeded, smooth, safe ride.

- Quality of the pavement surface and of bridge decks are key factors in providing an acceptable level of mobility and safety. Clean and well-placed signs, functional and well-timed signals, and safety devices in good repair (e.g., guardrails and crash attenuators) are other examples of the role that infrastructure plays in promoting highway network operations.

- In recent years there has been an increasing trend by agencies to install specialized infrastructure to improve system operations on highways. Variable message signs, road weather information systems, advanced traveler information systems, and urban traffic control centers (with linkages to speed monitoring loops and road surveillance cameras) are examples. These and similar technologies benefit both the road user and the transportation agency. For motorists, they provide optimized system efficiency,

increased safety, and a source of information for traveler advisories. For the transportation agency, they "provide real-time surveillance of the road network, allowing rapid response to emergencies and traffic incidents."[3]

- High-technology transportation infrastructure entails not only capital construction, but also maintenance to keep it in working order and to sustain high system reliability needed for operational effectiveness. "Managing these technology-based assets requires skilled technicians and a proper preventive maintenance program to assure maximum operability and optimum cost effectiveness."[4] Developing and sustaining these skills within the maintenance organization will require agencies to consider how they deliver maintenance services for these assets, and to provide complementary investments in maintenance employee training or to outsource these services to skilled contractors.

- A key operational aspect of infrastructure is its contribution to safety. Safety is built into infrastructure through roadway and structures design, installation of safety features and appurtenances, and continual proper maintenance.

- Security involves protecting the integrity of transportation systems, services, and users from unconventional attacks. Regrettably, State DOTs are experiencing a sharply increased need to incorporate security in their resource allocation decisions. Managing security is an evolving challenge, however, as potential threats are newly identified. While certain principles of asset management relate to security as well (e.g., the need for good information, such as knowledge of the structural and materials characteristics of existing assets), the inherently unconventional nature of the possible threats requires a broader view across a range of possibilities that are not traditionally addressed by asset management data and procedures. FHWA, AASHTO, and other agencies are now working with state DOTs and other operating agencies to identify assets and techniques that need to be incorporated within a comprehensive approach to security.

- In addition to these direct effects, infrastructure also has an indirect effect on operations. The importance of work zones to infrastructure preservation was described in the preceding section. Work zones occupy a portion of the roadway or bridge surface, creating a new source of recurring congestion and potential crashes. Agencies have experimented with several approaches to reducing this congestion and maintaining safety, particularly on heavily-traveled urban highways:
  - Performing work off-peak, at night or on weekends;
  - Constructing bypass lanes within the right-of-way to route traffic around the work site;

[3] R.B. Hamilton and W.A. Hyman, **Transportation in the New Millennium – Looking Forward: A Perspective on Maintenance and Operations**, TRB Committee A3C01 (now AHD10), 1999.

[4] Ibid.

- Rerouting traffic to detours on other roads in the network to bypass a work site; and
- Closing lengths of the facility completely for a defined period of time to complete a comprehensive set of repairs and maintenance tasks concurrently and without interruption.

Capacity Expansion

Capacity expansion creates new infrastructure to serve changing demands for personal and commercial travel. It affords an opportunity for agencies to build new facilities that reflect the latest design concepts, materials, and products to benefit their customers. Many of the ideas on the role of materials technology, economic analysis, employee training, and the use of information technology that were discussed in the section on System Preservation apply here as well, but in the context of new construction rather than rehabilitation or repair.

- Capacity expansion projects are expensive; obtaining reliable cost estimates that accurately account for engineering and site requirements, environmental mitigation, and ancillary features is a challenge. Controlling these costs as the project evolves from concept through design to implementation requires good management and well understood internal procedures and criteria.

- Analytic tools for sketch planning and preliminary feasibility studies could help to develop more reliable cost estimates at early stages of a project. These estimates would help agencies focus more effectively on viable project approaches, and could be continually updated and refined based on the experience of completed projects. The difficulty in developing these systems is the high variability observed in both construction and maintenance costs, and the complexities in attributing these variations to clearly defined causes in each project.

- Capacity expansion creates a set of alternatives that should be subject to tradeoff analyses with system preservation and operations improvements on existing infrastructure. Once again, management systems and good data on the relative performance and cost of investment options are needed for these analyses. Tools to structure these analyses more effectively are now being developed in NCHRP Project 20-57. Performance monitoring and feedback are particularly important to verify the performance of the infrastructure design and construction and to gauge the benefits of the investment to road users.

2.3 Infrastructure Considerations in the Transportation Facility Life Cycle

Given the close association of infrastructure with both major capital construction projects and with highway maintenance and operations, considerations of infrastructure and asset management can occur throughout the facility life-cycle as described below.

Long-Range System Planning

Long-range system planning is the logical stage at which to evaluate strategic options and tradeoffs among possible investments. Long-range planning considers the need for new infrastructure, often by mode, and in comparison with improving existing infrastructure through operations improvements. Issues that arise in planning for infrastructure include the following:

- While some agencies have a strong relationship between planning and later stages of project development and resource allocation, in other agencies this linkage could be strengthened.

- There is a disparity in the availability of management systems appropriate for use at the planning stage. Sketch planning tools such as the ITS Deployment and Analysis System (IDAS) are appropriate, but are focused on a particular asset class. Systems for pavements, bridges, and maintenance are also available, as discussed below. Systems or tools for other assets may be lacking at the planning stage, as are systems to better understand the environmental impacts of proposed investments.

- While long-range plans stress modal, capacity expansion, and operations-related opportunities for investment, they are less consistent on including long-term information on system preservation. A stronger presentation of the typically substantial investments in preserving system assets would provide a clearer picture of the total demands on an agency's forecasted revenues, and make the case for the geographic equity inherent in the distribution of system preservation dollars throughout a state.

- Existing management systems for pavements, bridges, and maintenance are efficient enough to be used in planning. The fact that agencies often use only a percentage of available features and options, however, inhibits their greater use in planning for tradeoff analyses of long-term performance versus potential funding and budget levels. The analysis of "what-if" scenarios, which many modern systems already support, would be especially valuable at the planning stage.

- Agencies are recognizing and increasingly dealing with integration of information from their management systems to provide a more comprehensive report of current conditions, projected needs, and investment options to executives and managers, and to strengthen the linkages among planning, project development, resource allocation, and project implementation.

Project Development

Project development takes the transportation investment strategies that have been outlined in planning to formulate project options in more detail.

- It is at this stage that options among materials, construction and maintenance methods, work zone and site logistics, project timing and sequencing, and other aspects of project work are considered.

- Preliminary design and environmental reviews begin in this stage, and each may shape the project outlines and preferred approaches. Site visits and field tests are conducted as needed, and staff in specialized disciplines in the central office and districts become involved to evaluate options and recommend the preferred construction or maintenance method.

- An issue of concern is the development of accurate cost estimates that remain stable throughout project development, budget approval, and design, to the point of bid advertisement. Accurate, stable estimates are in part a matter of accounting for the variations in project characteristics, regional economics, and the current bidding climate; and in part a matter of good management of the project development process. In either case, accurate estimates are important to good asset management. Accurate costs contribute to accurate estimates of a project's merit, expressed through a benefit-cost calculation. They also reduce the need for later program adjustments to compensate for unexpectedly higher project costs.

- The means of project or service delivery may also be considered at this step, particularly for major projects, or deferred to later time.

- Depending on agency practice, these findings are compiled into a project submittal or nomination. In states that have refined this process to a high degree, the nomination includes the proposed scope of the project, rationale or justification, estimated cost, schedule, and projected benefit and other impacts.

Project Programming/Resource Allocation

Agencies have different approaches to capital project programming and resource allocation. These approaches vary as a function of agency policies and priorities, analytic capabilities, and the degree of formality with which projects are defined and described. Differences also occur in the manner by which candidate projects are managed to control "scope creep" and associated increases in cost and schedule.

- Ideally, the resource allocation process distributes the available funding among programs and projects that have been prioritized as the best use of the available investment dollars. Best practice calls for a benefit-cost analysis of each candidate project within a life-cycle framework, but agencies differ in their capabilities and inclinations to use this approach.

- Modern management systems, particularly those used for system preservation, are usually based on a life-cycle cost concept, coupled with a mathematical optimization to propose the best investment plan subject to budget constraints. Agencies differ, however, in the degree to which these systems drive prioritization as opposed to other ranking methods, whether objective or subjective. Other considerations such as the

need for geographic equity in allocating resources also are accounted for. The practical result is a compromise among asset management best practice, agency existing practice, and political reality.

- The project development and programming and resource allocation stages may also be the points at which an agency considers its investment philosophy toward system preservation. While analytic studies show that a preventive approach is preferred economically and technically, it is more difficult to sell politically (because of the appearance that facilities in "good" condition are being maintained at the expense of those that may already have deteriorated). There is also a transition period and cost that must be encountered before the preventive approach reaches its more efficient "steady state." Agencies that wish to pursue a preventive approach to system preservation are discussing ways in which the strategy can be promoted and better understood by policy makers.

Capital Project Delivery

Conventional infrastructure projects are delivered for the most part through traditional design-bid-build (DBB). Agencies are experimenting with more innovative methods, such as design-build (DB) and design-build-operate-maintain (DBOM), particularly in cases where the project schedule is necessarily short, agencies do not have adequate staff to design and manage projects by traditional methods, or public revenues are not sufficient to build the project and privatization is needed. While asset management principles do not favor any particular method of delivery, they do encourage looking at all available and feasible methods of delivery.

- The delivery method and the type of project will influence how projects evolve from the approved program. Projects are typically divided into at least three phases: right-of-way acquisition, preliminary engineering, and actual construction. Critical decisions are made particularly in the preliminary engineering phase of capacity expansion projects and very large or complex preservation projects. These decisions shape the project and can affect its scope and cost significantly.

- Agencies differ on the degree of control that is exercised between the originally estimated scope and cost that are included in the approved program budget, and the project scope and cost that are estimated for bid purposes as the result of the preliminary engineering phase. This lack of continuity between the resource allocation and the program delivery stages has been recognized by several agencies, but addressing it is complicated by the many ways in which projects evolve from initial conception to final implementation.

- Once the delivery method is selected and implemented, project delivery becomes a matter of good design and construction practice, effective project administration and management including the use of trained inspectors, proper testing procedures, and management tools to ensure compliance with schedule and budget, and identification of problems early enough to manage them well.

- A concern during delivery is unplanned increases in scope, cost, and schedule, and the impact that these changes may have on other projects in the program. Agencies that have been most effective in dealing with these issues have implemented management systems that track actual versus planned progress at a program as well as a project level, and a well-defined hierarchy of management responsibility for reviewing and approving changes in scope, cost, and schedule above certain thresholds. These mechanisms promote good asset management by demonstrating accountability for project commitments and by avoiding adjustments to the program that compensate for unexpectedly higher project costs, thereby enhancing the credibility of both the agency and the program.

- Each project and program develops a set of cost and construction performance data that can inform future programs. Many agencies track bid data and prepare summaries of winning low bid costs and cost ranges by bid item. Given the variability in construction costs by region and over time, these data help to prepare realistic bid estimates on future jobs, identify the risk inherent in estimates, and understand trends in costs of key items.

Operations & Maintenance

Agency responsibilities following completion of construction continue with operating the facility and maintaining the infrastructure to preserve it and enhance the safety, convenience, and comfort of motorists. Several aspects of maintenance and operations have already been discussed. Using asset management as a way to step back from the life-cycle process provides an opportunity to see additional ways in which this stage could reinforce future work in other stages – for example:

- Monitoring the data from maintenance and operations could suggest ways to improve project design and construction.

- Defining performance measures relating to structural health monitoring would help integrate the effects of routine maintenance with those of capital preservation projects to encourage capital-maintenance tradeoffs and comparative evaluations of different preservation options. Measurement techniques such as non-destructive testing (NDT) and instrumentation of key infrastructure components (e.g., sensors embedded in pavement layers or on bridge members) can quantify these performance measures.

- Similarly, operations performance measures could be related to measures used for capital expansion projects to develop an integrated approach to gauging mobility, accessibility, and modal performance, while once more encouraging tradeoffs among alternate approaches to system improvement.

2.4 Application of Asset Management Principles to Infrastructure

The examples by investment area and life-cycle process above give an idea of how asset management can improve management of infrastructure. This section reinforces key asset

management principles and strengthens the examples of their application to infrastructure.

Policy-Driven

Goals and objectives are established by policy makers, and reinforced by targets set by the agency. Ideally these policies cover the important public expectations of the transportation program, including both the priorities and anticipated budget to be addressed in resource allocation, and the targets to be met in program and service delivery. Policies should be realistic in light of current and future funding, guide the development and implementation of plans and programs, and be related to performance measures and targets that will be used by the agency to track progress. Examples of policy objectives related to infrastructure could include the following:

- Improve the percentage of network pavements with rideability rated "Very Good to Excellent";
- Improve the bridge deck area in good to excellent condition systemwide;
- Reduce the number or percentage of high-accident locations due to infrastructure condition;
- Reduce the frequency of crashes due to infrastructure condition; and
- Improve system reliability.

Performance-Based

Performance monitoring and tracking are central to an asset management approach. Specific performance measures need to be identified for each policy goal and objective that relates to infrastructure performance, together with targets and projected time frames for attaining these targets. It is important that targets also be realistic in light of projected funding and the likely allocation of resources among infrastructure and other programs -- expectations will be managed, the agency's credibility will be strengthened, and agency staff will understand better what is actually expected of them. No doubt there will be conflicts among competing objectives, and the agency may not be able to afford the infrastructure expenditures that would be expected in an ideal asset management setting. Analyzing these possibilities early in the process can help gauge the magnitude of impacts, and suggest strategies for dealing with them either in resource allocation (e.g., emphasizing relatively economical maintenance in lieu of capital preservation) or program delivery (e.g., alternate methods of delivery).

A range of performance measures applies to infrastructure. Many such measures are discussed in other papers in this series, and are not repeated here.[5] Measures that are not covered in depth in other papers include those for system preservation. System preservation measures are of several types – each has a use in understanding and managing system performance -- so agencies often define a set of measures comprising more than one type. Individual measures are defined for each asset class, but otherwise their computation and use are similar across all asset classes. Examples of the types of system preservation measures are as follows:

- Measures of specific distress, damage, or deterioration: e.g., amount of cracking, deformation, and surface deficiencies in pavements and bridge decks; area of deterioration in bridge decks and structural elements.

- Measures of serviceability or performance, defined from a road user's perspective: e.g., Roughness Index, Present Serviceability Rating, Rideability.

- Indexes of condition, serviceability, or performance: e.g., Pavement Condition Index (PCI), Present Serviceability Index (PSI), bridge Health Index.

Analysis of Options and Tradeoffs

Tradeoff analyses encourage agencies to consider options in addressing a need or problem. Several examples have already been given at different stages of the life-cycle process; they are summarized here to illustrate that the review of options and the consideration of tradeoffs is an ongoing effort.

- **Planning**: strategic choices between capital preservation and maintenance, or between capacity expansion and operations.

- **Project Development, Programming, and Resource Allocation**: investigations of different materials, construction methods, and maintenance approaches; consideration of the approach to be used in system preservation (preventive vs. reactive); tradeoff analyses among system preservation, operations, and system expansion; inclusion of security considerations as part of overall asset management.

- **Project and Service Delivery**: different mechanisms for delivery: e.g., accelerated bridge deployment, accelerated construction program; diligent management of program progress, and adjustments where needed to accommodate unplanned changes.

[5] See, for example, the papers relating Asset Management to Planning, Environment, Operations, and Safety.

Decisions Based on Quality Information

Quality information has been emphasized throughout this discussion. Complete, current, timely, and accurate data on the infrastructure inventory and its condition and performance are basic to good management in any agency function or stage of business process. Periodic inspection programs and solid management systems and analytic tools are critical elements in ensuring that field data are translated into useful information. The availability of good information presumes the ability to understand it and to act on it. Agency groups dealing with infrastructure have therefore historically placed emphasis on employee (and, if needed, contractor) training in a number of relevant topics: e.g., current design procedures, innovative materials, materials testing procedures, environmental protection, handling of hazardous substances, maintenance performance (agency maintenance academies), and so forth.

Monitoring to Provide Clear Accountability and Feedback

Performance monitoring and feedback are critical to improving existing processes and to keeping up to date with actual infrastructure performance in the field. Performance measures and tracking are needed in both the program planning/resource allocation stages and in delivery of projects and services.

3.0 FHWA Office of Infrastructure - Current and Future Activities Related to Asset Management

This section describes current activities of the FHWA Office of Infrastructure and the Office of Research, Development and Technology that relate to Asset Management, and identifies potential additional opportunities for the future.

The Office of Infrastructure encompasses five offices, each with responsibilities for particular types of infrastructure or aspects of infrastructure management. These offices and their respective missions are:

1. The Office of Program Administration enhances program delivery through improved understanding of the Federal-aid program, improved highway design, and more effective stewardship and oversight.

2. The Office of Bridge Technology improves the condition of the Nation's bridges and structures through innovations in technology.

3. The Office of Pavement Technology advances policies and technologies that provide safe, cost-effective, long-lasting pavements that meet customer needs and can be effectively maintained.

4. The Office of Asset Management provides national leadership, guidance and support in asset management implementation by developing and advancing methodologies for making comprehensive and cost-effective infrastructure investment decisions.

5. The Highways for LIFE office promotes a smarter, more efficient and effective method of highway construction to improve the performance of highways and bridges and reduce their maintenance, repair, and rehabilitation costs.

3.1 Current and Planned Activities

The following descriptions present a composite of the efforts of these individual offices in key areas of guidance and assistance.

Policy and Regulatory

The Office of Infrastructure develops and evaluates legislative proposals related to highway, pavement, and bridge programs and engineering and asset management issues in cooperation with other FHWA Headquarters offices and field offices. It also develops policy and program direction including appropriate regulations to implement and interpret transportation legislation. Specifically, this work includes establishing uniform requirements and eligibility policies for the apportionment, allocation, and use of Federal-aid highway and bridge funds, and the selection of projects for discretionary funding. In the area of Asset Management, the Office develops policies and provides guidance related to the application of value engineering, life-cycle cost analysis and investment analysis to Federal-aid highway projects and programs, and eligibility on the various Federal-aid categories of funds (e.g., maintenance, rehabilitation, construction, inspection).

Technical Assistance and Information Dissemination

A broad range of technical assistance and information is provided by the Office of Infrastructure through its constituent offices. In cooperation with other headquarters offices and the field offices, the Office of Infrastructure provides and maintains ongoing communication with FHWA customers (e.g., state DOTs, through FHWA division offices) and industry partners to disseminate information, implement its programs, and deploy new technologies to advance the state of the practice in infrastructure management. The Office also develops and delivers educational and informational materials and training courses on various topics pertaining to infrastructure planning, economic analysis, design, construction, inspection/data collection, and maintenance and operations, among others. Some of the asset management-related products and activities that have been produced or are now being developed include:

- Primers, case studies and synthesis reports on asset management, GASB Statement 34, data integration, economic analysis and life-cycle cost analysis.

- Support of the Transportation Asset Management Guide, the companion NHI course on transportation asset management, and the AASHTO Asset Management website.

- Informational materials and training courses (in collaboration with the National Highway Institute, or NHI) on pavement design and management, bridge management, maintenance management, roadway hardware management, construction, system preservation, quality management, data collection and integration, work zone management, and engineering economic analysis and life-cycle costing.

- Approaches to improve pavement surface characteristics (e.g., friction, smoothness, noise) through better techniques, test procedures, analytic tools, and establishment or updating of standards.

- Support of the Highway Economic Requirements System and a version of HERS intended for use by state DOTs (HERS/ST).

- The FHWA conducts and supports a substantial program of infrastructure research and technology development and deployment, both through its Infrastructure Office and through the Office of Infrastructure Research, Development and Technology at the Turner-Fairbank Highway Research Center (TFHRC).

Research & Technology

Infrastructure research emphasizes development of better information, professional knowledge and skills, new technology, and deployment of solutions into practice.

For example, the Strategic Pavement Program Roadmap has the following research and technology focus areas:

- Improved pavement designs, models, and materials (e.g., contributions to, and review of, the 2002 AASHTO pavement design guide; support of Superpave implementation; investigations of new materials and techniques such as warm-mix asphalt and concrete repair techniques; and continuing support of improved pavement performance through the Long-Term Pavement Performance (LTPP) Program involving data collection, analysis, products, reporting/dissemination, and establishment of regional centers and support contracts).

- Implementation of quality assurance systems (e.g., improved test procedures, development and implementation of advanced quality systems, performance-related specifications).

- Pavement surface characteristics for user satisfaction (e.g., smooth ride, enhanced friction, quiet ride).

- Technical-capability building (e.g., knowledge-based systems, training).

- Environmental stewardship (e.g., pavement recycling, noise reduction).

The Bridge Technology Program has the following research and technology focus areas for bridges and tunnels:

- Improved structural performance and life (e.g., advanced design and construction practices such as Load Resistance Factor Design (LRFD), design for improved inspectability, maintainability, and future enhancements, and use of high-performance materials; improved quality control; and standards and specifications development, demonstration projects, education, and training in these areas).

- Construction and rehabilitation methods that reduce congestion and improve safety (e.g., work identification based on accurate condition assessment, use of accelerated construction techniques and advanced, long-life materials, and use of prefabricated or modular components).

- Provision of structures that provide a high level of safety and service under all conditions (e.g., mitigation of hazards to structures, optimization of service life and safety through better system preservation).

- Context-sensitive solutions to minimize adverse environmental impacts (e.g., greater flexibility in designing and building structures that meet different demands).

- Formation of a Engineering Assessment Team for Bridge Security and Vulnerability to provide technical advice, field reviews, and training to help infrastructure owners deal with security threats.

The Office of Asset Management has several research and technology initiatives recently completed, underway or planned, including:

- Research to develop a tunnel management system, in collaboration with the Federal Transit Administration (FTA).

- With the Office of Policy, development and incorporation of analysis procedures to predict remaining service life (RSL) of pavements for HERS-ST

- With the Office of Operations, evaluation of innovative work zone management techniques including mobile barrier systems, dust and noise control and night lighting.

- With the TFHRC Infrastructure Office, development of a relational database model and GIS interface for HERS-ST that includes bridge, pavement and other transportation assets.

- With the Office of Safety and TFHRC Safety Group, evaluation of existing systems for managing roadway hardware.

- With the Division Offices, evaluating the rolling wheel deflectometer (RWD) technology for measuring structural characteristics of pavements.

Coordination

The Office of Infrastructure engages in several coordination activities that help "get the word out" on new developments in infrastructure:

- Workshops and conferences in applicable areas such as advanced materials and methods, often jointly sponsored with organizations such as Transportation Research Board (TRB), AASHTO, state DOTs, and industry groups;
- Development of guidelines, standards, and specifications;
- Joint research efforts with other FHWA offices as identified above;
- Joint sponsorship with AASHTO in developing the ***Asset Management Guide*** and supporting national conferences and workshops;
- Collaboration with U.S. Army Corps of Engineers in sponsoring and conducting workshops on Bridge and Tunnel Security Vulnerability for federal and state agency staff;
- Coordination with other groups within and external to the FHWA that are dealing with asset management –related issues in planning, design, construction, maintenance, and operations.

3.2 Potential Future Activities

Technical Assistance and Information Dissemination

The descriptions in Sections 1 and 2 suggest a number of potential areas where the Office of Infrastructure can provide additional information and technical assistance to state DOTs and other partner agencies:

- While agencies now use management systems as part of their overall "asset management" approach (e.g., in maintaining asset inventories and records of condition over time, and generating candidate projects), there are recurring examples where these systems are not used to support actual asset management decision-making: e.g., in prioritizing projects, conducting tradeoff analyses of performance versus investment levels, and recommending a program budget. FHWA can assist agencies in addressing the technical and organizational issues involved in asset management decision-making, through training, information dissemination, and workshops.
- Limited tradeoff analyses are now done because of the lack of analytic tools, lack of understanding of how to apply existing systems and data to support these analyses, and the fact that the importance of tradeoffs for good asset management has only recently begun to be understood. The future completion of NCHRP Project 20-57 (Analytic Tools to Support Asset Management) takes initial steps to address these

impediments. Training, information, and workshops that FHWA could sponsor will help address the organizational issues involved, and can reinforce agencies' use of performance measures and economic analyses.

- Information on conducting tradeoffs among system preservation, operations, and improvement programs can complement the preceding point, and provide agencies with examples of how new analytic tools can be applied in decision-making. A case study approach involving several DOTs could provide a good model for developing guidelines and examples that have been applied in different agency and program contexts.

- Additional examples applying user costs could promote more widespread use of this concept to investment decisions, and reinforce FHWA's emphasis on economic analysis and life-cycle costing. Information on how to estimate these costs using models of vehicle operating costs, travel-time costs, and costs related to safety and environment, and continued promotion of analyses that apply user costs, would strengthen agencies' capabilities to apply user costs in a number of asset management situations.

- Continued help on infrastructure preservation and preventive maintenance strategies is also needed. New analytic tools – e.g., to identify "break points" where maintenance and minor repairs are no longer justified technically or economically, and more substantial preservation treatments are needed – would be particularly helpful.

- The growing use of Intelligent Transportation Systems (ITS), Road Weather Information Systems (RWIS), and similar systems for operations will create future needs for preserving these assets and sustaining a high degree of system reliability. Technical information on asset life, recommended techniques and timing of maintenance, and unit costs of system maintenance, repairs, and replacement will help structure a life-cycle approach to the preservation of these high-tech items. It will also provide a platform for coordination between the Office of Infrastructure and the Office of Operations.

- Analyses of capacity expansion projects would benefit from analytic tools to estimate infrastructure requirements and costs, particularly in early project stages where agencies analyzing alternatives need reliable cost estimates to make valid choices. The Office of Infrastructure's experience with pavement, bridge, maintenance, and tunnel management systems and data could be applied to work with other FHWA offices in developing these tools. A range of system preservation, operations, and capacity expansion tools would strengthen asset management tradeoff analyses.

- The case study approach has been used by the Office of Infrastructure to explain and illustrate specific topics of asset management through their implementation by specific state DOTs. For example, the series to date discusses life-cycle cost analysis as conducted by Pennsylvania DOT, economics in asset management as practiced by New York State DOT, and data integration as experienced in Michigan DOT. This material provides practical guidelines for other operating agencies, and has proven to

be very useful for educational purposes as well. The easy-to-read booklets provide a model that can be used to illustrate other aspects of asset management, including subjects documented in this series of white papers (e.g., planning, safety, environmental management, right-of-way management, etc.). See also the related discussion in the section on Coordination below.

Research & Technology

A comprehensive and ambitious vision of research and technology has been outlined by the FHWA.[6] This vision continues to focus on the four critical strategic elements of information (to support better decision-making), people (training and professional development), technology (better materials, tools, and techniques), and deployment (putting innovations into practice). Greater emphasis is placed on stakeholders in working with FHWA toward a successful research program, particularly in supporting a more strategic program, helping to set the focus, direction, and priorities of the program, identifying opportunities and champions for research efforts, and evaluating the quality and value of the research. Examples (a partial list) of recommended research topics include:

- Improved uses of existing management systems for engineering analysis and development of new tools for economic analysis to support transportation asset management.
- Development of new concepts of bridges that provide greater durability and flexibility of use at significantly lower life-cycle costs.
- Ensuring the safety, reliability, and security of the Nation's bridges.
- Enhanced user satisfaction with highway travel as affected by pavements, with emphasis on reduced congestion due to work zones, improved ride through reduced surface roughness both when new and in service, and reduced pavement-tire noise.
- Emphasis on better stewardship and management of infrastructure, and developing information and tools needed to support good stewardship.
- The implementation of asset management as a general, comprehensive approach to infrastructure management is still in its early stages within operating agencies. Documentation of the benefits of this approach, and guidelines on specific implementation techniques, will help other agencies in their asset management efforts and provide useful case studies.

Additionally, research topics may be needed to address several items discussed in the section on technical assistance: i.e., the development of analytic tools for preventive

[6] Infrastructure Research and Technology Stakeholder Workshop Summary Report: Workshop Proceedings, FHWA-RD-03-071, Chicago, September 2003.

maintenance strategies and for cost estimation for capacity expansion projects, and technical information on the life-cycle of high-tech assets used to manage facility operations.

Coordination

- The Office of Infrastructure's continuing expertise in system preservation, coupled with broadened coordination with other FHWA offices on aspects of asset management related more closely with operations and capacity expansion, will build a unified and coherent source of information for state DOTs, other transportation agencies, and academic institutions and training organizations. For example, the case study approach that has been used successfully by the Office of Infrastructure to document applications of economics to asset management, life-cycle cost analysis, and data integration can be extended to other areas of asset management analysis and decision-making.

- Strengthened approaches to asset management through the development of new analytic tools and associated technical information can result from broader coordination with other FHWA offices in, for example, safety, operations, environment, and planning, and with agencies that are interested in analytic methods for transportation infrastructure. Regardless of which office oversees tool development, the effort would benefit from Infrastructure's long and successful history in melding technical knowledge; focused research; useful analytic approaches; development, support, and application of management systems; data collection methods; deployment strategies; and training and skills development

FHWA White Paper:
Operations and Asset Management

The purpose of this paper is to define the relationship between transportation asset management and transportation system planning and to describe the current, and potential future, activities of the FHWA Office of Operations that support the implementation of asset management. The paper is one of a set of seven papers exploring the relationship of asset management to each of FHWA's major program areas including planning, right-of-way, environment, infrastructure, safety, operations, and Federal lands.

Section 1.0 provides a general overview of asset management relevant to all program areas. Section 2.0 defines the relationship between planning and asset management. Section 3.0 describes current, and potential future, activities of the Office of Operations that support asset management.

1.0 Overview of Transportation Asset Management

1.1 Definition of Asset Management

Transportation asset management is a set of guiding principles and best practice methods for making informed transportation resource allocation decisions, and improving accountability for these decisions. The term "resource allocation" covers not only allocation of money to program areas, projects, and activities but also covers deployment of other resources that add value (staff, equipment, materials, information, real estate, etc.). While several of these principles and practices were initially developed and applied within the domain of infrastructure preservation, most established definitions of asset management are considerably broader. The **Asset Management Guide**,[1] recently adopted by AASHTO defines asset management as:

[1] *Transportation Asset Management Guide*, prepared for the National Cooperative Highway Research Program (NCHRP) Project 20-24(11) by Cambridge Systematics, Inc. with Parsons Brinckerhoff Quade & Douglas, Inc., Roy Jorgensen Associates, Inc. and Paul D. Thompson, November 2002, AASHTO Publication RP-TAMG-1.

> *"… a strategic approach to managing transportation infrastructure. It focuses on…business processes for resource allocation and utilization with the objective of better decision-making based upon quality information and well-defined objectives."*

As Mary Peters, FHWA Administrator has frequently put it:

> *"If I have one additional dollar to spend on the transportation system, what is the most effective way to spend it?"*

The essence of asset management is answering that question.

Asset management is concerned with the entire life cycle of transportation decisions, including planning, programming, construction, maintenance, and operations. It emphasizes integration across these functions, reinforcing the fact that actions taken across this life cycle are interrelated. It also recognizes that investments in transportation assets must be made considering a broad set of objectives, including physical preservation, congestion relief, safety, security, economic productivity, and environmental stewardship.

1.2 Asset Management Principles

The core principles of asset management are:

- **Policy-Driven –** Resource allocation decisions are based on a well-defined and explicitly stated set of policy goals and objectives. These objectives reflect desired system condition, level of service, and safety provided to customers, and typically are tied to economic, community and environmental goals as well;

- **Performance-Based –** Policy objectives are translated into system performance measures that are used for both day-to-day and strategic management;

- **Analysis of Options and Tradeoffs –** Decisions on how to allocate resources within and across different types of investments (e.g., preventive maintenance, rehabilitation, pavements, bridges, capacity expansion, operations, different modal mixes, safety, etc.) are based on an analysis of how different allocations will impact achievement of relevant policy objectives. Alternative methods for achieving a desired set of objectives are examined and evaluated. These options are not constrained by established organizational unit boundaries – for example solving a congestion problem could involve a capacity expansion or an operational improvement (e.g., signal coordination). The best method is selected considering the cost (both initial and long-term) and likely impacts on established performance measures. The limitations posed by realistic funding constraints must be reflected in the range of options and tradeoffs considered;

- **Decisions Based on Quality Information –** The merits of different options with respect to an agency's policy goals are evaluated using credible and current data. These data may apply to specific functions (e.g., pavement and bridge management,

traffic monitoring) or reflect a more integrated, corporate view. [2] Where appropriate, decision support tools are used to provide easy access to needed information, to assist with performance tracking and predictions, and to perform specialized analysis (e.g., optimization, real-time simulation, scenario analysis, life-cycle cost analysis, benefit/cost analysis); and

- **Monitoring to Provide Clear Accountability and Feedback –** Performance results are monitored and reported for both impacts and effectiveness. Feedback on actual performance may influence agency goals and objectives, as well as resource allocation and utilization decisions.

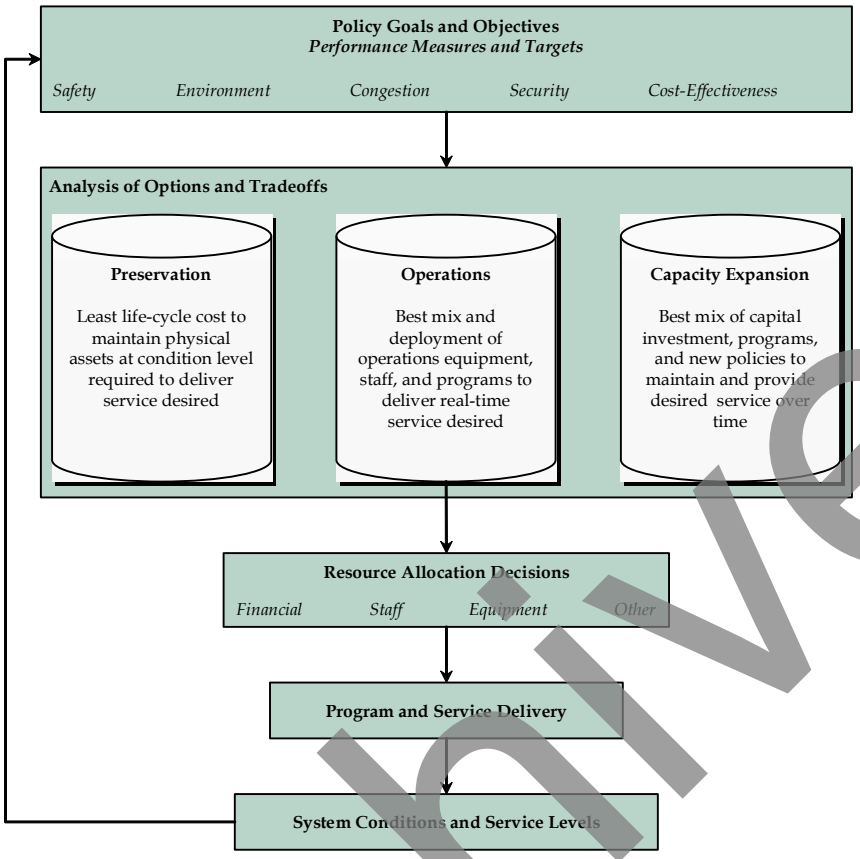
These principles are not unfamiliar, nor are they radical. Most transportation practitioners would agree that investment decisions should be based on weighing costs against likely outcomes, that a variety of options should be considered and evaluated, and that quality information is needed for decision-making. Many agencies are now pursuing performance-based approaches to planning and programming, monitoring system performance, and developing more integrated data and analysis tools to evaluate tradeoffs among capital expansion, operations, and preservation activities. Most agencies recognize that application of asset management principles is critical in times of constrained resources, when all investment and budget decisions are subject to increased public scrutiny.

1.3 Asset Management Practice

Figure 1 illustrates the strategic resource allocation process that embodies the asset management principles presented above.

[2] The FHWA plays a key role in standardizing the content and format of data that are mandated by federal law: e.g., the National Bridge Inventory (NBI) data that are reported by state DOTs.

Figure 1. Strategic Resource Allocation Process



The diagram includes the following elements:

- **Policy Goals and Objectives,** supported by performance measures are established through the policy and system planning process and used to guide the overall resource allocation process.

- **Analysis of Options and Tradeoffs** includes examination of options *within* each investment area, as well as tradeoffs *across* different investment areas. The definition of investment areas is flexible and can be tailored to how an individual agency does business. For example, an agency may have a separate safety investment area and also incorporate consideration of safety within system preservation, operations, and capacity expansion expenditures. Each option and tradeoff is evaluated with respect to established agency goals and performance objectives.

- **Resource Allocation Decisions** are based on the results of tradeoff analyses These decisions involve allocations of financial, staff, equipment, and other resources to the different investment areas and/or to different strategies, programs, projects, or asset classes within an individual investment area.

- **Program and Service Delivery** is accomplished in the most cost-effective manner which again involves consideration of different delivery options (e.g., use of contractors, interagency agreements), as well as a delivery tracking process involving recording of actions taken, costs, effectiveness, and lessons learned to guide future activity.

- **System Conditions and Service Levels** are tracked to see the extent to which established performance objectives are being addressed. This information is used to refine policy goals and priorities (e.g., put more emphasis on safety in response to an increase in crash rates).

1.4 Transportation Investment Categories

In Figure 1, the box labeled "Analysis of Options and Tradeoffs" shows three types of investment categories – preservation, operations, and capacity expansion. These are defined as follows:

1. **Preservation** encompasses work to extend the life of existing facilities (and associated hardware and equipment), or to repair damage that impedes mobility or safety. The purpose of system preservation is to retain the existing value of an asset and its ability to perform as designed. System preservation counters the wear and tear of physical infrastructure that occurs over time due to traffic loading, climate, crashes, and aging. It is accomplished through both capital projects and maintenance actions.

2. **Operations** focuses on the real-time service and operational efficiency provided by the transportation system for both people and freight movement on a day-to-day basis. Examples of operations actions include real-time traffic surveillance, monitoring, control, and response; intelligent transportation systems (ITS); signal phasing and real-time signal controllers at intersections; HOV lane monitoring and control; ramp metering; weigh-in-motion; road weather management; and traveler information systems. Although operations focuses on system management, the infrastructure needed to provide this capability may be substantial (e.g., traffic control centers; ITS hardware; environmental sensors and fire control systems in tunnels). Thus, an operations strategy requires capital and operating budget as well as substantial staff resources.

3. **Capacity expansion** focuses on the actions needed to expand the service provided by the existing system for both people and freight. Capacity expansion can be achieved either by adding physical capacity to an existing asset, or acquiring/constructing a new facility.

These three categories are defined in order to show that:

- Asset management is not just about preservation of highway network assets; it is about making investment decisions that address a wide range of policy goals.

- The three categories provide a simple, useful way for decision-makers to align program investment categories and priorities with key policy objectives. For example, many agencies establish a "preservation first" policy or favor maximizing efficiency of operations prior to investing in new capacity.

- The categories may present alternative ways of meeting a policy goal. For example, it may be appropriate to consider operational improvements to address a congestion problem as an alternative to adding a new lane.

- Decisions about the resources allocated to each category cannot be made independently. Meeting many policy goals (e.g., safety) may require a mix of investments across these categories. Similarly, an increase in capacity expansion investments may require increased operations and preservation expenditures at some point in time.

As noted above, tradeoff analysis may be done across *investment categories* as well as within them. An agency might wish to define investment areas coincident with the three categories discussed above (preservation, operations, capacity), or they may define a different set of categories. For example, a safety program could be defined as an investment category, with subareas for operational activities (e.g., signs, markings, signalization, channelization, etc.), preservation (replacement of guardrails), and capacity (project design features supporting safety, e.g., wide shoulders). This would provide the framework for understanding the best mix of complementary actions within the safety area as well as tradeoffs between safety and other objectives.

1.5 Asset Management and the Transportation Planning Process

A common reaction to the broad description of asset management is "how is this different from the overall planning and programming process in an agency?" The response is that asset management is not a new kind of business process that replaces planning and programming. Rather, it should be viewed as a set of best practices to be employed within the established planning and programming framework. Existing regulations pertaining to the planning process, together with statutes related to specific funding programs and their allocation criteria, and the body of environmental regulations affecting transportation planning – provide the context within which asset management practice occurs. In terms of Figure 1, transportation regulations and statutes impact establishment of policy objectives, the manner in which options are generated and evaluated, and they also provide certain constraints on resource allocation (based on Federal and state funding eligibility restrictions). Many of the core principles of asset management are embodied in the existing planning regulations (e.g., consideration of alternatives). Examining the planning process using the lens of asset management

provides an opportunity to explore ways to continue to strengthen the mission of transportation planning – for example:

- How to improve connections between long-range planning and resource allocation;
- How to strengthen agency and public consideration of preservation and operations investments within the long-range planning process;
- How to better integrate environmental considerations throughout the transportation planning and decision-making process – across capacity, operational and preservation investments; and
- How to provide a common information resource base to serve multiple activities across the transportation asset life cycle – long-range planning, corridor studies, safety studies, environmental assessments, multi-year capital programming, project development, preventive maintenance and system operations.

While asset management is closely associated with planning and programming activities, asset management best practices are also integral to design, construction, routine and preventive maintenance and operations activities. For example:

- Application of life-cycle cost analysis in the facility design process;
- Analysis of alternative construction materials and methods;
- Tradeoffs across different maintenance activities based on level of service and extended facility life provided to customers;
- Developing an appropriate mix of operations expenditures on technology upgrades, hardware/infrastructure maintenance and replacement, and skilled personnel;
- Evaluation of delivery options (e.g., design-build, use of private contractors for maintenance and operations, inter-agency agreements, etc.).

1.6 Key Opportunities

Despite the support for taking an asset management approach, many agencies face very real organizational, institutional, and technical challenges to making further progress in asset management. Each one of these challenges represents a potential opportunity for FHWA to work with its partners to encourage broader implementation of asset management principles. For example:

- Top management needs to set an organization-wide direction and framework for decision-making and to ensure that all parts of the organization are working together in a coordinated fashion. Maintaining continuity in leadership direction and understanding of key asset management principles can be particularly challenging with frequent turnover in agency executives;

- Clear roles for each organizational unit must be established to solve common problems or meet common objectives. Differences in perspectives and approaches, lack of established procedures, or turf battles must be reconciled;

- Established resource allocation methods, often constrained by externally imposed restrictions, historical allocations or formulas, or delicate and difficult political negotiations may restrict the range of options and tradeoffs that can be considered;

- Staff resource constraints together with a constant "fire-fighting" mode of operation also may restrict the amount of time and effort that can be spent on analyzing options;

- Developing a comprehensive set of reliable methods, data and tools to evaluate performance tradeoffs among the full set of investment options will take a sustained, multi-year effort;

- Establishing a causal link between an investment or action and a performance indicator of interest, due to the presence of external factors influencing performance (e.g., gas prices, vehicle fleet changes, growth patterns, etc.) may require additional research in some cases;

- Coordination among multiple agencies to achieve established objectives in areas such as operations and safety adds complexity to the decision-making process and program implementation efforts; and

- External and internal agency culture based on "bottom-up" decision-making, with a focus on specific projects rather than on broader system performance and outcomes.

While it is relatively straightforward to implement asset management within a well-defined area of the agency (a pavement management unit, for example), the issues identified above illustrate why it is much more challenging to implement it more fully within an agency, or across multiple agencies.

However, the need to allocate scarce resources as effectively as possible and demonstrate results and performance to the customers of the transportation system provides strong motivation and support for overcoming these challenges. A comprehensive, performance-based approach to transportation investment decisions will be essential to meeting the increasingly complex set of transportation needs of the 21st century.

2.0 Operations and Transportation Asset Management

2.1 Overview of Operations Activities

The specific scope of operations activities to be considered in this paper is described below. This is presented from the perspective of a state or local operating agency; FHWA Office of Operations program areas are discussed in Section 3.

As shown in Figure 2.1, operations activities respond to several objectives, including providing mobility, travel time reliability, safety and security for both freight and passengers. The following types of activities are included within the scope of operations:

Arterial Management – monitoring and managing traffic flow on surface streets, focusing on the deployment, timing, and operation of traffic signal systems.

Freeway Management – managing freeway traffic operations including monitoring of traffic (via electronic detectors and video cameras), ramp controls (e.g. ramp metering, priority systems), lane management (e.g. contraflow lanes, use of shoulders during peak periods, HOV lanes), information dissemination (e.g. variable message signs, traffic advisories, in-vehicle systems), and electronic toll collection.

Traffic Incident Management – the planned and coordinated program process to detect, respond to and remove traffic incidents and restore traffic capacity as safely and quickly as possible. This coordinated process involves a number of public and private sector partners including: Law Enforcement, Fire and Rescue, Emergency Medical Services, Transportation, Public Safety Communications, Emergency Management, Towing and Recovery, Hazardous Materials Contractors, and Traffic Information Media.

Road Weather Management – providing information about current and forecast weather and road conditions to decision-makers to help them respond with appropriate maintenance, traffic management, traveler information and emergency response strategies – including pretreating roads with anti-icing materials, pre-positioning trucks for de-icing, sanding and plowing, adjustments to traffic control (e.g. variable speed limits, signal timing), accelerated incident response, and radio motorist advisories.

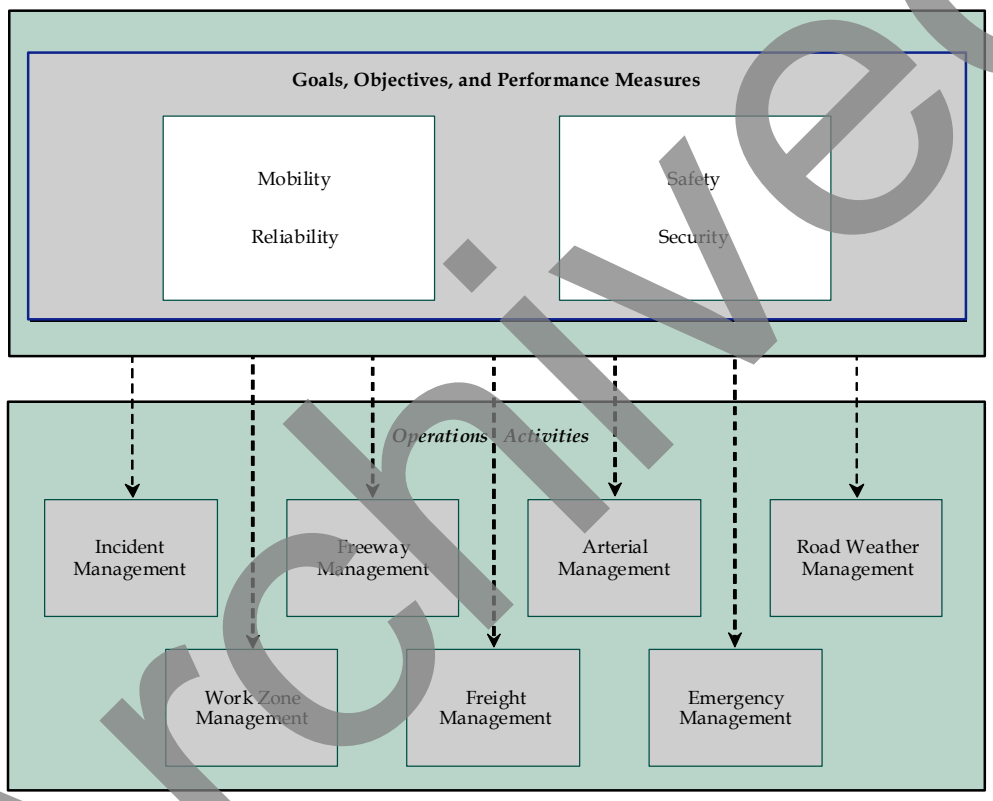
Work Zone Management – strategies to minimize construction work zone-related user delays and ensure safety for both workers and road users. These include a range of activities including full road closures to shorten construction times, night-time construction, traveler information systems and other ITS activities, enforcement methods, and modifications to project design and scheduling methods to better incorporate user cost considerations.

Emergency Management – ensuring that the transportation network operates effectively in the event of an emergency, including natural disasters, major highway incidents and

terrorist attacks. Includes emergency preparedness planning and establishment of communications and coordination mechanisms.

Freight Management – actions to provide a efficient, safe and secure intermodal freight transportation system. Includes facilitation of intermodal freight movements, strategies to reduce delays at border crossings, strategies to improve freight safety and security, enforcement of truck size and weight limits, and management of truck permitting processes.

Figure 2.1 Operations Activities



2.2 Operations Asset Management

Each of the operations program areas described in the previous section requires physical hardware and equipment – traffic signals, variable message signs, computers, communications equipment, etc. Management of these physical operations assets is an important operations activity within each of the program areas. However, there is an important distinction between the management of operations assets and the application of transportation asset management principles to operations. While the topic of "operations asset management" tends to conjure up images of inventory systems and replacement schedules for traffic signals and ITS equipment, the physical component of operations is just one part of the picture. In order to answer the questions: "What am I getting from my

operations investments" and "How can I achieve better performance", a broader systems-level approach is required.

Operations Asset Management takes a holistic, integrated view of the physical, system and personnel aspects of operations. It recognizes that improving operations performance requires coordinated investments in physical equipment; systems to monitor, control and connect this equipment; and skilled, effectively deployed staff.

2.3 Relationship to Transportation Investment Areas

Broadening Asset Management Beyond a Preservation Focus

Historically, asset management has its roots in one of the key investment areas: preservation. The reasons for this initial focus are clear and not surprising. Significant investments were made in expanding the country's transportation infrastructure throughout the second half of the 20th century. As new facilities were completed, the resources required to maintain, repair, and rehabilitate existing facilities began to grow at the same time that system expansion continued. As significant portions of the system aged, competition for resources increased and the need to develop the knowledge and tools to preserve the existing system as cost-effectively as possible stimulated a wide range of research/ development efforts as well as the development of new applications and approaches and integrated system management tools.

Preservation thus philosophically had a "leg up" in the highway management field, not only because of its importance to both state highway agencies and motorists, but also the early recognition that it had to be managed on a continuing basis. By contrast, while the analysis of system expansion needs and solutions also benefited from analytic methods and computerization, once a facility was built to certain standards, those characteristics resulting from expansion projects remained static for many years until upgraded during rehabilitation or reconstruction. It was therefore natural to cite preservation as a model for managing an existing highway (or transportation) network: it had well developed management procedures supported by sophisticated information systems, organized data collection efforts, modern data collection technology, and a longstanding program of research.

But what about operations? While operations has always been a component of highway management, responsibility for operations has been fragmented, both within and across agencies and jurisdictions, and not effectively integrated into an overall system management strategy.

However, similar to the realization that preservation is critical to ensure that infrastructure service life is extended cost-effectively, the recent focus on operations has recognized that maximizing the efficiency and effectiveness of the operation of the existing system is a strategic function and a key element of "good system management."

Role of Operations in the Broad Strategic Resource Allocation Process

From the perspective of a transportation agency CEO seeking to make strategic resource allocation decisions, operations is one of the three major types of investments to be made – its purpose is to manage how the system is used and make sure that the available capacity is utilized efficiently and effectively. High-level tradeoff questions might include:

- If I have additional money to spend, and want to gain the largest bang for my buck with respect to reducing congestion, how much should I spend on capacity projects that eliminate bottlenecks, and how much on operations programs that will contribute to improved traffic flow over a broader network? What combinations of operational investments with either preservation and capacity projects will achieve my objectives?
- Am I willing to divert money from pavement preservation to operations, and "trade" a decline in pavement condition and an increase in pavement life cycle costs for improved traffic flow?

An important challenge for operations asset management practice is to provide better information to support these high-level tradeoffs and reinforce the view of operations as one of the essential elements of a balanced strategy for achieving an agency's policy objectives.

Investment Areas Within the Operations Umbrella

Asset management principles encourage examination of tradeoffs across investment options. Within the operations investment area, it is therefore useful to define "sub-areas" for purposes of tradeoff analysis. Two levels of operations sub-areas can be identified. The first level corresponds to the types of operations activities shown in Figure 2.1 (e.g. freeway management, arterial management, etc). One can envision a DOT CEO looking at the distribution of operations dollars across these different program areas, and determining whether resources should be shifted in order to meet established objectives (e.g. move funds into expanding ramp metering in order to address worsening freeway congestion problems, integrating freeway and arterial ITS systems, leveraging state and local system operational and capital investments).

A second level of investment area can be defined based on the three key types of components that interconnect to support a regional operations system:

- **Physical** - equipment associated with existing operations functions: signs, signal heads, supports, ramp meters, etc.
- **System** – elements to provide interconnections across components: communications, software, and interfaces
- **Personnel** for management, operations and maintenance of the system

These components are interrelated in that an investment in one typically necessitates investments in the others – for example, upgrading a traffic signal system requires both physical and system investments as well as additional staff to operate and maintain it (or training of existing staff at a minimum).

An Operations manager must plan for and balance investments in personnel, physical hardware, and system improvement. Effective operations management requires consideration of how best to deploy available resources within each of these areas (e.g. for personnel, what is the best mix of in-house vs. contract labor?), as well as across areas, with consideration of the interconnections. Questions related to cross-area tradeoffs include:

- Should we invest more in expanding coverage of operations programs, or in replacing equipment?
- Can we reduce personnel costs by implementing more sophisticated technology?
- Can we reduce personnel costs by investing more in preventive maintenance and planned replacement of equipment (thereby improving reliability and reducing repair needs)
- When we expand an operations program, what are the long-term implications for maintenance and repair of physical operations equipment? What are the implications for personnel, in terms of numbers, geographic distribution and skill sets?

A key mistake of the past was not properly estimating and budgeting for the maintenance, preservation and operations costs associated with new major transportation investments. It is critical that all new major transportation investment projects include life cycle cost implications in the final benefit-cost analysis and project scoping decisions.

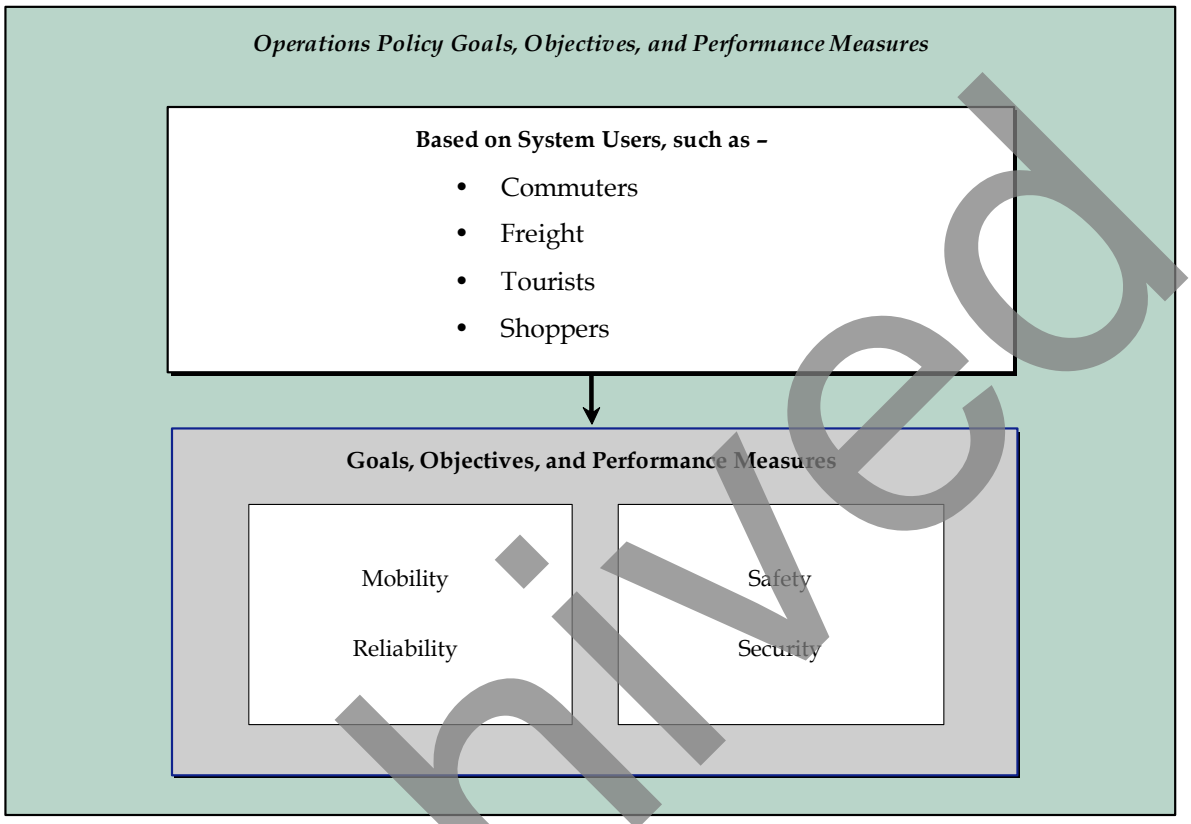
2.3 Application of Asset Management Principles to Operations

The application of each of the principles of good asset management to operations is discussed below.

Policy-Driven

Policies that can guide system operations must focus on customer service and issues such as mobility, reliability, and safety. Adding to the complexity is the fact that different goals and objectives might apply to freight and passenger trips and even different user groups (interregional freight versus local package delivery, commuter versus tourist trips, etc.). Defining clear goals and objectives that reflect key user groups is the first step in applying asset management principles to operations. Figure 2.2 illustrates some user groups and system performance characteristics that might be considered in establishing operations-oriented policy goals and objectives.

Figure 2.2 Operations Policy Goals, Objectives, and Performance Measures



Performance-Based

In order for broad policy goals and objectives to influence decision-making and to provide a method to measure "goals achievement" over time, they must be connected to outcome-oriented performance measures. Measures related to operations are more complex and must reflect the interaction among facility capacity and condition, operational strategies and programs, levels and patterns of demand on the system and external events and conditions that can affect system operations. While some performance measures related to aspects of system operations may remain static over time, many others must be more dynamic to capture the real-time nature of operations. Many state DOTs, MPOs, transit agencies and local governments are beginning to develop and implement performance measures that cut across a range of their programs and activities.

Almost without exception, the development of measures that reflect asset physical conditions and long-range service objectives are far ahead of efforts to define mobility and reliability measures related to real-time system operations. One reason for this is the reluctance to measure performance in an area where an agency has limited control over the outcome due to the influence of outside factors. Performance measures are needed to represent the user perspective and the facility owner or stewardship perspective. User-

oriented performance measures are concerned with total trip travel time, reliability and safety – even where the trip crosses jurisdiction and involves multiple modes. Facility owner performance measures may include the same technical measures, but focus on the agency's sphere of influence.

Additional research and field testing of user and facility-level operations performance measures, developing analytic capabilities to set targets for these measures, defining the data requirements to support key measures, and developing tools for performance prediction, all represent areas needing additional work.

Analysis of Options and Tradeoffs

The need to consider the full range of alternatives available at each level of decision-making has implications both for how elements of a comprehensive operations strategy need to be related to each other and for the types of technical tools necessary to evaluate operations program options.

Figure 2.1 illustrates the different categories of operations programs undertaken in state and local transportation agencies. All of these programs need to be related to a common set of goals, objectives, and performance measures. In developing an overall operations strategy, the issue is what contribution will these programs make collectively to achieve agency goals in operations relative to investments in preservation and expansion. Within the overall operations strategy, however, choices and tradeoffs must be evaluated among the operations programs themselves in terms of their contribution to an overall objective such as reducing delay. Every program shown in Figure 2.1 can contribute to this goal. The issue is what mix and balance among all the operations programs is most effective.

The notion of tradeoffs presumes that there is a single entity responsible for allocating resources across investment categories. Within each agency, there are indeed important decisions and tradeoffs to be made. However, it should be recognized that operations responsibilities are split across state DOTs, city and county agencies, and other organizations (e.g. state police, emergency services). Actions of these different entities need to be coordinated in order to improve system performance from a user "total trip" perspective. Each agency has a different set of resource constraints and priorities, which can make coordinated action difficult to achieve. However, tradeoff analysis in the multi-agency context offers a unique opportunity to leverage each agency's investments and provide tremendous value added for the traveling public.

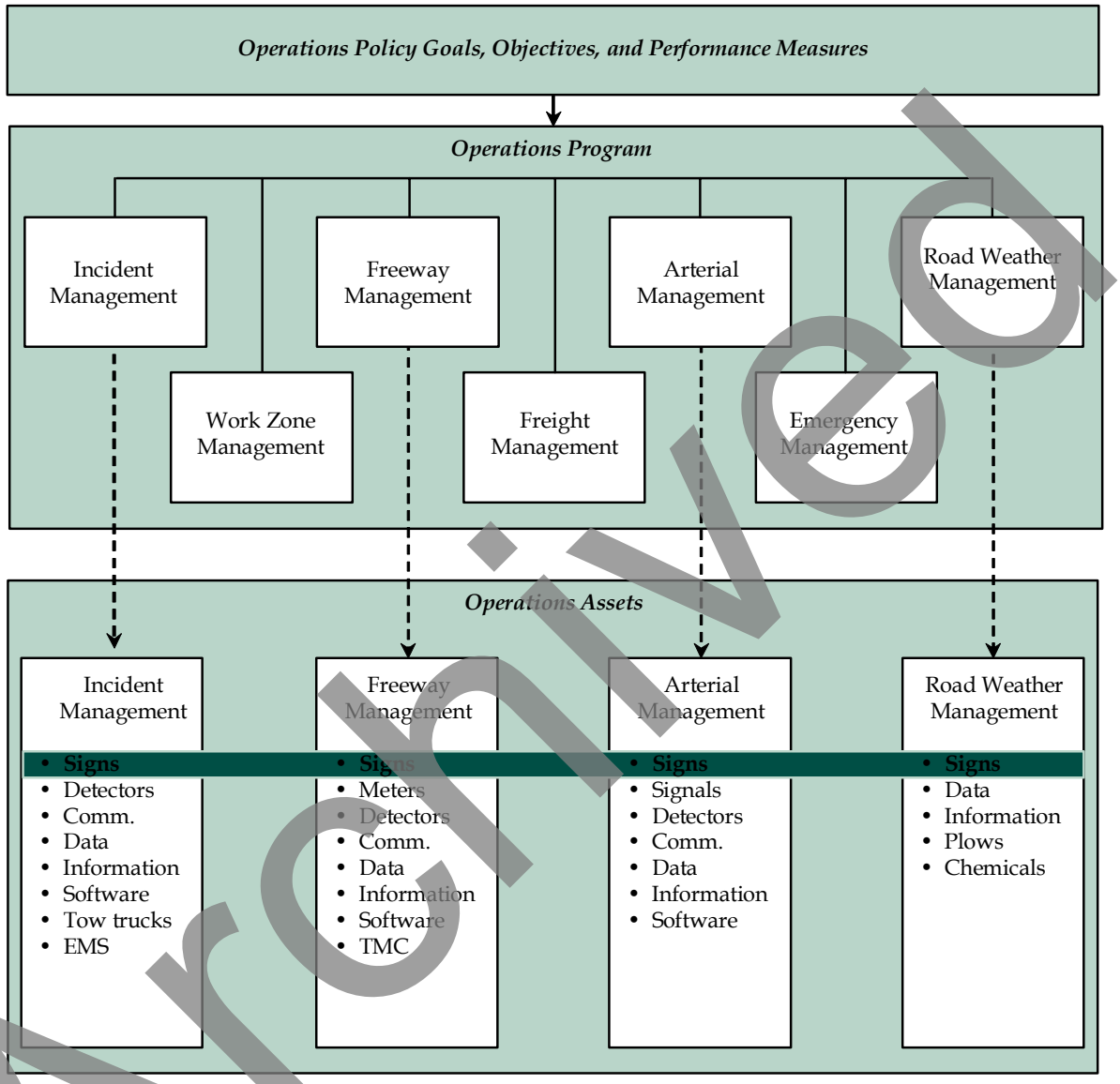
An additional complexity that needs to be considered as part an operations strategy and resource allocation process is the allocation of system capacity to different user groups. Balancing capacity and service needs among transit, high-occupancy vehicles, and general purpose traffic, or between freight and passenger travel, represents both a critical and complex set of choices and tradeoffs.

Even within a specific operations program, an array of options and tradeoffs must be considered. Taking Arterial Management as an example, a performance goal might be established to maximize throughput and minimize delay on a particular arterial. This

arterial road could cut across several jurisdictions and may be operated by multiple agencies – a scenario that is likely transparent to the user. A comprehensive Arterial Management Program might include: upgrading traffic signals; synchronizing traffic signals on regular intervals; improving signage, both static and dynamic; implementing incident management techniques; relocating utility poles and shrubbery to improve sight distance; extending turn lanes; minimizing access points; and re-striping or remarking lanes for both traffic control as well as visibility during rainstorms. Such a program includes both capital investments such as new signals or turn lane improvements and larger more systematic improvements such as synchronization of roadside assistance programs, which are labor intensive. Each component requires ongoing monitoring, management, and maintenance.

The analysis of investment options and tradeoffs within a comprehensive operations program is further complicated by the fact that many programs may share the same assets (i.e., equipment, software and facilities). Figure 2.3 shows a sample of operating assets across four program areas. For each operations program, there are assets that are either specific to that program or that cut across multiple programs. For example, ramp meters are generally thought of as primarily associated with a Freeway Management Program. In contrast, signage, both static and dynamic, is an asset that cuts across multiple program areas. The analysis of options and the potential performance benefits from investments in different operations programs must recognize that many programs require investments in a common set of operations assets. This provides an opportunity to achieve a greater degree of service coordination and equipment modernization than would be possible with a piecemeal approach.

Figure 2.3 Operation Programs and Assets



The evaluation of different strategies within an operations program, and to "make the case" for the benefits of operations investments, requires the data and tools to define current performance levels and to be able to predict future performance as well. By supporting the development of real-time traffic simulation tools and impact analysis tools, FHWA has provided important support in this area. Conceptually, congestion management, safety management, maintenance management, and intermodal management systems could provide additional capabilities for assessing operations-oriented programs. However, few of the operations-oriented management systems have the required capabilities today or enough of an application track record to be relied on to guide resource allocation decisions.

Another point to be considered in developing better tradeoff capabilities both within the operations area and across operations, preservation and capacity is the fact that different program areas have very different time horizons which makes them difficult to compare. An engineering-economic approach to this problem should be explored to address the issue of how to construct a useful life-cycle analysis to compare strategies across areas. Because of the high degree of uncertainty associated with future predictions of operational performance, such an approach would need to incorporate risk analysis and sensitivity analysis capabilities.

Decisions Based on Quality Information

The evaluation of operations programs should reflect the program's contribution to meeting performance objectives relative to cost. The objective is to be able to identify the most cost-effective mix of programs for meeting operations performance objectives for any given level of resources available. Wherever possible, decisions ought to be based on reliable information pertaining to desired system service outcomes and customer satisfaction. Producing comparisons of real time operational data with projected modeling results would be of value to better make the case for operational investments.

Monitoring to Provide Clear Accountability and Feedback

The performance of each operations program in supporting agency goals and objectives needs to be monitored and reported to establish credibility and accountability. While the use of performance measures and tracking results is now just a matter of good business practice, establishing this practice within the operations area is challenging because the focus must be on day-to-day delivery of real-time service.

Operations investments and strategies that have real-time and dynamic elements require different approaches and technologies for monitoring performance and in some cases, real-time response strategies. However, because of the real-time nature of performance monitoring for operations, as capabilities expand to cover more of the system with surveillance equipment, a rich data set is being generated that can support long-term performance monitoring efforts as well.

An agency can only be accountable to the extent that it has the responsibility and capability to make decisions that can impact performance. Performance in operations-related areas (mobility, travel delay, reliability, safety, etc.) will be affected by many factors outside of the control of an individual transportation agency. While it is important to track outcome-type performance measures which reflect the traveler perspective, monitoring programs for operations also need to include output-type measures that more directly relate to those aspects of system operations that are within an agency's control.

3.0 FHWA Office of Operations - Current and Future Activities Related to Asset Management

The purpose of this section is to describe the current activities of the FHWA Office of Operations that are supportive of asset management, and identify potential additional opportunities for the future. Asset management is not a new or separate function, but a set of best practice business principles that FHWA can encourage its partners to integrate into existing processes. Section 3.1 discusses how the Office of Operations is supporting its partners in understanding and implementing operations asset management. Section 3.2 describes potential future activities for asset management and operations.

3.1 Current and Planned Activities

The FHWA Office of Operations is already conducting or planning several activities that reflect the asset management principles discussed throughout this paper. The following sections highlight the key asset management activities in the areas of policy, technical assistance, research and technology, and coordination.

Operations Asset Management Program

The application of asset management principles to operations is a relatively new concept, and there are few policy guidelines in place today. However, the Office of Operations has taken the initiative to provide high-level guidance on operations asset management through their website and publications. This guidance defines asset management, relates asset management to operations and overall transportation policy goals, and outlines the next steps for the future.

Working with the Office of Asset Management, the Office of Operations is developing an asset management framework to enable its partners to make better resource allocation decisions for operations. Eventually, the Office of Operations plans to produce an operations needs and cost identification tool, life cycle costing methodology for operations components, and various operations asset management systems.

Technical Assistance and Information Dissemination

In 2002, the FHWA Office of Operations developed a discussion paper investigating the relationship between operations and asset management. Since then, the Office of Operations has introduced a website for Operations Asset Management. The website contains a two-page brochure that summarizes work to date concerning the establishment of an Operations Asset Management program.

Research & Technology

As mentioned above, the Office of Operations completed a study in 2002 that explores the relationship between operations and asset management, and included a preliminary high-level categorized list of operational physical assets. This information was used in the development of the operations asset management program plan and roadmap.

As a result of the study, the Office of Operations is also conducting a pilot investigation of an operations asset management system for the subsystem of traffic signals. This project is using data from across the country to identify the components for a comprehensive signal management system, including physical, system, and human resource assets, and also investigate how to incorporate investment scenario analysis and tradeoff analysis tools. The research will identify policy guidelines, data requirements, performance measures, and analytical tools necessary to support operations asset management decision-making. Analysis will also be conducted on the benefits of a traffic signal asset management approach by comparing the predicted benefits and risks of various investment scenarios.

Coordination

The Office of Operations is working with a number of other offices and program areas to develop coordinated strategies and joint efforts. It is coordinating with the Office of Asset Management in developing an operations asset management program plan.

3.2 Potential Future Activities

Building on many activities that already are underway, including joint efforts with the Office of Asset Management, the Office of Operations has developed a program plan for further development of Operations Asset Management. This program plan will be pursued in coordination with the Office of Asset Management. Key elements of this plan outline future activities and are summarized below.

- **Establish an Analytical Foundation for the Management of Operations Assets**: This involves development of performance measures, life cycle costing methodologies, and analysis methods for operations resource allocation. This analytical foundation will enable practitioners to identify and evaluate strategic investment scenarios that enhance the capabilities and performance of operations assets. This work will build on the current investigation of signal system asset management practices and characteristics described in section 3.1. Future activities include development of an operations need identification and costing tool to estimate national level operations improvement needs and costs; development of life cycle cost methodologies for different operations areas; development of management of assets systems for Signal Systems, Data and Information, Traffic Management and Control, Freeway Management, and Roadway Management; and development of an Operations Asset Management Investment Science.

- **Create Linkages between Operations Asset Management and Transportation Asset Management**: This effort will develop an approach and methodology to integrate operations resource allocation decisions within the broader transportation asset management framework. This will provide a mechanism to compare and integrate operations resource allocation recommendations with those from other program areas (e.g. infrastructure, safety). It will also facilitate identification and evaluation of combinations of investments across multiple program areas that best meet established agency objectives. Specific activities include development of a theoretical framework, investigation of processes and procedures, and development of an umbrella Operations Asset Management system with linkages to support broader Transportation Asset Management analysis.

- **Institutionalize Operations Asset Management Practices**: To obtain the full benefits of transportation asset management, its principles must be embraced by an organization. Operations asset management must become the way of doing business, i.e. institutionalized. Institutionalizing an operations asset management process within an organization will greatly advance the making of sound investments in operations as well as overall transportation. Outreach activities will involve work with AASHTO, TRB and ITE committees, and will include presentations and workshops, preparation and distribution of guidance materials, tool development and training.

FHWA White Paper: *Planning and Asset Management*

The purpose of this paper is to define the relationship between transportation asset management and transportation system planning and to describe the current, and potential future, activities of the FHWA Office of Planning that support the implementation of asset management. The paper is one of a set of seven papers exploring the relationship of asset management to each of FHWA's major program areas including planning, right-of-way, environment, infrastructure, safety, operations, and Federal lands.

Section 1.0 provides a general overview of asset management relevant to all program areas. Section 2.0 defines the relationship between planning and asset management. Section 3.0 describes current, and potential future, activities of the Office of Planning that support asset management.

1.0 Overview of Transportation Asset Management

1.1 Definition of Asset Management

Transportation asset management is a set of guiding principles and best practice methods for making informed transportation resource allocation decisions, and improving accountability for these decisions. The term "resource allocation" covers not only allocation of money to program areas, projects, and activities but also covers deployment of other resources that add value (staff, equipment, materials, information, real estate, etc.). While several of these principles and practices were initially developed and applied within the domain of infrastructure preservation, most established definitions of asset management are considerably broader. The **Asset Management Guide**,[1] recently adopted by AASHTO defines asset management as:

[1] *Transportation Asset Management Guide*, prepared for the National Cooperative Highway Research Program (NCHRP) Project 20-24(11) by Cambridge Systematics, Inc. with Parsons Brinckerhoff Quade & Douglas, Inc., Roy Jorgensen Associates, Inc. and Paul D. Thompson, November 2002, AASHTO Publication RP-TAMG-1.

> *"… a strategic approach to managing transportation infrastructure. It focuses on…business processes for resource allocation and utilization with the objective of better decision-making based upon quality information and well-defined objectives."*

As Mary Peters, FHWA Administrator has frequently put it:

> *"If I have one additional dollar to spend on the transportation system, what is the most effective way to spend it?"*

The essence of asset management is answering that question.

Asset management is concerned with the entire life cycle of transportation decisions, including planning, programming, construction, maintenance, and operations. It emphasizes integration across these functions, reinforcing the fact that actions taken across this life cycle are interrelated. It also recognizes that investments in transportation assets must be made considering a broad set of objectives, including physical preservation, congestion relief, safety, security, economic productivity, and environmental stewardship.

1.2 Asset Management Principles

The core principles of asset management are:

- **Policy-Driven –** Resource allocation decisions are based on a well-defined and explicitly stated set of policy goals and objectives. These objectives reflect desired system condition, level of service, and safety provided to customers, and typically are tied to economic, community and environmental goals as well;

- **Performance-Based –** Policy objectives are translated into system performance measures that are used for both day-to-day and strategic management;

- **Analysis of Options and Tradeoffs –** Decisions on how to allocate resources within and across different types of investments (e.g., preventive maintenance, rehabilitation, pavements, bridges, capacity expansion, operations, different modal mixes, safety, etc.) are based on an analysis of how different allocations will impact achievement of relevant policy objectives. Alternative methods for achieving a desired set of objectives are examined and evaluated. These options are not constrained by established organizational unit boundaries – for example solving a congestion problem could involve a capacity expansion or an operational improvement (e.g., signal coordination). The best method is selected considering the cost (both initial and long-term) and likely impacts on established performance measures. The limitations posed by realistic funding constraints must be reflected in the range of options and tradeoffs considered;

- **Decisions Based on Quality Information –** The merits of different options with respect to an agency's policy goals are evaluated using credible and current data. These data may apply to specific functions (e.g., pavement and bridge management,

traffic monitoring) or reflect a more integrated, corporate view. [2] Where appropriate, decision support tools are used to provide easy access to needed information, to assist with performance tracking and predictions, and to perform specialized analysis (e.g., optimization, real-time simulation, scenario analysis, life-cycle cost analysis, benefit/cost analysis); and

- **Monitoring to Provide Clear Accountability and Feedback –** Performance results are monitored and reported for both impacts and effectiveness. Feedback on actual performance may influence agency goals and objectives, as well as resource allocation and utilization decisions.

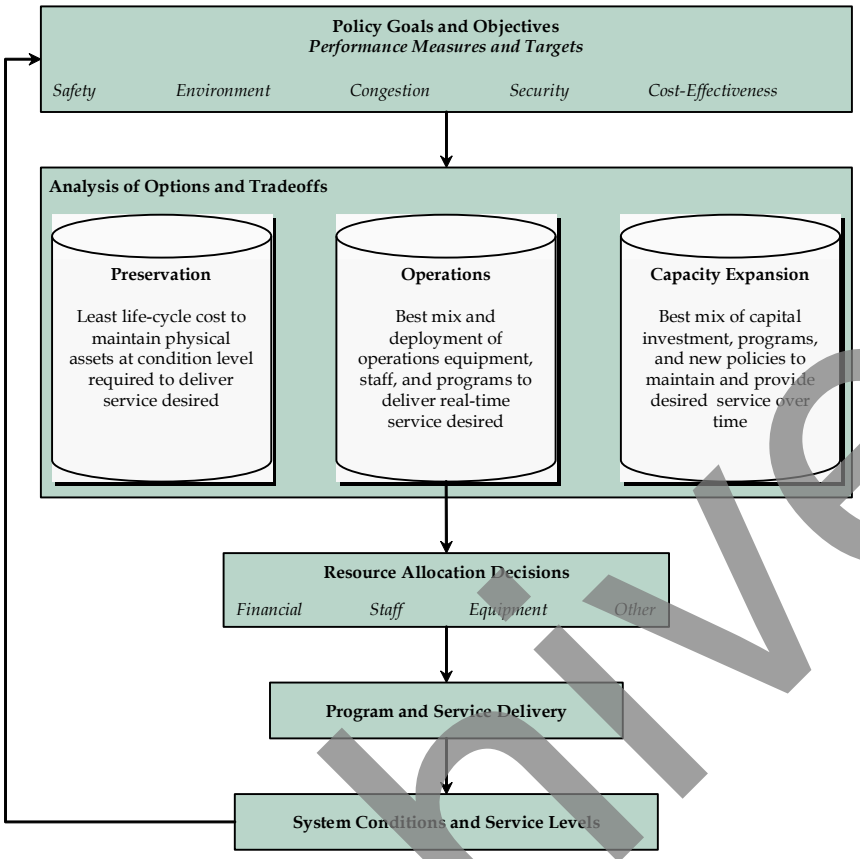
These principles are not unfamiliar, nor are they radical. Most transportation practitioners would agree that investment decisions should be based on weighing costs against likely outcomes, that a variety of options should be considered and evaluated, and that quality information is needed for decision-making. Many agencies are now pursuing performance-based approaches to planning and programming, monitoring system performance, and developing more integrated data and analysis tools to evaluate tradeoffs among capital expansion, operations, and preservation activities. Most agencies recognize that application of asset management principles is critical in times of constrained resources, when all investment and budget decisions are subject to increased public scrutiny.

1.3 Asset Management Practice

Figure 1 illustrates the strategic resource allocation process that embodies the asset management principles presented above.

[2] The FHWA plays a key role in standardizing the content and format of data that are mandated by federal law: e.g., the National Bridge Inventory (NBI) data that are reported by state DOTs.

Figure 1. Strategic Resource Allocation Process



The diagram includes the following elements:

- **Policy Goals and Objectives,** supported by performance measures are established through the policy and system planning process and used to guide the overall resource allocation process.

- **Analysis of Options and Tradeoffs** includes examination of options *within* each investment area, as well as tradeoffs *across* different investment areas. The definition of investment areas is flexible and can be tailored to how an individual agency does business. For example, an agency may have a separate safety investment area and also incorporate consideration of safety within system preservation, operations, and capacity expansion expenditures. Each option and tradeoff is evaluated with respect to established agency goals and performance objectives.

- **Resource Allocation Decisions** are based on the results of tradeoff analyses These decisions involve allocations of financial, staff, equipment, and other resources to the different investment areas and/or to different strategies, programs, projects, or asset classes within an individual investment area.

- **Program and Service Delivery** is accomplished in the most cost-effective manner which again involves consideration of different delivery options (e.g., use of contractors, interagency agreements), as well as a delivery tracking process involving recording of actions taken, costs, effectiveness, and lessons learned to guide future activity.

- **System Conditions and Service Levels** are tracked to see the extent to which established performance objectives are being addressed. This information is used to refine policy goals and priorities (e.g., put more emphasis on safety in response to an increase in crash rates).

1.4 Transportation Investment Categories

In Figure 1, the box labeled "Analysis of Options and Tradeoffs" shows three types of investment categories – preservation, operations, and capacity expansion. These are defined as follows:

1. **Preservation** encompasses work to extend the life of existing facilities (and associated hardware and equipment), or to repair damage that impedes mobility or safety. The purpose of system preservation is to retain the existing value of an asset and its ability to perform as designed. System preservation counters the wear and tear of physical infrastructure that occurs over time due to traffic loading, climate, crashes, and aging. It is accomplished through both capital projects and maintenance actions.

2. **Operations** focuses on the real-time service and operational efficiency provided by the transportation system for both people and freight movement on a day-to-day basis. Examples of operations actions include real-time traffic surveillance, monitoring, control, and response; intelligent transportation systems (ITS); signal phasing and real-time signal controllers at intersections; HOV lane monitoring and control; ramp metering; weigh-in-motion; road weather management; and traveler information systems. Although operations focuses on system management, the infrastructure needed to provide this capability may be substantial (e.g., traffic control centers; ITS hardware; environmental sensors and fire control systems in tunnels). Thus, an operations strategy requires capital and operating budget as well as substantial staff resources.

3. **Capacity expansion** focuses on the actions needed to expand the service provided by the existing system for both people and freight. Capacity expansion can be achieved either by adding physical capacity to an existing asset, or acquiring/constructing a new facility.

These three categories are defined in order to show that:

- Asset management is not just about preservation of highway network assets; it is about making investment decisions that address a wide range of policy goals.

- The three categories provide a simple, useful way for decision-makers to align program investment categories and priorities with key policy objectives. For example, many agencies establish a "preservation first" policy or favor maximizing efficiency of operations prior to investing in new capacity.

- The categories may present alternative ways of meeting a policy goal. For example, it may be appropriate to consider operational improvements to address a congestion problem as an alternative to adding a new lane.

- Decisions about the resources allocated to each category cannot be made independently. Meeting many policy goals (e.g., safety) may require a mix of investments across these categories. Similarly, an increase in capacity expansion investments may require increased operations and preservation expenditures at some point in time.

As noted above, tradeoff analysis may be done across *investment categories* as well as within them. An agency might wish to define investment areas coincident with the three categories discussed above (preservation, operations, capacity), or they may define a different set of categories. For example, a safety program could be defined as an investment category, with subareas for operational activities (e.g., signs, markings, signalization, channelization, etc.), preservation (replacement of guardrails), and capacity (project design features supporting safety, e.g., wide shoulders). This would provide the framework for understanding the best mix of complementary actions within the safety area as well as tradeoffs between safety and other objectives.

1.5 Asset Management and the Transportation Planning Process

A common reaction to the broad description of asset management is "how is this different from the overall planning and programming process in an agency?" The response is that asset management is not a new kind of business process that replaces planning and programming. Rather, it should be viewed as a set of best practices to be employed within the established planning and programming framework. Existing regulations pertaining to the planning process, together with statutes related to specific funding programs and their allocation criteria, and the body of environmental regulations affecting transportation planning – provide the context within which asset management practice occurs. In terms of Figure 1, transportation regulations and statutes impact establishment of policy objectives, the manner in which options are generated and evaluated, and they also provide certain constraints on resource allocation (based on Federal and state funding eligibility restrictions). Many of the core principles of asset management are embodied in the existing planning regulations (e.g., consideration of alternatives). Examining the planning process using the lens of asset management

provides an opportunity to explore ways to continue to strengthen the mission of transportation planning – for example:

- How to improve connections between long-range planning and resource allocation;
- How to strengthen agency and public consideration of preservation and operations investments within the long-range planning process;
- How to better integrate environmental considerations throughout the transportation planning and decision-making process – across capacity, operational and preservation investments; and
- How to provide a common information resource base to serve multiple activities across the transportation asset life cycle – long-range planning, corridor studies, safety studies, environmental assessments, multi-year capital programming, project development, preventive maintenance and system operations.

While asset management is closely associated with planning and programming activities, asset management best practices are also integral to design, construction, routine and preventive maintenance and operations activities. For example:

- Application of life-cycle cost analysis in the facility design process;
- Analysis of alternative construction materials and methods;
- Tradeoffs across different maintenance activities based on level of service and extended facility life provided to customers;
- Developing an appropriate mix of operations expenditures on technology upgrades, hardware/infrastructure maintenance and replacement, and skilled personnel;
- Evaluation of delivery options (e.g., design-build, use of private contractors for maintenance and operations, inter-agency agreements, etc.).

1.6 Key Opportunities

Despite the support for taking an asset management approach, many agencies face very real organizational, institutional, and technical challenges to making further progress in asset management. Each one of these challenges represents a potential opportunity for FHWA to work with its partners to encourage broader implementation of asset management principles. For example:

- Top management needs to set an organization-wide direction and framework for decision-making and to ensure that all parts of the organization are working together in a coordinated fashion. Maintaining continuity in leadership direction and understanding of key asset management principles can be particularly challenging with frequent turnover in agency executives;

- Clear roles for each organizational unit must be established to solve common problems or meet common objectives. Differences in perspectives and approaches, lack of established procedures, or turf battles must be reconciled;

- Established resource allocation methods, often constrained by externally imposed restrictions, historical allocations or formulas, or delicate and difficult political negotiations may restrict the range of options and tradeoffs that can be considered;

- Staff resource constraints together with a constant "fire-fighting" mode of operation also may restrict the amount of time and effort that can be spent on analyzing options;

- Developing a comprehensive set of reliable methods, data and tools to evaluate performance tradeoffs among the full set of investment options will take a sustained, multi-year effort;

- Establishing a causal link between an investment or action and a performance indicator of interest, due to the presence of external factors influencing performance (e.g., gas prices, vehicle fleet changes, growth patterns, etc.) may require additional research in some cases;

- Coordination among multiple agencies to achieve established objectives in areas such as operations and safety adds complexity to the decision-making process and program implementation efforts; and

- External and internal agency culture based on "bottom-up" decision-making, with a focus on specific projects rather than on broader system performance and outcomes.

While it is relatively straightforward to implement asset management within a well-defined area of the agency (a pavement management unit, for example), the issues identified above illustrate why it is much more challenging to implement it more fully within an agency, or across multiple agencies.

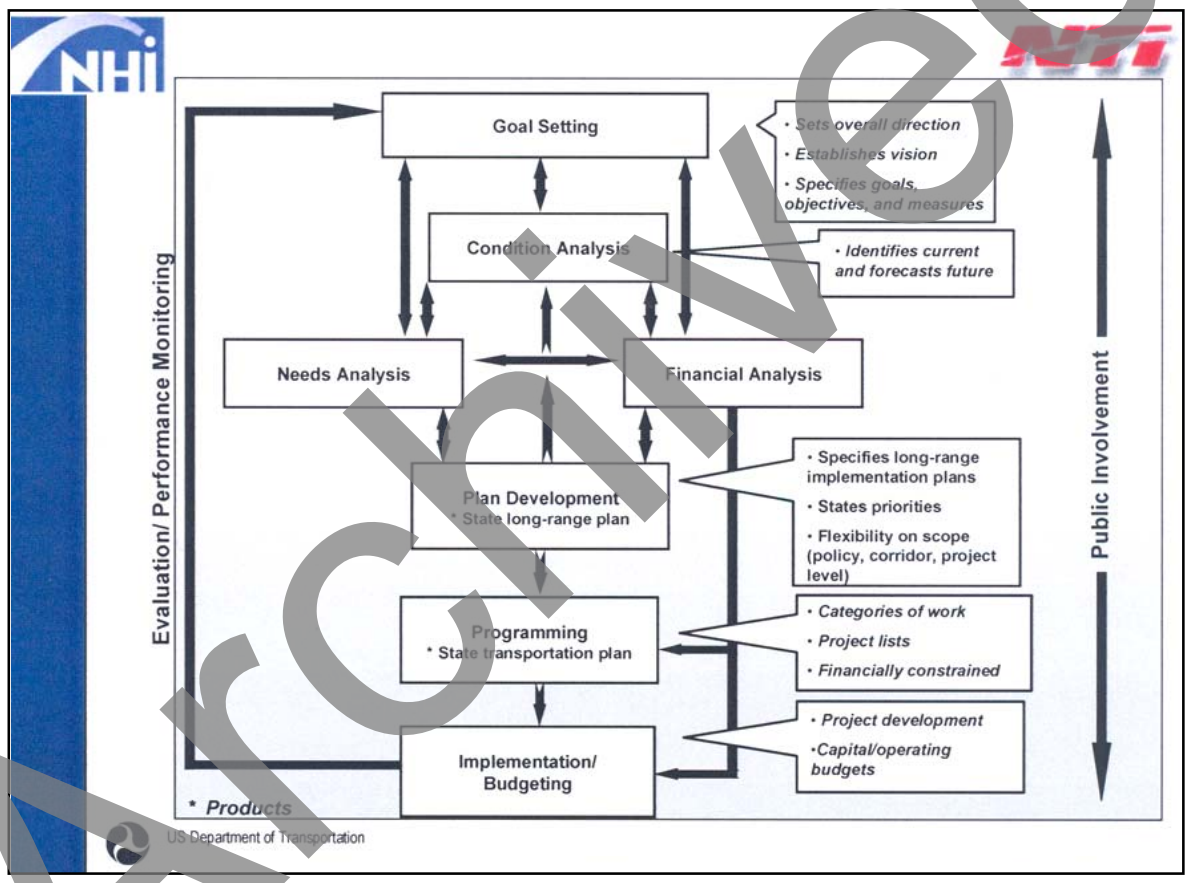
However, the need to allocate scarce resources as effectively as possible and demonstrate results and performance to the customers of the transportation system provides strong motivation and support for overcoming these challenges. A comprehensive, performance-based approach to transportation investment decisions will be essential to meeting the increasingly complex set of transportation needs of the 21st century.

2.0 Planning and Transportation Asset Management

As Section 1.5 described, asset management principles and how they should be applied in the strategic resource allocation process sounds remarkably similar to good transportation system planning and particularly performance-based planning and programming.

Therefore it is worth repeating that asset management is not a new or separate function but a set of best practice principles to be integrated into existing planning and programming processes. Figure 2 taken from the National Highway Institute/National Transit Institute (NHI/NTI) training course on statewide transportation planning is clearly very consistent with Figure 1 defining a broad strategic resource allocation process. However, as noted earlier, asset management principles also can be integrated into other functions beyond planning including operations, maintenance, design, construction and right-of-way.

Figure 2. Overview of Statewide Transportation Planning



Source: NHI/NTI Course 151038.

The purpose of this section is to define the relationship between planning and asset management. It is written from the perspective of an operating agency (e.g., state DOT). Because many of the principles of asset management also could describe good planning practice, and in fact are reflected in both statute and regulation to a degree, the focus will be on how these principles can be further strengthened within the planning process. However, reflecting asset management principles in planning, if planning in turn does not directly impact resource allocation and other programmatic and project decisions, will

have limited value. Thus the need to have planning closely integrated with programming and budgeting processes will also be explored.

2.1 Overview of Planning Activities

The planning function covers a diverse set of activities that focus on different transportation modes and systems, timeframes, geographic scales, policy issues and stakeholder groups. Many planning requirements, including some that support good asset management, are defined in Federal statute and regulation, and are consistent, at least as requirements, across all states. However, there are many other aspects of a particular state's planning process that reflect state and local requirements and tradition, and actual planning practice varies widely. Typical activities performed by the planning function in many states include:

- Long-range transportation planning;
- Policy planning and analysis;
- Establishing system performance measures (e.g., infrastructure condition, service levels and reliability, safety, etc.);
- Regional and corridor planning;
- Project priority setting, programming and development of STIP/TIP;
- Project planning and development;
- Coordination with MPOs and other planning partners;
- Public participation, outreach, and communication;
- Coordination and integration with land use planning and economic development strategies;
- Community, economic, and environmental impact assessment, mitigation, and air quality conformity analysis;
- Management systems development and use (varies widely); and
- Data collection, management, analysis, and reporting.

While asset management principles can be integrated into most of these activities to some extent, there are several key planning functions and activities where asset management principles are likely to have the most impact and where the current state of practice could be strengthened significantly. These activities include:

- **Long-Range Plan Development and Updates –** The development and update of long-range plans offer a great opportunity to develop clear policy goals embraced by executive management and key stakeholders, establish system performance measures, broaden the range of investments and actions included in the planning effort including freight, safety, preventive maintenance, operations, intermodal and multimodal options as appropriate, and broaden the range and level of integration of the data and analysis tools used to support the planning and programming process. All of these areas would support key asset management principles and develop a more comprehensive planning process.

- **Performance Measurement –** Whether established as part of a long-range plan update or as a stand alone initiative, defining a set of system performance measures is a prerequisite to good asset management. By focusing on system performance these measures can help encourage the culture change required for asset management which is a "systems view" not a project view. To be successful, measures need to be tied to policy goals and objectives that have emerged from the planning process.

- **Strategic Resource Allocation and Tradeoffs –** The planning function is the most logical place to examine strategic resource allocation issues and tradeoffs. While in some agencies finance, budget, or policy offices might have this responsibility, it is unlikely that such groups could examine these issues without significant support from the skills, tools and data typically found in the planning function. Most agencies do not have the full set of tools, data or organizational structure and roles to really examine expenditures in all key areas in a consistent manner and consider options and tradeoffs. Different investment areas are treated independently to some degree. Broadening the role and focus of planning can incrementally broaden the type of tradeoffs that are considered and move an agency toward a more integrated decision-making model consistent with good asset management.

- **Linkage to Programming and Budgeting –** The extent to which plans and planning activities influence program and budget decisions varies widely. Unless this linkage is clear and strong the value of planning can be questioned. In a white paper produced for the AASHTO Standing Committee on Planning, the ability to directly impact programming and budgeting decisions was viewed as the single most important criterion for judging the effectiveness of statewide planning. Unless planning is able to influence decision-making its impact on promoting asset management is limited.

- **Data and Analytic Tool Development and Support –** The planning function is a key customer of a wide range of data and analytic tools that support forecasting demand and system performance, evaluating plans, programs, and projects across a wide range of performance measures and impacts and analyzing tradeoffs. In many agencies, the planning function is the "owner" of some of the data and tools required to support a variety of planning activities. However, as the range of issues and investment tradeoffs considered in planning increases, many key databases and tools will be maintained by other functional units (e.g., system physical conditions, real-time operations data, crash statistics, pavement and bridge management systems). Ownership and maintenance of specific databases and tools is not the issue, but shared

access to, and common definition of, data and joint use and understanding of analysis tools is important. The planning function provides a platform for a more integrated agencywide data collection and management strategy and the development of new, or enhanced, analytic tools to support a broader and more integrated set of tradeoff analyses.

2.2 Relationship to Transportation Investment Areas

In terms of the strategic resource allocation process described earlier, planning is the logical function to define and analyze key system- and program-level tradeoffs as part of long-range planning, programming and budgeting. While historically long-range planning has focused on capacity expansion and capital projects, the planning process must focus on the full set of investment choices in order for asset management principles to be reflected in the highest-level program tradeoffs. Ongoing initiatives related to operations planning, freight planning and safety conscious planning reflect a broadening of planning activities occurring at the Federal, state and regional levels. As discussed earlier, decisions about the appropriate investment levels in each program area are not independent and always made in the face of budget constraints.

Preservation

The implications of various funding levels for the preservation of major infrastructure including pavements and bridges on the highway side and other state-owned facilities for other modes are routinely a component of long-range transportation plans and needs analyses. While historically, management systems have not always been used to drive these analyses, increasingly these tools are being used to evaluate budget/condition tradeoffs. In addition to heavy infrastructure, the facilities and equipment needed to monitor and operate the system must also be considered.

Operations

Initiatives related to operations planning, freight planning, and safety conscious planning are increasing the consideration of operations programs and operations expenditures in the planning process. For long-range planning there is a need to examine operations strategies as potential substitutes for, or complements to, capacity expansion actions. Similarly, the need for an increase in operations program expenditures as system expansion occurs over the long term also must be addressed. Operations planning activities that focus on the near-term, real-time operation of the system are typically separated from the broader long-term system planning function.

Capacity Expansion

Capacity expansion and capital project programming and development have been the key focus of planning activities historically and will continue to be a key element of effective long-range planning. Initiatives related to environmental streamlining, environmental

stewardship and context sensitive design all impact the cost and time associated with developing and implementing capacity expansion projects.

2.3 Application of Asset Management Principles to Planning

The overlap between asset management principles and good planning practice has already been acknowledged. This section simply summarizes the connection between these principles and planning practice.

Policy-Driven

Goals and objectives are typically established as part of the long-range planning process including extensive stakeholder and partner involvement and coordination. Asset management principles suggest that these goals and objectives cover the full set of transportation policies of concern and guide the development and implementation of plans and programs, provide a framework for establishing performance measures and directly influence budget decisions. The range of goals and objectives that might be included in a typical state DOT long-range plan include:

- Preserve the existing system in a state of "good repair";
- Increase mobility and accessibility;
- Improve system reliability via better management of non-recurring congestion;
- Improve the safety and security;
- Support economic development and competitiveness;
- Protect and enhance the natural and built environment; and
- Reflect fiscal constraints and cost-effectiveness.

The number and focus of the goals and objectives adopted in any state or region will vary, but they need to emerge from a long-range planning process that includes significant public participation. Typically gaining acceptance of a broad set of transportation goals is not difficult, however gaining consensus on the appropriate balance among inherently conflicting goals and objectives is the key challenge and focus of the planning and strategic resource allocation processes.

Performance-Based

Specific performance measures need to be identified for each policy goal and objective in order to define how goal achievement is going to be determined and monitored over time. Just as goals and objectives must be developed as part of an ongoing transportation planning process, performance measures related to those goals help evaluate and communicate the impacts and implications of different plan alternatives. Similarly in the strategic resource allocation and budgeting process, performance measures provide the criteria for analyzing and evaluating tradeoffs. Determining the appropriate number and

type of performance measures at different levels of decision-making is a key challenge to operationalize this principle of good asset management. The notion that at its essence asset management is really "total performance management" derives from the critical role that performance measurement plays in implementing the concepts of asset management. Performance-based planning and performance-based programming are essential components of asset management and all rely on specification of performance measures that reflect key policy goals. A wide range of performance measures have been adopted by transportation agencies and the list of candidate measures below is just illustrative:

- Level of service;
- User costs;
- Travel time reliability;
- Crash rate, fatality rate, injury rate;
- Incident response time;
- Condition of key physical assets.
- Mobil source emissions;
- Wetland acreage;
- Community cohesion;
- Economic development; and
- Life-cycle cost.

Analysis of Options and Tradeoffs

The essence of good planning is the analysis of options and tradeoffs. However, at the strategic resource allocation level this analysis needs to consider tradeoffs across all major investment categories including preservation, operations and capacity expansion. The system planning process is the most appropriate place for this comprehensive analysis to occur. Typical tradeoffs might include:

- Tradeoffs among preservation, operations and capacity expansion expenditures and programs for achieving appropriate balance among all objectives;
- Tradeoffs between passenger and freight mobility;
- Tradeoffs among modal and intermodal options;
- Tradeoffs among different geographic areas or functional systems;
- Balancing safety, mobility, environmental and equity objectives.

Decisions Based on Merit and Quality Information

A key element of planning is the collection, management and analysis of a broad range of different data sets. While the planning function is often not the "owner" of some important data sets (e.g., facility condition and performance, safety, maintenance, financial, etc.), planning is often the function that integrates data from a wide range of sources and is a key customer for data from a wide variety of sources both within and outside an agency. Similarly, a wide variety of models and analysis tools are needed to do good planning and to establish a link to programming and ownership and maintenance of some of these tools also may be the responsibility of other units. Effective display and communication of data and technical analyses increasingly is viewed as critical as the analysis itself in supporting decision-making.

Monitoring and Feedback

Monitoring and reporting on system performance and conditions over time is often the responsibility of different organizational units within an operating agency. For real-time system conditions, an operations unit or traffic management center is typically responsible. Similarly, infrastructure condition is generally tracked by engineering, maintenance and district/regional offices. Nonetheless, the planning function is often involved in, if not leading, efforts to periodically report on system conditions and performance via annual performance reports or more frequent reporting via web sites, etc. In addition, in plan update cycles, programming and the budgeting process it is often the planning function that provides the feedback necessary to make adjustments based on actual versus predicted results and targets.

3.0 FHWA Office of Planning – Current and Future Activities in Support of Asset Management

The section describes current activities of the FHWA Office of Planning that are supportive of asset management, and identify potential additional opportunities for the future.

3.1 Current and Planned Activities

The Office of Planning is organized into two teams. The Planning Oversight and Stewardship Team provides transportation planning program assistance and guidance to the Division Offices in the administration of the various transportation planning and programming elements of the Federal-aid Highway Program. In addition, the team closely collaborates with FTA's Office of Systems Planning in developing and disseminating mechanisms and tools to increase the efficiency, timeliness, and consistency of Federal oversight and stewardship of statewide and metropolitan transportation

planning processes. The Planning Capacity Building Team is focused on improving the state of the practice through the development and dissemination of best practice information, peer reviews and conferences and by supporting the development of improved planning methods and tools. Staff from both teams are involved in a number of initiatives that directly support incorporating asset management principles in the planning process. Again, it should be stressed that since there is a strong overlap between asset management principles and good planning practice, the issue is how the planning process can be strengthened to encourage both good planning and good asset management. A number of the key activities in the Office of Planning that support asset management are listed below.

Policy and Regulatory

Guidelines for state and metropolitan planning reflect a number of the principles of asset management including defining policy directions as a part of the long-range planning process based on extensive stakeholder involvement, use of performance measures, examination of the full range of alternatives including multimodal and intermodal solutions, and recognition of realistic funding constraints. Periodic planning reviews at both the state and metropolitan levels offer opportunities to assess an agency's current efforts in following guidelines and regulations and offer suggestions for further strengthening these efforts.

Technical Assistance and Information Dissemination

A wide range of efforts are being undertaken in the Office of Planning to provide technical assistance and information directly related to asset management including:

- The Transportation Planning Capacity Building program focuses on a broad range of planning-related topics some of which are directly relevant to asset management. The program includes dissemination of best practices, development of case studies, peer reviews and exchanges, development of research and development priorities, training, etc. Among the topics covered that relate to asset management are:
  - Asset management;
  - Financial planning;
  - Freight planning;
  - Multimodal tradeoffs;
  - Performance measures;
  - Safety;
  - Data analysis and tools;
  - Management and operations;
  - Transportation and land use;

  - Cost estimation;
  - Programming process;
  - Environment; and
  - Public involvement.

- Encouraging the broader use of data, modeling and the use of analytic tools including congestion management systems, pavement management systems, bridge management systems and other planning analysis packages and capabilities.
- Providing support for various planning tools, GIS, and travel demand modeling.
- Exploring the use of scenario analysis techniques and visualization tools as methods to support the definition and evaluation of system alternatives at the planning stage.
- Public involvement including training and guidelines on the appropriate techniques to use in different situations.

Research and Technology

A number of areas of research and development undertaken by the Office of Planning support improved asset management including:

- Fiscal constraint/financial planning;
- GIS and remote sensing;
- Land use and transportation/sustainability;
- Linking planning and environment;
- Multimodal/intermodal planning;
- Operations and freight planning;
- Performance-based planning/performance measures;
- Planning oversight and stewardship;
- Public involvement;
- Safety and transportation planning;
- Scenario planning;
- Statewide and metropolitan planning;
- Transportation planning capacity building program; and
- Travel modeling.

Coordination

The Office of Planning is working with a number of other offices and program areas to develop coordinated strategies and joint efforts. A number of these initiatives can support better asset management and reflect the fact that a truly comprehensive planning process is the logical place to integrate issues and address tradeoffs that have often been addressed somewhat independently in separate functional areas.

- Working with the Office of Travel Management to identify areas where closer coordination and joint efforts would be useful. For example, assessing the existing planning tools that evaluate ITS and operations-oriented strategies, identifying gaps in the current stable of associated planning-level analytical methods and tools, and defining a research program to address these gaps will promote a "more level playing field" in the consideration and prioritization of transportation capital and operations/management solutions.

- Working with the Office of Safety, an initiative on safety conscious planning is focused on helping to integrate safety considerations more effectively into the planning process.

- Working with the Office of Freight Management and Operations to better integrate freight planning in the transportation planning process. By better integrating freight into the transportation planning process, there will be an improvement in the public sector's ability to examine tradeoffs between multimodal freight capacity and operations improvements versus automobile-oriented capacity and operations improvements and to identify capacity expansion, operations, and preservations programs that can benefit both freight and passenger movement.

- Working with the Office of Asset Management to begin to define the strong linkages between performance-based planning and asset management and identify opportunities to integrate these efforts.

- Working with the Office of Federal Lands and Tribal Government transportation planning may also create opportunities to support improved asset management.

- FHWA Office of Planning jointly develops regulations, guidance, and outreach with the FTA Office of Systems Planning to ensure effective, accountable administration of cooperative, continuing, and comprehensive statewide and metropolitan planning programs.

3.2 Potential Future Activities

Building on many activities that already are underway, including joint efforts with the Offices of Operations, Safety and Asset Management, the Office of Planning can take a number of steps to further strengthen the relationship between planning and asset management. Some of these activities include:

- Working with the Office of Asset Management to develop a more consistent message that performance-based planning that examines key investment choices across all functional areas is a key building block of good asset management. Reducing the confusion that these similar sounding concepts are different will allow a more productive focus on the data, tool and institutional/decision-making gaps that need to be addressed to improve the state of the practice.

- Including a focus on asset management in the Transportation Planning Capacity Building Program could provide a significant opportunity to both further define the relationship of asset management and planning and provide support to agencies involved in asset management initiatives. Similarly, a focus on performance measurement also will create an opportunity to make the connection between performance-based planning and asset management.

- Identifying data and analysis tool gaps in any areas required to create more integrated planning including operations, safety, and freight and defining research programs to develop these gaps with other Offices as appropriate.

- Through capacity building and other efforts, identify and promote the use of tools such as management systems as part of long-range planning, programming and budgeting efforts. Develop case studies of the use of tools such as HERS-ST where they have been used to support long-range plan updates, program-level economic impact assessments and other applications.

- Document case studies at the state and MPO levels illustrating best practice with respect to asset management and planning. Identify lead states in reflecting asset management principles in long-range plan development efforts.

FHWA White Paper:
Safety and Asset Management

The purpose of this paper is to define the relationship between transportation asset management and transportation system planning and to describe the current, and potential future, activities of the FHWA Office of Safety that support the implementation of asset management. The paper is one of a set of seven papers exploring the relationship of asset management to each of FHWA's major program areas including planning, right-of-way, environment, infrastructure, safety, operations, and Federal lands.

Section 1.0 provides a general overview of asset management relevant to all program areas. Section 2.0 defines the relationship between planning and asset management. Section 3.0 describes current, and potential future, activities of the Office of Safety that support asset management.

1.0 Overview of Transportation Asset Management

1.1 Definition of Asset Management

Transportation asset management is a set of guiding principles and best practice methods for making informed transportation resource allocation decisions, and improving accountability for these decisions. The term "resource allocation" covers not only allocation of money to program areas, projects, and activities but also covers deployment of other resources that add value (staff, equipment, materials, information, real estate, etc.). While several of these principles and practices were initially developed and applied within the domain of infrastructure preservation, most established definitions of asset management are considerably broader. The **Asset Management Guide**,[1] recently adopted by AASHTO defines asset management as:

[1] *Transportation Asset Management Guide*, prepared for the National Cooperative Highway Research Program (NCHRP) Project 20-24(11) by Cambridge Systematics, Inc. with Parsons Brinckerhoff Quade & Douglas, Inc., Roy Jorgensen Associates, Inc. and Paul D. Thompson, November 2002, AASHTO Publication RP-TAMG-1.

> *"… a strategic approach to managing transportation infrastructure. It focuses on…business processes for resource allocation and utilization with the objective of better decision-making based upon quality information and well-defined objectives."*

As Mary Peters, FHWA Administrator has frequently put it:

> *"If I have one additional dollar to spend on the transportation system, what is the most effective way to spend it?"*

The essence of asset management is answering that question.

Asset management is concerned with the entire life cycle of transportation decisions, including planning, programming, construction, maintenance, and operations. It emphasizes integration across these functions, reinforcing the fact that actions taken across this life cycle are interrelated. It also recognizes that investments in transportation assets must be made considering a broad set of objectives, including physical preservation, congestion relief, safety, security, economic productivity, and environmental stewardship.

1.2 Asset Management Principles

The core principles of asset management are:

- **Policy-Driven –** Resource allocation decisions are based on a well-defined and explicitly stated set of policy goals and objectives. These objectives reflect desired system condition, level of service, and safety provided to customers, and typically are tied to economic, community and environmental goals as well;

- **Performance-Based –** Policy objectives are translated into system performance measures that are used for both day-to-day and strategic management;

- **Analysis of Options and Tradeoffs –** Decisions on how to allocate resources within and across different types of investments (e.g., preventive maintenance, rehabilitation, pavements, bridges, capacity expansion, operations, different modal mixes, safety, etc.) are based on an analysis of how different allocations will impact achievement of relevant policy objectives. Alternative methods for achieving a desired set of objectives are examined and evaluated. These options are not constrained by established organizational unit boundaries – for example solving a congestion problem could involve a capacity expansion or an operational improvement (e.g., signal coordination). The best method is selected considering the cost (both initial and long-term) and likely impacts on established performance measures. The limitations posed by realistic funding constraints must be reflected in the range of options and tradeoffs considered;

- **Decisions Based on Quality Information –** The merits of different options with respect to an agency's policy goals are evaluated using credible and current data. These data may apply to specific functions (e.g., pavement and bridge management,

traffic monitoring) or reflect a more integrated, corporate view. [2] Where appropriate, decision support tools are used to provide easy access to needed information, to assist with performance tracking and predictions, and to perform specialized analysis (e.g., optimization, real-time simulation, scenario analysis, life-cycle cost analysis, benefit/cost analysis); and

- **Monitoring to Provide Clear Accountability and Feedback –** Performance results are monitored and reported for both impacts and effectiveness. Feedback on actual performance may influence agency goals and objectives, as well as resource allocation and utilization decisions.

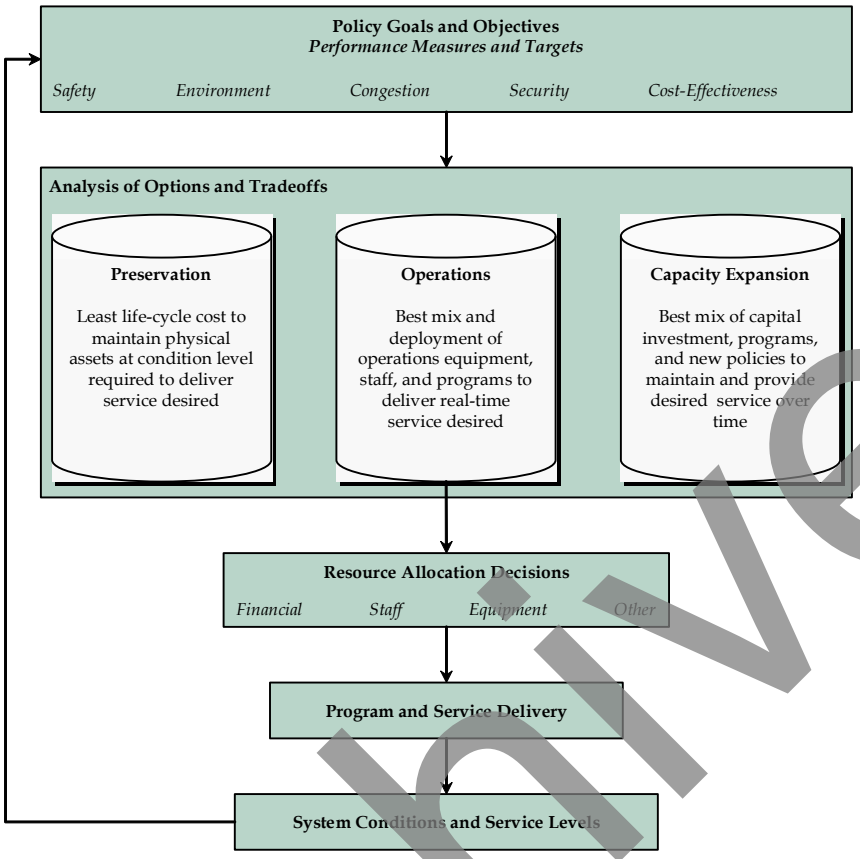
These principles are not unfamiliar, nor are they radical. Most transportation practitioners would agree that investment decisions should be based on weighing costs against likely outcomes, that a variety of options should be considered and evaluated, and that quality information is needed for decision-making. Many agencies are now pursuing performance-based approaches to planning and programming, monitoring system performance, and developing more integrated data and analysis tools to evaluate tradeoffs among capital expansion, operations, and preservation activities. Most agencies recognize that application of asset management principles is critical in times of constrained resources, when all investment and budget decisions are subject to increased public scrutiny.

1.3 Asset Management Practice

Figure 1 illustrates the strategic resource allocation process that embodies the asset management principles presented above.

[2] The FHWA plays a key role in standardizing the content and format of data that are mandated by federal law: e.g., the National Bridge Inventory (NBI) data that are reported by state DOTs.

Figure 1. Strategic Resource Allocation Process



The diagram includes the following elements:

- **Policy Goals and Objectives,** supported by performance measures are established through the policy and system planning process and used to guide the overall resource allocation process.

- **Analysis of Options and Tradeoffs** includes examination of options *within* each investment area, as well as tradeoffs *across* different investment areas. The definition of investment areas is flexible and can be tailored to how an individual agency does business. For example, an agency may have a separate safety investment area and also incorporate consideration of safety within system preservation, operations, and capacity expansion expenditures. Each option and tradeoff is evaluated with respect to established agency goals and performance objectives.

- **Resource Allocation Decisions** are based on the results of tradeoff analyses These decisions involve allocations of financial, staff, equipment, and other resources to the different investment areas and/or to different strategies, programs, projects, or asset classes within an individual investment area.

- **Program and Service Delivery** is accomplished in the most cost-effective manner which again involves consideration of different delivery options (e.g., use of contractors, interagency agreements), as well as a delivery tracking process involving recording of actions taken, costs, effectiveness, and lessons learned to guide future activity.

- **System Conditions and Service Levels** are tracked to see the extent to which established performance objectives are being addressed. This information is used to refine policy goals and priorities (e.g., put more emphasis on safety in response to an increase in crash rates).

1.4 Transportation Investment Categories

In Figure 1, the box labeled "Analysis of Options and Tradeoffs" shows three types of investment categories – preservation, operations, and capacity expansion. These are defined as follows:

1. **Preservation** encompasses work to extend the life of existing facilities (and associated hardware and equipment), or to repair damage that impedes mobility or safety. The purpose of system preservation is to retain the existing value of an asset and its ability to perform as designed. System preservation counters the wear and tear of physical infrastructure that occurs over time due to traffic loading, climate, crashes, and aging. It is accomplished through both capital projects and maintenance actions.

2. **Operations** focuses on the real-time service and operational efficiency provided by the transportation system for both people and freight movement on a day-to-day basis. Examples of operations actions include real-time traffic surveillance, monitoring, control, and response; intelligent transportation systems (ITS); signal phasing and real-time signal controllers at intersections; HOV lane monitoring and control; ramp metering; weigh-in-motion; road weather management; and traveler information systems. Although operations focuses on system management, the infrastructure needed to provide this capability may be substantial (e.g., traffic control centers; ITS hardware; environmental sensors and fire control systems in tunnels). Thus, an operations strategy requires capital and operating budget as well as substantial staff resources.

3. **Capacity expansion** focuses on the actions needed to expand the service provided by the existing system for both people and freight. Capacity expansion can be achieved either by adding physical capacity to an existing asset, or acquiring/constructing a new facility.

These three categories are defined in order to show that:

- Asset management is not just about preservation of highway network assets; it is about making investment decisions that address a wide range of policy goals.

- The three categories provide a simple, useful way for decision-makers to align program investment categories and priorities with key policy objectives. For example, many agencies establish a "preservation first" policy or favor maximizing efficiency of operations prior to investing in new capacity.

- The categories may present alternative ways of meeting a policy goal. For example, it may be appropriate to consider operational improvements to address a congestion problem as an alternative to adding a new lane.

- Decisions about the resources allocated to each category cannot be made independently. Meeting many policy goals (e.g., safety) may require a mix of investments across these categories. Similarly, an increase in capacity expansion investments may require increased operations and preservation expenditures at some point in time.

As noted above, tradeoff analysis may be done across *investment categories* as well as within them. An agency might wish to define investment areas coincident with the three categories discussed above (preservation, operations, capacity), or they may define a different set of categories. For example, a safety program could be defined as an investment category, with subareas for operational activities (e.g., signs, markings, signalization, channelization, etc.), preservation (replacement of guardrails), and capacity (project design features supporting safety, e.g., wide shoulders). This would provide the framework for understanding the best mix of complementary actions within the safety area as well as tradeoffs between safety and other objectives.

1.5 Asset Management and the Transportation Planning Process

A common reaction to the broad description of asset management is "how is this different from the overall planning and programming process in an agency?" The response is that asset management is not a new kind of business process that replaces planning and programming. Rather, it should be viewed as a set of best practices to be employed within the established planning and programming framework. Existing regulations pertaining to the planning process, together with statutes related to specific funding programs and their allocation criteria, and the body of environmental regulations affecting transportation planning – provide the context within which asset management practice occurs. In terms of Figure 1, transportation regulations and statutes impact establishment of policy objectives, the manner in which options are generated and evaluated, and they also provide certain constraints on resource allocation (based on Federal and state funding eligibility restrictions). Many of the core principles of asset management are embodied in the existing planning regulations (e.g., consideration of alternatives). Examining the planning process using the lens of asset management

provides an opportunity to explore ways to continue to strengthen the mission of transportation planning – for example:

- How to improve connections between long-range planning and resource allocation;
- How to strengthen agency and public consideration of preservation and operations investments within the long-range planning process;
- How to better integrate environmental considerations throughout the transportation planning and decision-making process – across capacity, operational and preservation investments; and
- How to provide a common information resource base to serve multiple activities across the transportation asset life cycle – long-range planning, corridor studies, safety studies, environmental assessments, multi-year capital programming, project development, preventive maintenance and system operations.

While asset management is closely associated with planning and programming activities, asset management best practices are also integral to design, construction, routine and preventive maintenance and operations activities. For example:

- Application of life-cycle cost analysis in the facility design process;
- Analysis of alternative construction materials and methods;
- Tradeoffs across different maintenance activities based on level of service and extended facility life provided to customers;
- Developing an appropriate mix of operations expenditures on technology upgrades, hardware/infrastructure maintenance and replacement, and skilled personnel;
- Evaluation of delivery options (e.g., design-build, use of private contractors for maintenance and operations, inter-agency agreements, etc.).

1.6 Key Opportunities

Despite the support for taking an asset management approach, many agencies face very real organizational, institutional, and technical challenges to making further progress in asset management. Each one of these challenges represents a potential opportunity for FHWA to work with its partners to encourage broader implementation of asset management principles. For example:

- Top management needs to set an organization-wide direction and framework for decision-making and to ensure that all parts of the organization are working together in a coordinated fashion. Maintaining continuity in leadership direction and understanding of key asset management principles can be particularly challenging with frequent turnover in agency executives;

- Clear roles for each organizational unit must be established to solve common problems or meet common objectives. Differences in perspectives and approaches, lack of established procedures, or turf battles must be reconciled;

- Established resource allocation methods, often constrained by externally imposed restrictions, historical allocations or formulas, or delicate and difficult political negotiations may restrict the range of options and tradeoffs that can be considered;

- Staff resource constraints together with a constant "fire-fighting" mode of operation also may restrict the amount of time and effort that can be spent on analyzing options;

- Developing a comprehensive set of reliable methods, data and tools to evaluate performance tradeoffs among the full set of investment options will take a sustained, multi-year effort;

- Establishing a causal link between an investment or action and a performance indicator of interest, due to the presence of external factors influencing performance (e.g., gas prices, vehicle fleet changes, growth patterns, etc.) may require additional research in some cases;

- Coordination among multiple agencies to achieve established objectives in areas such as operations and safety adds complexity to the decision-making process and program implementation efforts; and

- External and internal agency culture based on "bottom-up" decision-making, with a focus on specific projects rather than on broader system performance and outcomes.

While it is relatively straightforward to implement asset management within a well-defined area of the agency (a pavement management unit, for example), the issues identified above illustrate why it is much more challenging to implement it more fully within an agency, or across multiple agencies.

However, the need to allocate scarce resources as effectively as possible and demonstrate results and performance to the customers of the transportation system provides strong motivation and support for overcoming these challenges. A comprehensive, performance-based approach to transportation investment decisions will be essential to meeting the increasingly complex set of transportation needs of the 21st century.

2.0 Safety and Transportation Asset Management

This section discusses the relationship between safety and the transportation asset management framework and principles described above.

2.1 Overview of Safety Activities

Transportation safety programs have traditionally encompassed the "4E's" of Engineering, Enforcement, Education and Emergency Response. While state DOT safety offices have primary responsibility for the engineering aspect of safety (geometric design, traffic control, barriers, signs, etc.), they work in coordination with a variety of other agencies – state highway safety offices, local public works departments, departments of motor vehicles, law enforcement, emergency services, hospitals – on implementation of broader safety programs.

The AASHTO *Strategic Highway Safety Plan* (SHSP) was developed with participation from a broad set of stakeholders and represents a comprehensive approach to improving transportation safety. The Plan describes strategies in six key areas – drivers, vulnerable users, vehicles, highways, emergency medical services, and safety management. Within each of these areas, there is a mix of engineering, enforcement, education and emergency response strategies, as summarized below.

- The *Drivers* element includes strategies such as graduated driver licensing programs; education to increase safety awareness; legislative, education and law enforcement actions to address impaired driving; and enforcement to curb aggressive driving.
- The *Vulnerable Users* element includes engineering, education and enforcement actions to improve safety of travel for pedestrians and non-motorized vehicles (e.g. street and intersection design improvements, motorist education, model ordinances for pedestrian rights).
- The *Vehicles* element includes improvements to vehicle safety features, and improved compatibilities between roadside safety elements (e.g. guide rails, side slopes) and certain types of vehicles.
- The *Highways* element includes six goal areas:
  - Reducing Vehicle-Train Crashes (improved traffic control, grade separation, driver training)
  - Keeping Vehicles on the Roadway (improving visibility, decreasing speed variance, maintenance best practices)
  - Minimizing the Consequences of Leaving the Road (improved roadside safety hardware, addressing fixed object hazards such as trees and utility poles, roadside slope improvements, urban streetscape design improvement)
  - Improving the Design and Operation of Highway Intersections (improved signal timing/coordination, collision warning systems, access management)
  - Reducing Head-on and Across-median Crashes (countermeasures such as median barriers, center rumble strips)
  - Designing Safer Work Zones (technology; design, construction, operations guidelines; education)

- The *Emergency Medical Services* area includes improvements to emergency response systems, trauma systems, and first responder training.
- The *Safety Management* area includes improvements to information and decision support systems, and safety program management.

NCHRP Report 500: *Guidance for Implementation of the AASHTO Strategic Highway Safety Plan* presents specific objectives and strategies for addressing different types of highway crashes (e.g. head-on collisions) or factors which cause crashes (aggressive driving, unlicensed drivers). NCHRP Report 501: *Integrated Management Process to Reduce Highway Injuries and Fatalities Statewide* provides an overall framework and management process for coordinating and integrating safety programs, independent of where they reside within a governmental organization. NCHRP Synthesis Report 322: *Safety Management Systems* describes current agency practices and reviews two model state SMS initiatives.

2.2 Relationship to Transportation Investment Areas

Safety Considerations in Transportation Preservation, Operations and Capacity Expansion

The three transportation investment areas discussed in Section 1 and presented in Figure 1 provide a framework for state DOT's to examine where their transportation resources are going and how different investment mixes affect multiple objectives, including safety, congestion relief, economic development/access to markets, environmental stewardship, and preservation of infrastructure investment. Safety is viewed as integral to all program areas; DOT's understand that all projects to be developed and delivered, whether operational, maintenance-related or capital, will be designed with safety in mind and will in fact contribute to overall system safety. Each of the three investment areas have a safety component which is considered in the identification, evaluation and selection of options:

Preservation actions keep infrastructure in safe, serviceable condition. Road surfaces with rutting, major distresses (e.g. potholes) or low skid resistance can adversely impact safety; pavement repair, resurfacing and rehabilitation activities reduce the likelihood of crashes related to road surface conditions. Bridge maintenance, rehabilitation and replacement programs keep important safety features (bridge railings) in good repair and reduce risks of structural failure.

Operations includes actions to maintain the safe and efficient flow of traffic. A wide range of operations strategies are implemented to address safety objectives. These include geometric improvements, access management, traffic control, coordination with enforcement activities for installation and monitoring of red light cameras; real-time motorist warning systems at intersections; road weather management; traveler information and roadway reports; physical safety improvements such as rumble strips; and deployment of guardrails, impact attenuators, lighting, signs, signals, and pavement markings.

Preservation and ***Operations*** investments are frequently combined – for example, many agencies implement improvements such as shoulder paving, slope flattening, installation of guardrails, etc. in conjunction with resurfacing projects in order to improve safety and operational efficiency.

Capacity Expansion investments offer state DOTs the opportunity to utilize safety best practices and examine design options with respect to potential safety benefits. Safety-related design considerations also may include provisions for emergency response and enforcement (e.g. pull-off locations for HOV lane enforcement). Alternatives for providing instrumentation to support better traffic management and operations within the project scope may also be considered.

Work zone safety is an important consideration within each of these areas.

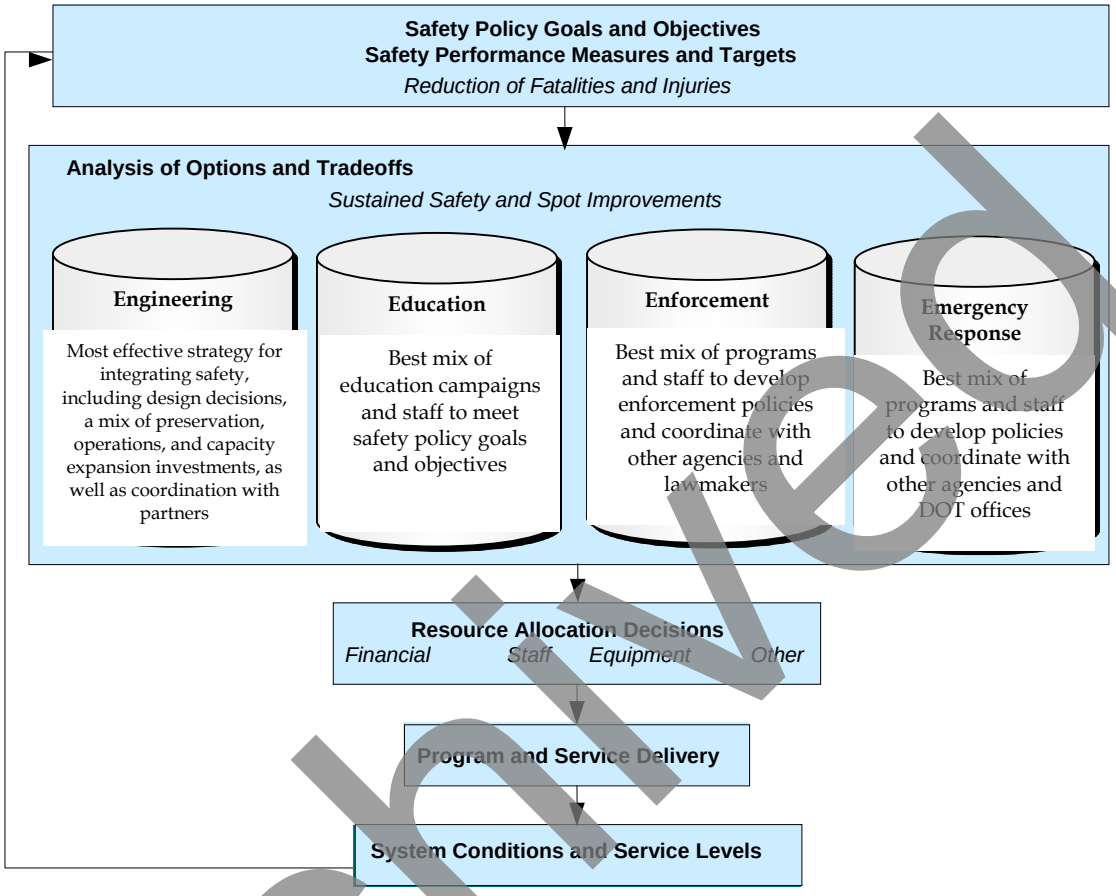
Safety Program Investment Areas

From the perspective of improving transportation safety, there is a much broader set of investments that should be undertaken to achieve the goal of reducing crashes and associated injuries and fatalities, consistent with the AASHTO SHSP.

Figure 2 presents a view of the strategic resource allocation process within the safety area. In this figure, investment areas are defined based on the 4E s - engineering, education, enforcement and emergency response. Within and across each of these investment areas, options and tradeoffs can be considered to provide the mix of actions that achieves the greatest reduction in injuries and fatalities. Such tradeoffs can be considered for an overall safety program, or for a specific goal area. For example, the goal of improving safety for pedestrians can be addressed through engineering actions such as properly designed pedestrian crossings, highway user education to raise awareness of pedestrian safety, enforcement for both motorists and pedestrians, and improved emergency response.

Each of the four safety investment areas includes actions to reduce fatalities and injuries systemwide ("sustained safety"), and actions targeted at specific locations or corridors to lower the incidence of crashes or reduce risks. In this figure, DOTs have direct responsibility for the engineering component, which encompasses the preservation, operations and new capacity categories discussed above. They cooperate with other partners for education, enforcement, and emergency response activities.

Figure 2 Strategic Resource Allocation Process for Safety



2.3 Application of Asset Management Principles to Safety

This section describes how each of the asset management principles outlined in Section 1.2 can be applied to safety.

Policy-Driven

Transportation safety programs by definition respond to the policy objective of preventing crashes and associated injuries and fatalities. Policies can also be established for specific safety program elements or emphasis areas; for example prevention of crashes involving pedestrians or bicyclists; prevention of crashes involving trucks.

Performance-Based

Safety objectives are easily translated into quantitative performance measures. Most commonly, numbers (or rates per vehicle mile of travel) of crashes, injuries and fatalities are tracked, along with a variety of associated data to help understand causal factors:

- Vehicle types and classifications (school bus, commercial vehicle, etc.)
- Accurate location on the roadway (intersection type, curve, midblock, ramp, etc)
- Roadway types and classifications (interstates, arterials, collectors, local roads, etc.)
- Roadway geometrics
- Condition of traffic control devices (retro-reflectivity)
- Type of crash (intersection, roadway departure, pedestrian, etc.)
- Driver demographics, including age and seat belt usage
- Pedestrian, bicyclist, or motorcyclist-involved
- Behavioral causal factors (speeding, alcohol, etc.)
- Traffic control (stop signs, signals, etc.)
- Rural/urban area
- Work zone area
- Weather
- Day of week, time of day

The condition of safety physical assets (guardrails, crash cushions, pavement markings, signals, etc.) is also tracked by many agencies to determine maintenance and rehabilitation needs.

Analysis of Options and Tradeoffs

A key principle of asset management is the analysis of options and tradeoffs. For the safety area, options and tradeoffs can be considered in two different contexts – within a statewide, regional or local safety program seeking to reduce injuries through a variety of strategies, and within a broader transportation program where safety is one of several objectives being considered.

The allocation of available safety resources for different types of safety activities should reflect an analysis of the expected payoff from each investment with respect to established performance measures. Considerable research has been done to better understand the impacts of safety features, projects and programs. Analysis methods for some types of safety investments (e.g. intersection improvements) are more tractable, and are therefore further developed than for others (e.g. public awareness campaigns). Many agencies make use of benefit-cost analysis techniques to prioritize spot safety projects.

The States are implementing the AASHTO Strategic Highway Safety Plan and many have established themselves as a Lead State to implement and evaluate safety problem countermeasures. This evaluation not only requires proper evaluation methods such as before and after studies, but needs more detailed information about the type, location and performance of the asset.

NCHRP Report 501 presents an integrated safety management process that involves consideration of options and tradeoffs for determining an effective combination of strategies to achieve safety goals. This process includes steps to identify emphasis areas and specific objectives within each emphasis area, evaluate potential strategies for achieving the objectives, and optimization of strategies given a budget constraint. The report presents supporting analytical methodologies that address the following questions:

- For a given strategy, how is the economic benefit of injury and fatality reduction related to the cost and level of implementation?
- How is the potential economic benefit of injury and fatality reduction in a jurisdiction related to the overall level of investment in a set of selected strategies?
- What is an optimal level of investment to obtain a jurisdictional goal?
- What are the impacts of varying investment programming options?

Options and tradeoffs related to safety investments also need to be considered in the context where program resources are being allocated to achieve a broad set of transportation objectives. Ideally, safety best-practices are integral to transportation design, construction, operations and maintenance. However there are many situations in which analysis is warranted to assist with both program and project-level tradeoff questions:

- If we allocate more resources to safety projects and programs, what will we gain (in terms of economic benefit of injury and fatality reduction) and what will we give up (benefit related to congestion relief or higher life-cycle costs due to less preservation work)?
- For a specific project being implemented for preservation or congestion relief purposes, should safety-related improvements be built in – for example, should a pavement resurfacing project include widening and paved shoulders, or should the incremental resources needed to do this be invested in resurfacing additional miles?

Decisions Based on Quality Information

The principle of using solid, credible information to make good decisions about resource allocation and strategy selection is fundamental to transportation safety. While the need to improve the collection, accuracy and integration of safety information is widely recognized, information on crashes, their characteristics and causes is routinely collected, analyzed and used to identify emphasis areas for safety programs. Research and analysis on the effectiveness of different types of safety strategies has been ongoing for decades, and this research is used to identify appropriate countermeasures and conduct benefit-cost analysis.

Key sources of national safety data include:

- Fatality Accident Reporting System (FARS) – census of all fatal traffic crashes (NHTSA);

- National Automotive Sampling System – General Estimates System (NASS-GES) – national sample of police-reported crashes (NHTSA);
- Motor Carrier Management Information System (MCMIS) – motor carrier and hazardous material shipper safety performance data, including crash reports (FMCSA); and
- The Highway Safety Information Systems Database (HSIS) – a nine-state database maintained by FHWA with crash records, highway inventory, and traffic volume data used for research and evaluation of countermeasure effectiveness.

New technologies for state and local crash and law enforcement data collection are available to improve the accuracy and efficiency of data collection. The FHWA-sponsored Traffic and Criminal Software package (TrACS) system being distributed by Iowa DOT is an important example.

A number of tools exist for integrating safety with design and engineering, including the Interactive Highway Safety Design Model (IHSDM), which helps highway planners and designers estimate the safety impacts of design decisions, and the Resurfacing Safety Resource Allocation Program (RSRAP), a software tool that optimizes system-wide safety benefits across a program of resurfacing projects within a user-specified budget constraint.

The transportation community is also recognizing the need to apply asset management principles to safety physical assets, such as signs, signals, pavement markings, detectors, impact attenuators, lighting, and guardrails. As a subset of transportation infrastructure, these physical assets should be managed to meet policy goals and objectives most cost-effectively. Research into safety management systems includes the development of inventory and analysis tools for evaluating the tradeoffs between preserving safety assets (e.g., sign repair and pavement markings), operating safety assets (e.g., real-time monitoring of impact attenuators), and expanding safety assets (e.g. provision of guardrails).

Monitoring to Provide Clear Accountability and Feedback

Continuous collection and analysis of crash, injury and fatality data is integral to a performance-based highway safety program. This information is used to track progress towards established targets, and to assess the overall effectiveness of safety programs. At a June 2003 AASHTO Highway Safety Leadership Summit, a new national effort was launched to lower the highway fatality rate by one-third to 1.0 per 100 million VMT by 2008[3]. Monitoring of progress will provide essential feedback along the way.

Monitoring of safety strategy effectiveness also provides important information that can be used to make course corrections in safety programs, document lessons learned and establish best practices to guide future efforts. The Integrated Safety Management Process described in NCHRP Report 501 defines an explicit responsibility for evaluating the

[3] AASHTO – NCHRP Project 17-18, "Lifelines", Volume 1, Number 1, March, 2004,

impacts of safety programs; Appendix D of that report provides examples of impact measures. The NCHRP Report 500 Implementation Guides include evaluation criteria for each safety strategy that can be used to design a monitoring program.

3.0 FHWA Current and Future Safety Activities Related to Asset Management

The purpose of this section is to describe the current safety activities of FHWA that are relevant to asset management, and identify potential activities for the future. Asset management is not a new or separate function, but a set of best practice business principles to be integrated into existing processes. Section 3.1 discusses FHWA Safety initiatives that reflect asset management principles. Section 3.2 describes how the Office of Safety is adopting a new resource allocation process that mirrors the core asset management principles. Finally, Section 3.3 describes potential future activities for asset management and safety.

3.1 Current and Planned Activities

FHWA is already conducting or planning several activities that reflect the asset management principles discussed throughout this paper. The following sections highlight the key safety-related asset management activities in the areas of policy, technical assistance, research, technology deployment, and coordination.

Policy and Regulatory

Safety-Conscious Planning: The 1998 Transportation Equity Act for the 21st Century (TEA-21) explicitly included safety as a planning factor to be considered in development of metropolitan and statewide transportation plans and programs. In response to this legislation, FHWA has been working with its partners to define and support a more proactive approach to safety planning and to integrate safety considerations throughout the transportation planning process.

SAFETEA: The transportation reauthorization bill calls for the establishment of a performance-based highway safety program. This program is intended to provide flexibility to apply funds to where they will be achieve the greatest payoff.

AASHTO Strategic Highway Safety Plan: FHWA has worked in coordination with AASHTO and other partners to support the development and implementation of this comprehensive plan for improving safety.

Vital Few: Safety is one of FHWA's three "Vital Few" areas of focus (the other two are Congestion Mitigation and Environmental Stewardship and Streamlining). FHWA's

stated goal is "to continually improve highway safety by reducing the number of highway fatalities and injuries including large trucks".

USDOT Target: USDOT has established the goal of reducing the national highway fatality rate to 1.0 per 100 million VMT by 2008. FHWA has identified three emphasis areas, each with a specific fatality reduction target – roadway departures, intersections, and pedestrians.

National Intersection Safety Agenda: FHWA has worked in collaboration with partner agencies to develop a national agenda for improving intersection safety.

Technical Assistance and Information Dissemination

FHWA provides technical assistance to its partners and provides information through the Internet, training, and publications. These activities help transportation agencies to develop strategic approaches to safety investments and provide needed information to support decision making.

- Supporting the implementation guidance (NCHRP Reports 500 and 501) for the AASHTO *Strategic Highway Safety Plan*.
- Providing technical assistance to the States in developing strategic plans on safety programs and policy objectives;
- Conducting numerous training sessions and issuing publications on safety procedures, research, best practices, and new technology. There are programs targeted at a variety of safety issues including rail crossings, bicycle/pedestrians, older drivers, work zones, roadside safety, and intersections. These initiatives help provide the quality information and data necessary for states to adopt the performance-based, data-driven approach embodied in the *Strategic Highway Safety Plan* and to identify areas with the greatest opportunities;
- Publicizing a wide range of safety research results and tools, such as the Roadside Safety Analysis Program (RSAP), which is a tool developed under NCHRP Project 22-9 for analyzing the benefits and costs of installing roadside safety devices;
- Developing a compendium of resources for intersection safety improvements; and
- Development of procedures for road safety audits, along with an associated NHI training course and web site with resource materials.

Research & Technology

Research and technology is an important part of FHWA's activities. These activities include studies of safety countermeasure effectiveness, and development of methods and tools for analysis of safety impacts, and benefit-cost analysis to improve resource allocation decisions:

- Development and continued improvements the Interactive Highway Safety Design Model (IHSDM), which is a tool that helps highway planners and designers to estimate

safety impacts of design decisions. IHSDM is the result of a multi-year research effort. It currently provides capabilities for two-lane rural highways, and can be used to analyze designs for new construction and improvement of existing roadways.

- Support for development (through NCHRP) of the Resurfacing Safety Resource Allocation Program (RSRAP) tool, which can be used to evaluate trade-offs between options of resurfacing roads with or without safety improvements.
- Research on intersection safety in support of FHWA's "Vital Few" safety objectives. Specific activities include developing crash avoidance systems, evaluating intersection design improvements, evaluation of non-traditional intersections, validating accident models for intersections, developing guidelines for signalized intersections, and development of surrogate safety assessment measures. These activities will help link engineering decisions with safety impacts;
- Research using finite element analysis (FEA). FEA is a tool for highway planners and designers used to develop safer highway guardrails, bridge supports, signposts, and other roadside structure designs. FEA can predict the outcome of a crash test when motor vehicles run-off-the-road and either rollover or are involved in collisions with a roadside object, instead of the real-life costly crash tests typically conducted. FEA is not a replacement for crash testing, but can help designers evaluate multiple designs more quickly and cost-effectively;
- Development of the Digital Highway Measurement (DHM) vehicle which is instrumented to measure roadway geometry, assess pavement condition, and collect high-resolution digital videos of the roadway and its features such as lane markings, signs and guardrails. The instruments are the most accurate, state-of-the-art, off the shelf items currently available. The DHM can collect data while traveling at normal highway speeds. Several states and the Office of Federal Lands Highways have requested an expansion of the initial DHM technologies to include an ability to identify sub-surface assets, such as culverts and conduits. Safety R&D is looking into ground penetrating radar as a possible means to accomplish this need.
- Sponsorship of TrACS data collection technology – FHWA worked with Iowa DOT to develop and demonstrate a National Model for Technology in Highway Safety and Law Enforcement. This effort has produced the Traffic and Criminal Software package (TrACS), an automated data collection and reporting system for crashes and citations. TrACS is now being used in 22 states.
- FHWA is developing SafetyAnalyst in cooperation with thirteen state highway agencies. SafetyAnalyst is a set of software tools to assist state and local highway agencies in making decisions on where to make safety improvements on the existing highway network, and what safety improvements to make. It can also be used to evaluate safety improvements that have been implemented. The tools incorporate state-of-the-art approaches to safety management. They will address site-specific highway safety improvements involving physical modifications of the highway system – they are not designed to address driver or vehicle-related safety programs.
- Participation in the proposed AASHTO Transportation Safety Information Management Systems (TSIMS) project to develop a software package that links existing

safety-related data at the state DOT level, including crash records, Geographic Information Systems (GIS), driver and vehicle registrations, roadway inventory data, and commercial vehicle databases. TSIMS will also include analysis and reporting tools;

- Studies on the relationship between human factors and safety to understand drivers' capabilities and limitations, for example, research on nighttime driving, aging drivers, roadway lighting, and sign reflectivity;
- Participation in an AASHTO study on integrated Roadway Hardware and Safety Management Systems to build inventory and condition databases. The effort is focused on seven areas of hardware or safety features that are either "on" the roadway (pavement markings), "in" the roadway (loop detectors), or on the roadside (guardrail); and
- Continued support of the AASHTO *Strategic Highway Safety Plan* (SHSP) and NCHRP Reports 322, 500, and 501, as well as continued support of SHSP implementation and the evaluation of best practices included in the Guides.

The Office of Safety R&D has lead on research, development or coordination of many of the above topics.

Coordination

FHWA safety activities involve joint efforts across multiple offices to ensure a consistent, coordinated approach. Examples include:

- The Safety Conscious Planning effort (coordinated between the Office of Planning, Environment, and Realty and the Office of Safety);
- Collaboration between the Office of Safety, Office of Operations, and Office of Infrastructure on work zone safety efforts.
- Ongoing coordination and communication between the Office of Safety and the Office of Operations for issues and technologies related to intelligent transportation systems (ITS). ITS technologies, both in the vehicle and embedded in roadway infrastructure, could potentially have significant safety benefits.
- Updates to the Manual on Uniform Traffic Control Devices (MUTCD) is a joint effort between the Office of Safety and the Office of Operations. Since many safety activities are interrelated with operations activities, adopting an asset management approach will require continued close coordination between these two offices.
- Working with the Office of Operations, Office of Safety R&D, and Chief Council's office to develop retroreflectivity standards for signs and pavement markings.
- The Roadway Hardware and Safety Management Systems project described above is a joint effort with the Office of Safety R&D, Office of Asset Management, Office of Safety, Office of Operations, and AASHTO. The seven areas of hardware and safety features under investigation affect both safety and operations.

3.2 Implementation of Asset Management Principles at the FHWA Office of Safety

The FHWA Office of Safety has begun implementing the performance-based approach, as reflected by asset management principles, in their own internal resource allocation process. Unlike a state DOT, the primary resources to be allocated at the FHWA Office of Safety are staff and program dollars, instead of capital and maintenance expenditures. This section describes how the current activities of the Office of Safety relate to each of the core principles of asset management.

Policy-Driven

The FHWA Office of Safety is initiating strategies driven by five guiding principles for the office. They are, briefly:

- **Serve as a strong voice for safety.** The Office of Safety will provide leadership and advocacy to increase the prominence of safety within the overall framework of Federal-aid decision-making.
- **Leverage resources.** The Office of Safety will maximize its resources by planning strategically and working with other agencies, states, and industry.
- **Focus on high payoff areas.** The Office of Safety will target its strategies and resources using data driven decision-making.
- **Assure both short-term and long-term accomplishments.** The Office of Safety will structure its programs to assure both short-term and long-term success.
- **Support strategic planning efforts of all states.** The Office of Safety will encourage, facilitate, and support strategic planning efforts of all states.

Performance-Based

The U.S. DOT's goal is to reduce fatalities to 1.0 per 100 million VMT by 2008. FHWA's goals are by 2007 to reduce fatalities by 10% for roadway departure, intersection, and pedestrian crashes. The performance-based approach is shifting the Office of Safety activities from a first-come, first-served policy to concentrating resources on where the safety impacts are likely to be greatest, and then make merit-based investments in programs and projects regardless of ownership or functional classification of the facility.

Analysis of Options and Tradeoffs

The primary resources to be allocated at the Office of Safety are staff and program dollars. The purpose of analyzing options and tradeoffs is to evaluate the relative benefits and costs of investments among the different program areas. In a document titled "Linking

Key Process Information to Strategic Planning," the Office of Safety has identified its key processes and subprocesses as investment categories. These are:

- National Policy Leadership
  - Program Leadership
  - Issuance of Policy Guidance
  - Reauthorization Rollout (issue guidance, develop program elements)
  - Rulemaking
  - Legislative Issues/Congressional Inquiries (clarification of policy, positions)
  - Regulatory Approvals
- Technical Assistance
  - Training
  - National expertise (overall technical guidance)
  - Resource Center Safety Technical Service Team
- Technology Deployment
  - Marketing of Safety Products
  - Rollout of NCHRP Guide 500 Series
  - Web Site Management
- Program Delivery
  - Contract Management
  - Funding Administration
  - Support of Research, Development, and Technology projects
  - New Programs Development
  - Communications and Outreach
- Administration
  - Personnel (Performance, Awards, Training)
  - Document Management (correspondence, files, Freedom of Information Act requests, etc.)
  - Suspense Items
  - Time and Attendance
  - Travel
  - GOE Management
  - Quality Journey Activities

Besides tradeoffs among the investment categories listed above, the Office of Safety and the Office of Safety RD&T direct and analyze the investment of FHWA safety research resources. Initially, 17 research areas were identified in a plan for investment. These have been reduced to 4 high-impact areas. The goal is to invest research dollars most productively on areas with problems and gaps with the greatest payoffs.

Decisions Based on Quality Information

All staff has reported expenses and time projections, mapped against each of the Office of Safety processes defined above. This data is helping the Office of Safety understand current resource allocation, in order to assess whether the FHWA safety goal can be achieved given the distribution of resources and identify changes in the resource allocation. The current resource allocation can also be compared to the guiding principles to see if resources are allocated appropriately to meet agency and office goals.

Monitoring to Provide Clear Accountability and Feedback

The Office of Safety works with other agencies to collect data on safety performance measures (e.g., National Highway Traffic Safety Administration, state DOTs) to assess whether the U.S DOT is on track to meeting its 1.0 by 2008 safety goal, and whether FHWA is meeting its goals for the "Vital Few" safety area. In addition, the staff reporting of expenses and hours, matched against the processes outlined above, provides accountability for whether resources are actually spent as planned.

The Office of Safety recently volunteered to serve as the Headquarters pilot office for Managerial Cost Accounting. This effort is expected to allow HSA to further refine and formalize the process of tracking expenditures against achievement of safety goals and objectives.

3.3 Future Activities

Building on the activities that are already underway, the Office of Safety will be taking a number of actions to further strengthen safety through the application of asset management principles, including:

- Communicate the performance-based approach to safety goals and programs through training, publications, and other outreach efforts. Increase awareness and implementation of the AASHTO *Strategic Highway Safety Plan* and implementation guides (NCHRP Reports 500 and 501). As a first step, help states commit to safety policy goals through publication of best practices, technical assistance with the SHSP and implementation guidance, and peer exchange. Demonstrating the measurable benefits from safety programs has significant value in building acceptance of the asset management approach.

- Use asset management principles to increase focus and accountability for safety with decision makers. Relate results to actions using analytic capabilities available today to estimate impacts of safety programs and demonstrate predicted benefits of safety investments.
- Promote more integrated decision-making by emphasizing safety objectives throughout the entire cycle of transportation planning. Continue working with the Office of Planning, Environment, and Realty to integrate safety considerations into transportation planning, programming, and project delivery.
- Continue support for the development and refinement of analytical tools such as IHSDM and RSRAP to improve the consideration of safety in the planning, programming and design of preservation, operations, and capacity expansion activities.
- Continue working with AASHTO and other organizations on the development of information systems improvements in support of safety management, including TSIMS, new processes to more accurately collect, locate and analyze crash data and the Roadway Hardware and Safety Management Systems projects.

FHWA White Paper:
Environment and Asset Management

The purpose of this paper is to define the relationship between transportation asset management and transportation system planning and to describe the current, and potential future, activities of the FHWA's two Environment Offices that support the implementation of asset management. The paper is one of a set of seven papers exploring the relationship of asset management to each of FHWA's major program areas including planning, right-of-way, environment, infrastructure, safety, operations, and Federal lands.

Section 1.0 provides a general overview of asset management relevant to all program areas. Section 2.0 defines the relationship between planning and asset management. Section 3.0 describes current, and potential future, activities of the Office of Project Development and Environmental Review that support asset management.

1.0 Overview of Transportation Asset Management

1.1 Definition of Asset Management

Transportation asset management is a set of guiding principles and best practice methods for making informed transportation resource allocation decisions, and improving accountability for these decisions. The term "resource allocation" covers not only allocation of money to program areas, projects, and activities but also covers deployment of other resources that add value (staff, equipment, materials, information, real estate, etc.). While several of these principles and practices were initially developed and applied within the domain of infrastructure preservation, most established definitions of asset management are considerably broader. The **Asset Management Guide**,[1] recently adopted by AASHTO defines asset management as:

[1] *Transportation Asset Management Guide*, prepared for the National Cooperative Highway Research Program (NCHRP) Project 20-24(11) by Cambridge Systematics, Inc. with Parsons Brinckerhoff Quade & Douglas, Inc., Roy Jorgensen Associates, Inc. and Paul D. Thompson, November 2002, AASHTO Publication RP-TAMG-1.

> *"… a strategic approach to managing transportation infrastructure. It focuses on…business processes for resource allocation and utilization with the objective of better decision-making based upon quality information and well-defined objectives."*

As Mary Peters, FHWA Administrator has frequently put it:

> *"If I have one additional dollar to spend on the transportation system, what is the most effective way to spend it?"*

The essence of asset management is answering that question.

Asset management is concerned with the entire life cycle of transportation decisions, including planning, programming, construction, maintenance, and operations. It emphasizes integration across these functions, reinforcing the fact that actions taken across this life cycle are interrelated. It also recognizes that investments in transportation assets must be made considering a broad set of objectives, including physical preservation, congestion relief, safety, security, economic productivity, and environmental stewardship.

1.2 Asset Management Principles

The core principles of asset management are:

- **Policy-Driven –** Resource allocation decisions are based on a well-defined and explicitly stated set of policy goals and objectives. These objectives reflect desired system condition, level of service, and safety provided to customers, and typically are tied to economic, community and environmental goals as well;

- **Performance-Based –** Policy objectives are translated into system performance measures that are used for both day-to-day and strategic management;

- **Analysis of Options and Tradeoffs –** Decisions on how to allocate resources within and across different types of investments (e.g., preventive maintenance, rehabilitation, pavements, bridges, capacity expansion, operations, different modal mixes, safety, etc.) are based on an analysis of how different allocations will impact achievement of relevant policy objectives. Alternative methods for achieving a desired set of objectives are examined and evaluated. These options are not constrained by established organizational unit boundaries – for example solving a congestion problem could involve a capacity expansion or an operational improvement (e.g., signal coordination). The best method is selected considering the cost (both initial and long-term) and likely impacts on established performance measures. The limitations posed by realistic funding constraints must be reflected in the range of options and tradeoffs considered;

- **Decisions Based on Quality Information –** The merits of different options with respect to an agency's policy goals are evaluated using credible and current data.

These data may apply to specific functions (e.g., pavement and bridge management, traffic monitoring) or reflect a more integrated, corporate view. [2] Where appropriate, decision support tools are used to provide easy access to needed information, to assist with performance tracking and predictions, and to perform specialized analysis (e.g., optimization, real-time simulation, scenario analysis, life-cycle cost analysis, benefit/cost analysis); and

- **Monitoring to Provide Clear Accountability and Feedback –** Performance results are monitored and reported for both impacts and effectiveness. Feedback on actual performance may influence agency goals and objectives, as well as resource allocation and utilization decisions.

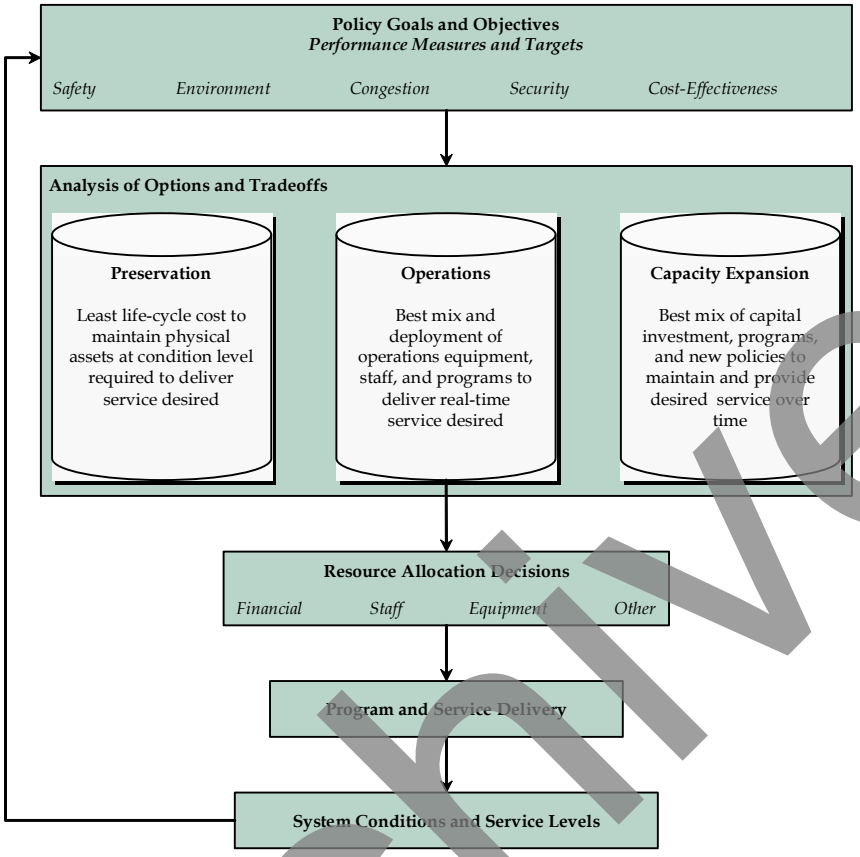
These principles are not unfamiliar, nor are they radical. Most transportation practitioners would agree that investment decisions should be based on weighing costs against likely outcomes, that a variety of options should be considered and evaluated, and that quality information is needed for decision-making. Many agencies are now pursuing performance-based approaches to planning and programming, monitoring system performance, and developing more integrated data and analysis tools to evaluate tradeoffs among capital expansion, operations, and preservation activities. Most agencies recognize that application of asset management principles is critical in times of constrained resources, when all investment and budget decisions are subject to increased public scrutiny.

1.3 Asset Management Practice

Figure 1 illustrates the strategic resource allocation process that embodies the asset management principles presented above.

[2] The FHWA plays a key role in standardizing the content and format of data that are mandated by federal law: e.g., the National Bridge Inventory (NBI) data that are reported by state DOTs.

Figure 1. Strategic Resource Allocation Process



The diagram includes the following elements:

- **Policy Goals and Objectives**, supported by performance measures are established through the policy and system planning process and used to guide the overall resource allocation process.

- **Analysis of Options and Tradeoffs** includes examination of options *within* each investment area, as well as tradeoffs *across* different investment areas. The definition of investment areas is flexible and can be tailored to how an individual agency does business. For example, an agency may have a separate safety investment area and also incorporate consideration of safety within system preservation, operations, and capacity expansion expenditures. Each option and tradeoff is evaluated with respect to established agency goals and performance objectives.

- **Resource Allocation Decisions** are based on the results of tradeoff analyses These decisions involve allocations of financial, staff, equipment, and other resources to the different investment areas and/or to different strategies, programs, projects, or asset classes within an individual investment area.

- **Program and Service Delivery** is accomplished in the most cost-effective manner which again involves consideration of different delivery options (e.g., use of contractors, interagency agreements), as well as a delivery tracking process involving recording of actions taken, costs, effectiveness, and lessons learned to guide future activity.

- **System Conditions and Service Levels** are tracked to see the extent to which established performance objectives are being addressed. This information is used to refine policy goals and priorities (e.g., put more emphasis on safety in response to an increase in crash rates).

1.4 Transportation Investment Categories

In Figure 1, the box labeled "Analysis of Options and Tradeoffs" shows three types of investment categories – preservation, operations, and capacity expansion. These are defined as follows:

1. **Preservation** encompasses work to extend the life of existing facilities (and associated hardware and equipment), or to repair damage that impedes mobility or safety. The purpose of system preservation is to retain the existing value of an asset and its ability to perform as designed. System preservation counters the wear and tear of physical infrastructure that occurs over time due to traffic loading, climate, crashes, and aging. It is accomplished through both capital projects and maintenance actions.

2. **Operations** focuses on the real-time service and operational efficiency provided by the transportation system for both people and freight movement on a day-to-day basis. Examples of operations actions include real-time traffic surveillance, monitoring, control, and response; intelligent transportation systems (ITS); signal phasing and real-time signal controllers at intersections; HOV lane monitoring and control; ramp metering; weigh-in-motion; road weather management; and traveler information systems. Although operations focuses on system management, the infrastructure needed to provide this capability may be substantial (e.g., traffic control centers; ITS hardware; environmental sensors and fire control systems in tunnels). Thus, an operations strategy requires capital and operating budget as well as substantial staff resources.

3. **Capacity expansion** focuses on the actions needed to expand the service provided by the existing system for both people and freight. Capacity expansion can be achieved either by adding physical capacity to an existing asset, or acquiring/constructing a new facility.

These three categories are defined in order to show that:

- Asset management is not just about preservation of highway network assets; it is about making investment decisions that address a wide range of policy goals.

- The three categories provide a simple, useful way for decision-makers to align program investment categories and priorities with key policy objectives. For example, many agencies establish a "preservation first" policy or favor maximizing efficiency of operations prior to investing in new capacity.

- The categories may present alternative ways of meeting a policy goal. For example, it may be appropriate to consider operational improvements to address a congestion problem as an alternative to adding a new lane.

- Decisions about the resources allocated to each category cannot be made independently. Meeting many policy goals (e.g., safety) may require a mix of investments across these categories. Similarly, an increase in capacity expansion investments may require increased operations and preservation expenditures at some point in time.

As noted above, tradeoff analysis may be done across *investment categories* as well as within them. An agency might wish to define investment areas coincident with the three categories discussed above (preservation, operations, capacity), or they may define a different set of categories. For example, a safety program could be defined as an investment category, with subareas for operational activities (e.g., signs, markings, signalization, channelization, etc.), preservation (replacement of guardrails), and capacity (project design features supporting safety, e.g., wide shoulders). This would provide the framework for understanding the best mix of complementary actions within the safety area as well as tradeoffs between safety and other objectives.

1.5 Asset Management and the Transportation Planning Process

A common reaction to the broad description of asset management is "how is this different from the overall planning and programming process in an agency?" The response is that asset management is not a new kind of business process that replaces planning and programming. Rather, it should be viewed as a set of best practices to be employed within the established planning and programming framework. Existing regulations pertaining to the planning process, together with statutes related to specific funding programs and their allocation criteria, and the body of environmental regulations affecting transportation planning – provide the context within which asset management practice occurs. In terms of Figure 1, transportation regulations and statutes impact establishment of policy objectives, the manner in which options are generated and evaluated, and they also provide certain constraints on resource allocation (based on Federal and state funding eligibility restrictions). Many of the core principles of asset management are embodied in the existing planning regulations (e.g., consideration of

alternatives). Examining the planning process using the lens of asset management provides an opportunity to explore ways to continue to strengthen the mission of transportation planning – for example:

- How to improve connections between long-range planning and resource allocation;
- How to strengthen agency and public consideration of preservation and operations investments within the long-range planning process;
- How to better integrate environmental considerations throughout the transportation planning and decision-making process – across capacity, operational and preservation investments; and
- How to provide a common information resource base to serve multiple activities across the transportation asset life cycle – long-range planning, corridor studies, safety studies, environmental assessments, multi-year capital programming, project development, preventive maintenance and system operations.

While asset management is closely associated with planning and programming activities, asset management best practices are also integral to design, construction, routine and preventive maintenance and operations activities. For example:

- Application of life-cycle cost analysis in the facility design process;
- Analysis of alternative construction materials and methods;
- Tradeoffs across different maintenance activities based on level of service and extended facility life provided to customers;
- Developing an appropriate mix of operations expenditures on technology upgrades, hardware/infrastructure maintenance and replacement, and skilled personnel;
- Evaluation of delivery options (e.g., design-build, use of private contractors for maintenance and operations, inter-agency agreements, etc.).

1.6 Key Opportunities

Despite the support for taking an asset management approach, many agencies face very real organizational, institutional, and technical challenges to making further progress in asset management. Each one of these challenges represents a potential opportunity for FHWA to work with its partners to encourage broader implementation of asset management principles. For example:

- Top management needs to set an organization-wide direction and framework for decision-making and to ensure that all parts of the organization are working together in a coordinated fashion. Maintaining continuity in leadership direction and

understanding of key asset management principles can be particularly challenging with frequent turnover in agency executives;

- Clear roles for each organizational unit must be established to solve common problems or meet common objectives. Differences in perspectives and approaches, lack of established procedures, or turf battles must be reconciled;

- Established resource allocation methods, often constrained by externally imposed restrictions, historical allocations or formulas, or delicate and difficult political negotiations may restrict the range of options and tradeoffs that can be considered;

- Staff resource constraints together with a constant "fire-fighting" mode of operation also may restrict the amount of time and effort that can be spent on analyzing options;

- Developing a comprehensive set of reliable methods, data and tools to evaluate performance tradeoffs among the full set of investment options will take a sustained, multi-year effort;

- Establishing a causal link between an investment or action and a performance indicator of interest, due to the presence of external factors influencing performance (e.g., gas prices, vehicle fleet changes, growth patterns, etc.) may require additional research in some cases;

- Coordination among multiple agencies to achieve established objectives in areas such as operations and safety adds complexity to the decision-making process and program implementation efforts; and

- External and internal agency culture based on "bottom-up" decision-making, with a focus on specific projects rather than on broader system performance and outcomes.

While it is relatively straightforward to implement asset management within a well-defined area of the agency (a pavement management unit, for example), the issues identified above illustrate why it is much more challenging to implement it more fully within an agency, or across multiple agencies.

However, the need to allocate scarce resources as effectively as possible and demonstrate results and performance to the customers of the transportation system provides strong motivation and support for overcoming these challenges. A comprehensive, performance-based approach to transportation investment decisions will be essential to meeting the increasingly complex set of transportation needs of the 21st century.

2.0 Environment and Transportation Asset Management

The purpose of this section is to define the relationship between environmental activities and asset management. It is written from the perspective of an operating agency (e.g. State DOT).

2.1 Overview of Environment Activities

Environmental concerns thread through the full cycle of the transportation planning and delivery process. Most agencies find that environmental considerations are taking on increasing importance to their ability to fulfill their transportation mission. This is reflected in the range of regulatory requirements related to environmental protection at both the planning and project level, as well as in the increasing attention of the public to the potential environmental implications of transportation activities. The variety of concerns is broad, ranging from the effects of transportation projects on the preservation of individual species and the viability of ecosystems, to concerns about the most appropriate and "community-friendly" design of transportation facilities, to concerns about the relationship between transportation infrastructure, air quality, and public health.

To address this growing list of environmental issues, State DOTs and other transportation agencies are involved in a range of environmental activities. These may typically include:

- Air quality conformity;
- Meeting NEPA requirements, including preparation of environmental impact statements;
- Ensuring compliance with state and federal environmental regulations related to water quality, wetlands protection, endangered species, species habitat, historic preservation, noise, community impacts, and other environmental factors;
- Preparation and implementation of environmental mitigation plans;
- Public participation, outreach, and communication;
- Development of environmental policies, procedures, and commitments;
- Establishment and monitoring of environmental performance measures;
- Participation in coastal zone management, watershed, and landscape-scale protection planning and mitigation;
- Coordination with MPOs and regional air quality agencies to integrate air quality plans and transportation plans;

- Coordination with partners and resource agencies to develop and implement programmatic agreements to meet environmental requirements;
- Development and implementation of environmental management systems; and
- Data collection, management and analysis.

The principles of asset management discussed in Section 1.0 readily apply to most of these activities, as evidenced by the efforts of many state DOTs to more systematically integrate environmental concerns throughout the transportation decision-making process.

2.2 Relationship to Transportation Investment Areas

Environmental protection and stewardship are major considerations in evaluating each area of transportation investment. Understanding and incorporating the projected costs and benefits of environmental activities is essential not only to assess the relative value of different environmental strategies, but, more broadly, for an agency to accurately weigh tradeoffs across investment approaches. Included in this analysis should be consideration of costs avoided through effective environmental strategies that reduce fines or delays, and reduce the risk of costlier future mitigation requirements.

Preservation

- An accurate assessment of the investment levels required to repair and maintain existing infrastructure needs to include costs to meet environmental requirements, including permits, testing, and mitigation / restoration expenses.
- The tradeoffs between maintenance activities and environmental impacts need to be assessed. For example, the frequency of bridge painting or the selection of maintenance materials will each affect the cost, durability, and frequency of maintenance activity; total long-term maintenance costs, including level of agency resources invested in labor; and type and degree of environmental impacts requiring mitigation.
- Prospective preservation projects may provide agencies with opportunities for cost-effectively meeting long-range program or project-level environmental commitments or enhancing environmental stewardship through the implementation of environmental best practices. For example, bridge retrofits to improve fish passage or construction of wildlife crossing passages may be incorporated into routine highway improvement projects at low cost.

Operations

- Operations and management activities can support or hamper environmental goals. For example, use of surface treatment chemicals to manage snow and ice affects the quality of water runoff; choices for roadside vegetation can promote invasive species

or – in contrast – promote the restoration of critical habitat; appropriate use of lighting and signalization techniques can reduce road kill and improve safety conditions.

- Operations strategies may represent cost-effective options to support air quality improvements. For example, signalization improvements to optimize traffic flow reduce emissions from idling vehicles.

Capacity Expansion

- The cost and feasibility of capacity expansion projects are affected by environmental stewardship goals, environmental impacts and design requirements. Understanding upfront the environmental conditions of possible sites for capacity expansion – which may include challenges for environmental protection and compliance, good opportunities to meet regional environmental stewardship goals, or both – is essential to accurately assess the true potential of expansion alternatives.
- Once specific projects are selected, decisions about how to implement expansion plans - including decisions about construction procedures, materials, and timing – also have varying environmental effects that need to be assessed.

2.3 Application of Asset Management Principles to Environmental Activities

The principles of asset management are consistent with the best practices developed by transportation agencies to integrate environmental considerations into each phase of transportation planning and project development.

Policy Driven

Transportation agencies are working to move beyond a project-level regulatory focus to establish clear environmental policies and set environmental goals and objectives for their transportation program as a whole. These policies are developed within the context of their primary mission to provide safe and reliable transportation infrastructure and services that ensure personal mobility and economic growth for their state or region. The environmental policies set by transportation agencies are influenced by a range of factors, including the regulations and guidance of resource agencies, public expectations for environmental protection, and specific environmental stresses that are of particular concern in individual regions. The move to establish a larger ***policy-driven*** framework is enabling agencies to improve their environmental stewardship, gain credibility with resource agency partners and the general public, and realize efficiencies in meeting their environmental responsibilities.

Performance-Based

Specific performance measures need to be identified for each policy goal and objective in order to define how progress in meeting these objectives is going to be determined and

monitored over time. Setting appropriate performance measures for environment is a complicated matter for transportation agencies, because the ultimate environmental outcomes in a location or region are generally the result of a myriad of factors, only some of which are under the agency's control. Air pollution levels, for example, are the combined result of emissions from transportation vehicles, off-road agricultural and construction vehicles, and stationary sources, as well as how these combined emissions are affected by atmospheric conditions, terrain, and climate.

Nonetheless, agencies have developed a wide range of performance measures to track their progress in meeting their environmental goals and objectives at each phase of the transportation process. These include efficiency measures for managing environmental processes, output measures to target and track levels of program activity, and outcome measures that gauge progress in environmental improvements.

As an integral part of the long-range transportation planning process, performance measures are used to assess the environmental efficacy of investment alternatives for transportation projects. Secondly, performance measures are used to evaluate the relative effectiveness and efficiency of different environmental strategies as options to meet environmental objectives, such as reducing air pollutant emissions, improving storm run-off, or improving habitat. Performance measures are also used to track and assess process efficiencies, such as the time taken to complete environmental impact statements or conduct reviews.

The definition of clear measures enables agencies to analyze options and tradeoffs in terms of total costs, environmental benefits, transportation benefits, and process efficiencies.

Decisions based on merit and quality information

A number of State agencies are working in different ways to improve the quality and accessibility of data and other information needed to support sound decisions involving environmental factors. Decisions with environmental aspects are required at each stage of the transportation process – from long-range planning to operations and maintenance. During each phase, transportation managers need to incorporate a broad range of information and considerations, including observed data, model outputs, regulatory requirements from multiple Federal and state resource agencies, input from partners and stakeholders, public commitments, engineering and design requirements, and budget constraints.

At both the project and planning levels, efforts to optimize environmental results of transportation decisions are constrained by the quality and sufficiency of ecological data available, and by the extent to which transportation staff are able to integrate this data with other relevant information to weigh transportation options.

Agencies are becoming increasingly sophisticated in their collection and use of environmental data to inform transportation decisions. The availability of GIS and other

tools to analyze and present complex data has enabled agencies to better assess the implications of transportation choices at the systems level – both in terms of environmental impacts and mobility impacts. This trend has required increased coordination with those organizations with primary responsibility for collecting environmental data, including Federal and State resource agencies. This enhanced level of cooperation requires that agencies develop effective mechanisms for sharing data, integrating and analyzing multiple sources of data, developing clear criteria for evaluating alternatives, providing input, drafting agreements, and tracking results.

Quality data for decision-making includes reliable information about the relative costs of implementing alternative environmental strategies. Cost is a critical matrix for transportation agencies in electing to implement specific environmental activities. An accurate analysis of costs needs to consider the direct costs or savings related to specific alternatives, as well as the indirect financial impact to a project or an overall program that can result from project delays and revisions.

More difficult to measure quantitatively is the financial effect of the development of solid and trusting working relationships with regulatory agencies, environmental advocates, and partners. Across all three investment areas, effective working relationships can enable transportation agencies to more efficiently carry out their mission, saving time and resources.

Monitoring and Feedback

The application of the good management principles cited above presumes a system of ongoing monitoring and feedback to provide timely and relevant information that can inform management decisions. Setting performance measures, for example, is only useful if they are then used as part of an ongoing process of program and project evaluation that feeds future improvements or program redirection. Effective monitoring and feedback requires clear and standardized processes for program and project review, collection of information, and analysis of results.

Many transportation agencies are developing new, computer-supported systems to help manage environmental information including monitoring and feedback of relevant data. These *environmental information management and decision support* tools address a variety of planning and management needs, depending on the priorities of each agency. For example, some states have developed systems to track environmental policies and commitments; others to mange public review and comment processes; others to monitor maintenance and operations environmental activities; and still others to facilitate watershed-level planning and coordination with resource agencies. The range of activity in environmental management systems is indicative of the attention many agencies are giving to the integration of environmental objectives and activities into their core business processes.

3.0 FHWA Environment Offices - Current and Future Activities Related to Asset Management

FHWA has identified environment as an agency-wide strategic goal, and "Environmental Stewardship and Streamlining" is one of its three Vital Few priorities. Through its strategic plan and its 2003 Performance Plan, the agency has defined National Strategic and Performance Objectives to support this priority goal, and has developed specific, quantitative performance measures to be used to gauge its progress in meeting these objectives. These goals and performance measures address both improvements in environmental quality (e.g. expanded ecosystem preservation, reductions in mobile source pollution emissions) and improvements in the efficiency with which transportation agencies fulfill their environmental commitments.

Two offices within FHWA's Office of Planning, Environment and Realty hold primary responsibility for coordinating the Agency's environmental work. They are the Office of Natural and Human Environment and the Office of Project Development and Environmental Review. This section provides a summary of the roles and responsibilities of these offices as they relate to asset management, and identifies potential additional opportunities for the future.

The Office of Natural and Human Environment primarily focuses on environmental programs associated with air quality, noise, and water quality, and on programs associated with the built environment, including transportation enhancements, bicycle and pedestrian facilities and scenic byways. This office is organized into five teams that address different environmental concerns related to transportation:

- Air Quality;
- Transportation Conformity;
- Noise;
- Water and Ecosystems; and
- Scenic Byways, Bike-Pedestrian, Trails and Enhancements.

The Office of Project Development and Environmental Review provides policy development, support and technical assistance related to the NEPA project development process. This office has three teams:

- Project Development Team;
- Program/Policy Development Team; and
- Training, Technology & Technical Assistance Team.

Working closely with FHWA Division offices, the teams from both Offices provide guidance and technical support to state DOTs, MPOs, and other state and local agencies; support policy development and coordination with other Federal agencies; and conduct research to build knowledge and tools related to environmental issues.

3.1 Current and Planned Activities

FHWA's environment offices support transportation agencies in achieving compliance with the broad range of Federal environmental regulatory statutes that apply to Federal Aid highway projects, including those under the Clean Air Act, Clean Water Act, Endangered Species Act, National Historic Preservation Act, and NEPA. Beyond meeting regulatory requirements, however, these Offices lead FHWA's work to ensure that highway improvements are delivered in ways that preserve and enhance communities, protect the natural environment, and encourage effective decision-making. This larger commitment requires a proactive program to build knowledge, identify and disseminate effective tools and procedures, and promote innovation and best practices.

Policy and Regulatory

FHWA environment offices support transportation agencies in meeting regulatory requirements under multiple Federal environmental statutes by providing resources, guidance, and technical assistance. Through the various technical teams, FHWA provides guidance related to the eligibility and likely environmental impacts of transportation projects under the Federal Aid program, meeting transportation air quality conformity requirements, complying with NEPA requirements, and meeting the full range of environmental regulations. Due to amended clean air conformity regulations, a current priority is to provide support to State and local partners in newly designated nonattainment areas. The Office of Natural and Human Environment also administers the Congestion Mitigation and Air Quality Improvement Program (CMAQ), which provides funding to State DOTs for projects that reduce emissions.

This broad range of policy and regulatory work requires routine coordination with other Federal agencies. FHWA environment offices work closely with several Federal partners, including the Environmental Protection Agency, the Departments of Interior, Energy, Commerce, and Agriculture, and the U.S. Army Corps of Engineers.

Technical Assistance and Information Dissemination

Both Offices provide a range of technical assistance, research products, and tools to assist transportation agencies in meeting their environmental responsibilities and effectively advancing environmental stewardship goals. The focus of these initiatives is in building agencies' awareness of and ability to implement strategies that will enable them 1) to achieve the best environmental result for their investment, and 2) manage the time and resources required to efficiently meet their environmental obligations. This approach is

consistent with the principles of asset management. A few examples of these initiatives follow.

FHWA has begun an *exemplary ecosystem initiatives* program to identify and publicize best practices in ecosystem and habitat conservation by transportation agencies. Exemplary initiatives may be unique in geographic scope, apply innovative scientific or technological practices, or achieve high environmental results. By supporting and highlighting these successful initiatives, FHWA seeks to encourage the use of more effective environmental strategies by transportation agencies.

To promote improved transportation decision-making that incorporates environmental concerns, FHWA is promoting *integrated, systems level approaches* to multi-modal planning, environmental processes, and project development. This effort, coordinated with FHWA's Offices of Planning and Infrastructure, provides guidance, information and training to States on integrating the planning and environmental processes and on context sensitive solutions / context sensitive design.

FHWA is a leader of the *DOT Center for Climate Change and Environmental Forecasting*. The Center conducts research, policy analysis, and outreach to build knowledge about the relationships between transportation and climate change, increase energy efficiency and reduce greenhouse gas emissions from transportation sources, and develop tools for use by transportation decision-makers and researchers.

FHWA is working with AASHTO's Center for Environmental Excellence to support and provide technical assistance to states to enhance their environmental stewardship through the development and implementation of *environmental management systems, environmental performance measures, and environmental cost accounting*.

To promote effective practices in meeting NEPA requirements and environmental stewardship, FHWA identifies and disseminates *best environmental practices*. These best practices include examples of management of environmental data, techniques to streamline environmental reviews, programmatic agreements, and mitigation strategies. Information about these best practices is promoted in several ways, including through a biannual *Environmental Excellence Awards* program.

To encourage more informed public participation in efforts to improve air quality through sound transportation strategies, FHWA is engaged in *public education initiatives* regarding transportation and air quality, including support of the Alliance for Clean Air and Transportation.

Research & Technology

FHWA's environment offices have undertaken a number of research efforts designed to build knowledge in emerging areas of environmental concern, develop better models and tools to project and assess environmental effects, identify strategies to achieve improved environmental results, and develop decision-support tools to assist transportation

planners and policy makers in integrating environmental issues into transportation decisions. Priorities for FHWA's research are informed by periodic environmental research needs conferences held in conjunction with the Transportation Research Board and involving a range of transportation researchers, practitioners, and environmental advocates.

Current research initiatives include:

- Research and scans to identify and document best transportation practices in ecosystem- and watershed-level management and protection strategies;
- Development of a long-range research plan to assess transportation emissions of particulate matter and air toxics;
- Research to document and summarize the state of scientific knowledge on the health effects of transportation air toxics from mobile sources;
- Study of strategies to reduce air pollution emissions from freight vehicles;
- Research to develop tools for vegetation management/control spread of invasive species;
- Identification of best practices for maintenance related to storm water runoff and tools for prediction of constituents of water quality;
- Research and technical support to develop knowledge and tools for maintenance agencies on handling hazardous materials;
- Research to develop tools for considering habitat connectivity, erosion control, prevention of sediments getting into a stream, analysis of impacts on endangered species, and water quality issues/permitting requirements; and
- Through the DOT Center for Climate Change and Environmental Forecasting, research to examine the relationship between transportation, energy use, and greenhouse gas emissions.

Coordination

Because environmental concerns cut across all transportation activities, coordination of FHWA's environment offices with other offices within FHWA, with other DOT operating administrations, and with Federal partners is particularly important. Examples of this coordination include:

- Coordination with the FHWA Office of Planning regarding air quality conformity and the promotion of integrated transportation decision-making best practices;
- Work with the Office of Operations to develop strategies and tools to ensure that operations techniques are considered in the alternatives analysis process. In addition, work with Operations to encourage use of freight models and information on commodity flows within the NEPA process;

- Work with the Office of Operations and Freight to develop strategies to reduce emissions from trucks;
- Coordination with the FHWA Office of Planning, FTA Office of Planning, and EPA to develop federal policies and guidance regarding new air quality standards and conformity regulations, and guidance regarding land use and air quality;
- Work with the Office of Motor Carriers to develop policies and guidance regarding emissions standards for Mexican trucks coming in to the United States;
- Coordination with Office of Infrastructure on environmental issues related to bridges, highway construction, and maintenance; and
- Coordination and support to Federal Lands on environmental policies and regulations affecting Federal Lands infrastructure and facilities.

3.2 Potential Future Activities

As demonstrated by the range of activities underway, the initiatives of FHWA's Environment Offices are aligned with asset management principles across all transportation functions. Coordination with several other FHWA offices helps to promote this integrated approach. Future activities can build on these efforts by working to more explicitly integrate environmental information, data, and activities into asset management initiatives where they are underway, and by reinforcing the principles of asset management in environmental activities. This two-pronged approach will support FHWA in advancing its Vital Few priority of Environmental Stewardship and Streamlining – enhancing the ability of transportation agencies to meet their transportation goals with enhanced efficiency and improved environmental outcomes.

Potential future focuses could include:

- Support to transportation agencies in integrating environmental data, information, and performance objectives into existing asset management systems (e.g. bridge management programs).
- Research and development on more environmentally-sound technologies, materials, and practices for transportation construction, preservation, and maintenance, including techniques for materials recycling; and on techniques for measuring the costs and performance of these technologies.
- Development and promotion of environmental management systems, decision support tools, and environmental performance measures. Use of research and technology to develop better information and tools to support merit-based decisions. Promotion of expanded data sharing, including application of geospatial tools for data integration and analysis as an environmental management tool.

- Research to develop, test and disseminate information about management techniques to improve environmental performance, streamline environmental activities, and improve cost management, including use of programmatic agreements and advanced mitigation strategies.

- Application of the principles of asset management to environmental assets (e.g. roadside habitat, wetlands and drainage catchment areas, mitigation banks, view sheds, recreational access) to maximize environmental benefits and minimize environmental damage, in cooperation with other owners and managers.

- Increased focus on providing leadership on environmental issues of regional or national scale that may not be fully addressed by individual state DOTs. These may include opportunities to improve national freight movement, large-scale habitat connectivity and ecosystem stewardship, cross-regional pollutant transport, relationship of transportation systems and emissions to public health, and relationships between transportation and climate change.

- Continued development and promotion of interjurisdictional and collaborative project planning and decision-making techniques, including use of "alternative futures" analysis, scenario planning, and consensus building techniques.

- Continued work to integrate environmental metrics with other key measures during the NEPA process, including economic, community, mobility, and safety effects, and analysis of full life-cycle effects of alternatives.

- Continued work to integrate transportation environmental planning with other environmental planning processes, such as coastal zone management planning.

FHWA White Paper:
Right-of-Way and Asset Management

The purpose of this paper is to define the relationship between transportation asset management and transportation system planning and to describe the current, and potential future, activities of the FHWA Office of Real Estate Services (ORES) that support the implementation of asset management. The paper is one of a set of seven papers exploring the relationship of asset management to each of FHWA's major program areas, including planning, right-of-way, environment, infrastructure, safety, operations, and Federal lands.

Section 1.0 provides a general overview of asset management relevant to all program areas. Section 2.0 defines the relationship between planning and asset management. Section 3.0 describes current, and potential future, activities of ORES that support asset management.

1.0 Overview of Transportation Asset Management

1.1 Definition of Asset Management

Transportation asset management is a set of guiding principles and best practice methods for making informed transportation resource allocation decisions, and improving accountability for these decisions. The term "resource allocation" covers not only allocation of money to program areas, projects, and activities but also covers deployment of other resources that add value (staff, equipment, materials, information, real estate, etc.). While several of these principles and practices were initially developed and applied within the domain of infrastructure preservation, most established definitions of asset management are considerably broader. The **Asset Management Guide**,[1] recently adopted by AASHTO defines asset management as:

[1] *Transportation Asset Management Guide*, prepared for the National Cooperative Highway Research Program (NCHRP) Project 20-24(11) by Cambridge Systematics, Inc. with Parsons Brinckerhoff Quade & Douglas, Inc., Roy Jorgensen Associates, Inc. and Paul D. Thompson, November 2002, AASHTO Publication RP-TAMG-1.

> *"… a strategic approach to managing transportation infrastructure. It focuses on…business processes for resource allocation and utilization with the objective of better decision-making based upon quality information and well-defined objectives."*

As Mary Peters, FHWA Administrator has frequently put it:

> *"If I have one additional dollar to spend on the transportation system, what is the most effective way to spend it?"*

The essence of asset management is answering that question.

Asset management is concerned with the entire life cycle of transportation decisions, including planning, programming, construction, maintenance, and operations. It emphasizes integration across these functions, reinforcing the fact that actions taken across this life cycle are interrelated. It also recognizes that investments in transportation assets must be made considering a broad set of objectives, including physical preservation, congestion relief, safety, security, economic productivity, and environmental stewardship.

1.2 Asset Management Principles

The core principles of asset management are:

- **Policy-Driven –** Resource allocation decisions are based on a well-defined and explicitly stated set of policy goals and objectives. These objectives reflect desired system condition, level of service, and safety provided to customers, and typically are tied to economic, community and environmental goals as well.

- **Performance-Based –** Policy objectives are translated into system performance measures that are used for both day-to-day and strategic management.

- **Analysis of Options and Tradeoffs –** Decisions on how to allocate resources within and across different types of investments (e.g., preventive maintenance, rehabilitation, pavements, bridges, capacity expansion, operations, different modal mixes, safety, etc.) are based on an analysis of how different allocations will impact achievement of relevant policy objectives. Alternative methods for achieving a desired set of objectives are examined and evaluated. These options are not constrained by established organizational unit boundaries – for example solving a congestion problem could involve a capacity expansion or an operational improvement (e.g., signal coordination). The best method is selected considering the cost (both initial and long-term) and likely impacts on established performance measures. The limitations posed by realistic funding constraints must be reflected in the range of options and tradeoffs considered.

- **Decisions Based on Quality Information –** The merits of different options with respect to an agency's policy goals are evaluated using credible and current data. These data may apply to specific functions (e.g., pavement and bridge management, traffic monitoring) or reflect a more integrated, corporate view.[2] Where appropriate, decision support tools are used to provide easy access to needed information, to assist with performance tracking and predictions, and to perform specialized analysis (e.g., optimization, real-time simulation, scenario analysis, life-cycle cost analysis, benefit/ cost analysis).

- **Monitoring to Provide Clear Accountability and Feedback –** Performance results are monitored and reported for both impacts and effectiveness. Feedback on actual performance may influence agency goals and objectives, as well as resource allocation and utilization decisions.

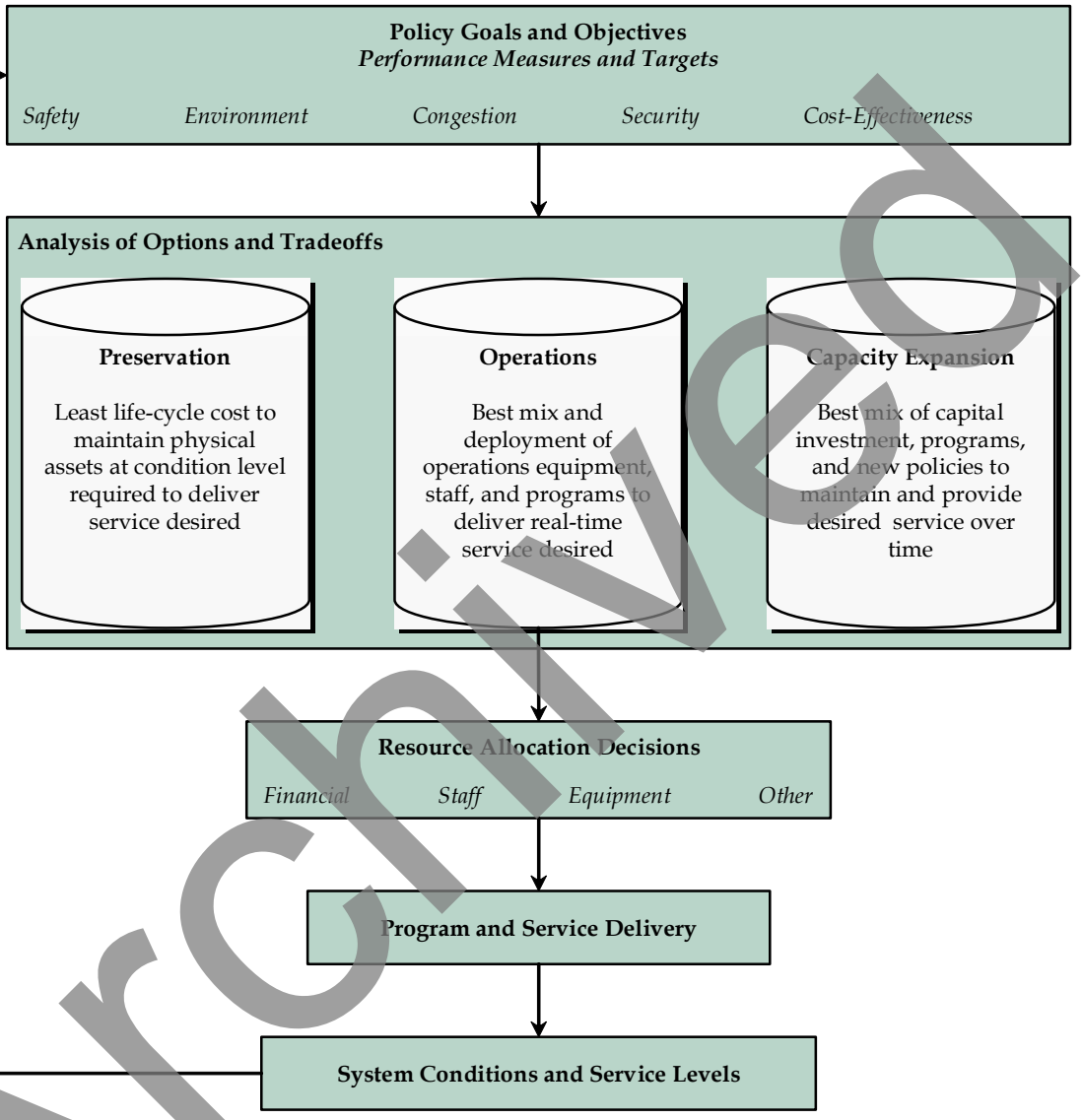
These principles are not unfamiliar, nor are they radical. Most transportation practitioners would agree that investment decisions should be based on weighing costs against likely outcomes, that a variety of options should be considered and evaluated, and that quality information is needed for decision-making. Many agencies are now pursuing performance-based approaches to planning and programming, monitoring system performance, and developing more integrated data and analysis tools to evaluate tradeoffs among capital expansion, operations, and preservation activities. Most agencies recognize that application of asset management principles is critical in times of constrained resources, when all investment and budget decisions are subject to increased public scrutiny.

1.3 Asset Management Practice

Figure 1 illustrates the strategic resource allocation process that embodies the asset management principles presented above.

[2] The FHWA plays a key role in standardizing the content and format of data that are mandated by federal law: e.g., the National Bridge Inventory (NBI) data that are reported by state DOTs.

Figure 1. Strategic Resource Allocation Process



The diagram includes the following elements:

- **Policy Goals and Objectives,** supported by performance measures are established through the policy and system planning process and used to guide the overall resource allocation process.

- **Analysis of Options and Tradeoffs** includes examination of options *within* each investment area, as well as tradeoffs *across* different investment areas. The definition of investment areas is flexible and can be tailored to how an individual agency does business. For example, an agency may have a separate safety investment area and also incorporate consideration of safety within system preservation, operations, and

capacity expansion expenditures. Each option and tradeoff is evaluated with respect to established agency goals and performance objectives.

- **Resource Allocation Decisions** are based on the results of tradeoff analyses These decisions involve allocations of financial, staff, equipment, and other resources to the different investment areas and/or to different strategies, programs, projects, or asset classes within an individual investment area.

- **Program and Service Delivery** is accomplished in the most cost-effective manner which again involves consideration of different delivery options (e.g., use of contractors, interagency agreements), as well as a delivery tracking process involving recording of actions taken, costs, effectiveness, and lessons learned to guide future activity.

- **System Conditions and Service Levels** are tracked to see the extent to which established performance objectives are being addressed. This information is used to refine policy goals and priorities (e.g., put more emphasis on safety in response to an increase in crash rates).

1.4 Transportation Investment Categories

In Figure 1, the box labeled "Analysis of Options and Tradeoffs" shows three types of investment categories – preservation, operations, and capacity expansion. These are defined as follows:

1. **Preservation** encompasses work to extend the life of existing facilities (and associated hardware and equipment), or to repair damage that impedes mobility or safety. The purpose of system preservation is to retain the existing value of an asset and its ability to perform as designed. System preservation counters the wear and tear of physical infrastructure that occurs over time due to traffic loading, climate, crashes, and aging. It is accomplished through both capital projects and maintenance actions.

2. **Operations** focuses on the real-time service and operational efficiency provided by the transportation system for both people and freight movement on a day-to-day basis. Examples of operations actions include real-time traffic surveillance, monitoring, control, and response; intelligent transportation systems (ITS); signal phasing and real-time signal controllers at intersections; HOV-lane monitoring and control; ramp metering; weigh-in-motion; road weather management; and traveler information systems. Although operations focuses on system management, the infrastructure needed to provide this capability may be substantial (e.g., traffic control centers; ITS hardware; environmental sensors and fire control systems in tunnels). Thus, an operations strategy requires capital and operating budget as well as substantial staff resources.

3. **Capacity expansion** focuses on the actions needed to expand the service provided by the existing system for both people and freight. Capacity expansion can be achieved either by adding physical capacity to an existing asset, or acquiring/constructing a new facility.

These three categories are defined in order to show that:

- Asset management is not just about preservation of highway network assets; it is about making investment decisions that address a wide range of policy goals.

- The three categories provide a simple, useful way for decision-makers to align program investment categories and priorities with key policy objectives. For example, many agencies establish a "preservation first" policy or favor maximizing efficiency of operations prior to investing in new capacity.

- The categories may present alternative ways of meeting a policy goal. For example, it may be appropriate to consider operational improvements to address a congestion problem as an alternative to adding a new lane.

- Decisions about the resources allocated to each category cannot be made independently. Meeting many policy goals (e.g., safety) may require a mix of investments across these categories. Similarly, an increase in capacity expansion investments may require increased operations and preservation expenditures at some point in time.

As noted above, tradeoff analysis may be done across *investment categories* as well as within them. An agency might wish to define investment areas coincident with the three categories discussed above (preservation, operations, capacity), or they may define a different set of categories. For example, a safety program could be defined as an investment category, with subareas for operational activities (e.g., signs, markings, signalization, channelization, etc.), preservation (replacement of guardrails), and capacity (project design features supporting safety, e.g., wide shoulders). This would provide the framework for understanding the best mix of complementary actions within the safety area as well as tradeoffs between safety and other objectives.

1.5 Asset Management and the Transportation Planning Process

A common reaction to the broad description of asset management is "how is this different from the overall planning and programming process in an agency?" The response is that asset management is not a new kind of business process that replaces planning and programming. Rather, it should be viewed as a set of best practices to be employed within the established planning and programming framework. Existing regulations pertaining to the planning process, together with statutes related to specific funding programs and their allocation criteria, and the body of environmental regulations affecting transportation planning – provide the context within which asset management practice occurs. In terms of Figure 1, transportation regulations and statutes impact establishment of policy objectives, the manner in which options are generated and evaluated, and they also provide certain constraints on resource allocation (based on Federal and state funding eligibility restrictions). Many of the core principles of asset management are embodied in the existing planning regulations (e.g., consideration of alternatives). Examining the planning process using the lens of asset management provides an opportunity to explore ways to continue to strengthen the mission of transportation planning – for example:

- How to improve connections between long-range planning and resource allocation;
- How to strengthen agency and public consideration of preservation and operations investments within the long-range planning process;
- How to better integrate environmental considerations throughout the transportation planning and decision-making process – across capacity, operational and preservation investments; and
- How to provide a common information resource base to serve multiple activities across the transportation asset life cycle – long-range planning, corridor studies, safety studies, environmental assessments, multi-year capital programming, project development, preventive maintenance and system operations.

While asset management is closely associated with planning and programming activities, asset management best practices also are integral to design, construction, routine and preventive maintenance and operations activities. For example:

- Application of life-cycle cost analysis in the facility design process;
- Analysis of alternative construction materials and methods;
- Tradeoffs across different maintenance activities based on level of service and extended facility life provided to customers;
- Developing an appropriate mix of operations expenditures on technology upgrades, hardware/infrastructure maintenance and replacement, and skilled personnel; and
- Evaluation of delivery options (e.g., design-build, use of private contractors for maintenance and operations, interagency agreements, etc.).

1.6 Key Opportunities

Despite the support for taking an asset management approach, many agencies face very real organizational, institutional, and technical challenges to making further progress in asset management. Each one of these challenges represents a potential opportunity for FHWA to work with its partners to encourage broader implementation of asset management principles. For example:

- Top management needs to set an organization-wide direction and framework for decision-making and to ensure that all parts of the organization are working together in a coordinated fashion. Maintaining continuity in leadership direction and understanding of key asset management principles can be particularly challenging with frequent turnover in agency executives.
- Clear roles for each organizational unit must be established to solve common problems or meet common objectives. Differences in perspectives and approaches, lack of established procedures, or turf battles must be reconciled.

- Established resource allocation methods, often constrained by externally imposed restrictions, historical allocations or formulas, or delicate and difficult political negotiations may restrict the range of options and tradeoffs that can be considered.

- Staff resource constraints together with a constant "fire-fighting" mode of operation also may restrict the amount of time and effort that can be spent on analyzing options.

- Developing a comprehensive set of reliable methods, data and tools to evaluate performance tradeoffs among the full set of investment options will take a sustained, multi-year effort.

- Establishing a causal link between an investment or action and a performance indicator of interest, due to the presence of external factors influencing performance (e.g., gas prices, vehicle fleet changes, growth patterns, etc.) may require additional research in some cases.

- Coordination among multiple agencies to achieve established objectives in areas such as operations and safety adds complexity to the decision-making process and program implementation efforts.

- External and internal agency culture based on "bottom-up" decision-making, with a focus on specific projects rather than on broader system performance and outcomes.

While it is relatively straightforward to implement asset management within a well-defined area of the agency (a pavement management unit, for example), the issues identified above illustrate why it is much more challenging to implement it more fully within an agency, or across multiple agencies.

However, the need to allocate scarce resources as effectively as possible and demonstrate results and performance to the customers of the transportation system provides strong motivation and support for overcoming these challenges. A comprehensive, performance-based approach to transportation investment decisions will be essential to meeting the increasingly complex set of transportation needs of the 21st century.

2.0 Right-of-Way and Transportation Asset Management

This section looks at the relationship between the right-of-way function and asset management. It is written from the perspective of an operating agency (e.g., a state DOT). Management of right-of-way is important for several reasons within the context of asset management:

- In an agency with a substantial highway network, such as a state DOT, the value of right-of-way holdings can easily amount to hundreds of millions, if not billions, of dollars at fair market value of the real estate. The highway network that is under the

jurisdiction of a DOT can be a state government's most valuable single asset, due in large part to the real value of the right-of-way.

- Right-of-way management is itself a major function. Most agencies regard right-of-way acquisition as a significant phase of project development, along with preliminary engineering and construction. Once needed parcels are acquired, agencies assume the responsibility to manage the property, whether it is developed relatively soon as part of a highway project, or it is placed in reserve for future network expansion.

- The availability of right-of-way can enable future projects to take place; conversely, the lack of sufficient right-of-way or the prohibitively high cost of acquiring needed land can constrain further system expansion. The effectiveness of right-of-way management in anticipating and acting upon future needs can therefore directly influence the asset management options that agencies have in meeting future transportation demands.

2.1 Overview of Right-of-Way Activities

An agency's right-of-way activities within an asset management framework include the following:

- Conventional real property management, responsibility for which is typically assigned to a headquarters office unit, including:
  - Acquisition of land for road improvements, including appraisal, title identification, negotiation, takings, and relocation assistance;
  - Right-of-way plan development and maintenance;
  - Property management, including sale or lease of property, negotiation of joint use agreements, and clearing properties for new construction;
  - Permitting and leasing for non-highway uses of right-of way, including utility and telecommunications construction where allowable;
  - Joint development agreements; and
  - Access management, including regulations, negotiation and permitting for access to public roadways.

- Strategic actions include advance acquisition of property, maintaining continuity among the parcels needed for future transportation system expansion, and access management to maintain intended design standards throughout a corridor. These actions more broadly influence the asset management options and decisions for investment that an agency will have in the future.

An asset-management perspective can help to frame the discussion of issues that DOTs and other transportation agencies face in their right-of-way function. For example:

- The availability and cost of real property can influence an agency's future options on the types of transportation solutions that will be available to meet customer demands for travel.

- Mechanisms to fund various right-of-way strategies, such as advance acquisition of real property, need to be evaluated. In so doing, agencies must balance short-term and long-term commitments to right-of-way versus other transportation investment needs. Undertaking near-term investments (as for advance right-of-way acquisition) to preserve long-term options (i.e., having land for future system expansion) may be financially as well as politically difficult.

- The costs to purchase real property and relocate residents and businesses are an important component of project and program costs; procedures and data to estimate these costs accurately and manage them effectively are critical to program asset management.

- Integration of right-of-way functions earlier in the project development cycle are necessary to help identify problems and evaluate options for solution more efficiently and enable better management of project cost and schedule.

Sections 2.2 through 2.4 explore these and other issues and provide suggestions on how the asset-management concepts in Section 1.0 can be applied to improving information flow and decision-making in operating agencies such as state DOTs.

2.2 Relationship to Transportation Investment Areas

Right-of-way historically has been associated with capacity expansion projects and major improvements that require additional land for travel lanes, ramps, interchanges, and structures. It is in this context that the conventional property management activities discussed earlier are most often applied. While the real-estate implications of preservation, maintenance, and operations are typically more limited, they nonetheless must still be considered. The broader perspective encouraged by asset management provides a framework for this more systemwide view of the right-of-way function across preservation, operations, and capacity expansion, as explained in the sections below.

Preservation

Preservation of the right-of-way includes acquisition and retention of adequate real property to facilitate safe and effective highway and roadside maintenance and upkeep, to assure safe and attractive surroundings for transportation facilities, and to protect the environment within the highway facility. This includes acting to keep the right-of-way free from encroachments. Routine maintenance activities such as drainage repairs and upgrades may result in the need for property rights in addition to those acquired for the original construction of the roadway. Adequate control of access to the highway contributes to safety as well as to the preservation and management of roadway capacity. The need to preserve and protect the public investment in the right-of-way dictates careful

management of the sale or lease of property, including careful valuation of the property rights before disposal.

Operations

While the right-of-way function typically is not involved in system operations, traffic operations decisions often may have right-of-way implications, and there may be right-of-way-based approaches to minimize costs and adverse impacts. One operational strategy in which right-of-way can play an important role is in access management. In preserving the operational "character" of existing facilities and corridors, access management helps maintain traffic flow and safety on the existing highway system while accommodating appropriate new development. Situations where the right-of-way unit can make contributions that benefit facility operations include the following:

- Influencing land use and the type and degree of development adjacent to the right-of-way is critical to the success of access management. Knowledge of the character, value, and developmental potential of the property abutting and in the proximity of the right-of-way can inform access management strategies, and an agency's right-of-way unit can assist in providing and interpreting this information.[3]

- New access that would be needed to support an economic development initiative would typically involve negotiations with the developer on matters such as project funding and contributions of property needed for interchanges, access ramps, etc. The right-of-way unit would likely be directly involved in discussions of property transactions, including valuation of joint-use rights, transfers, or swaps as part of such a public-private arrangement.

- Potential impacts of highway operations on abutters – and to what degree they may be compensable – need to be understood and monitored by the state DOT. Mitigation measures may need to be undertaken, such as installation of noise walls, at least to avoid political opposition even if financial compensation is not warranted.[4]

- Where such installations are allowed, the permitting process for the construction or maintenance of utilities and telecommunications lines within the right-of-way may require traffic control plans, which must be evaluated by the right-of-way unit in coordination with traffic operations and safety personnel. For telecommunications installations in Interstate highways, there often is a need to determine the value of the installation rights to support the compensation provisions of the telecommunications use and occupancy agreement.

- Where opportunities exist and where it is compatible with highway integrity and safety, agencies may pursue revenue maximization strategies involving right-of-way

[3] TRB has recently published an Access Management Manual, an initiative promoted by the TRB Committee on Access Management and funded by the FHWA.

[4] Refer to the related discussion in the following section on "Capacity Expansion."

through joint development or leasing of existing highway rights-of-way, and disposal of unneeded parcels. An agency must follow appraisal and valuation guidelines to establish a fair price in each of these situations.

- Traffic control and other operations measures may have impacts on abutting properties. Identifying such impacts and determining whether the impacts are compensable under applicable state and Federal laws and regulations can be an important right-of-way function.

Capacity Expansion

The right-of-way acquisition process is integral to capacity expansion projects.

- The availability and cost of parcels needed for new transportation facilities is a key driver of project cost and scheduling, and can strongly affect the feasibility of project alternatives considered by an agency. In highly developed urban environments, high cost of right-of-way can be a constraint to transportation options available to the agency.

- The timing and impact of land purchases present financial, program management, and political issues. Advance acquisition may enable land purchases of contiguous parcels at advantageous cost, and contribute to effective corridor preservation strategies that reserve land for future system expansion. They also may be perceived, however, to "lock in" decisions on the recommended project and corridor selection before feasibility studies, environmental reviews, and the agency's priority programming procedures have been completed.

- Expansion of transportation system capacity can have considerable community and economic impacts that are related to the value and use of real property. Positive impacts include the generation or expansion of economic activity due to improved accessibility and reduction in travel time and cost, and resulting increases in land values. Potential negative values include reduction in neighborhood cohesion and quality of life, adverse environmental impacts (e.g., increased noise, reduced visual quality), and resulting declines in land values. Interactions between the proposed transportation project and adjoining land use need to be accounted for, and often entail discussions with other jurisdictions. Joint development projects, which involve the transportation agency and a private sector entity, may involve zoning changes that likewise require communication with local jurisdictions. Impacts on residents, businesses, other governmental jurisdictions, and their properties ideally are dealt with throughout the project development cycle, but particularly beginning with project planning and public outreach regarding project alternatives and their potential consequences.

- With respect to the previous point, there is increasing public attention to "secondary impacts" of highway projects: i.e., impacts that do not result in taking of property, but that are perceived to affect its value and quality. Secondary impacts in this context include, for example, noise, loss of access, loss of parking, diversion of traffic, odors and emissions, loss of business profits or goodwill, losses during construction, loss of

views, and loss of visibility. A study performed for the FHWA notes that state courts have generally found that secondary impacts are not compensable. According to this study, actions to forestall claims on secondary impacts that a DOT could employ include better dissemination of information about a project, research studies to assess and quantify these impacts, use of contracting incentives to speed project completion and reduce construction-related claims, use of visuals that show "before" and "after" conditions, and informational meetings and videos.[5]

2.3 Right-of-Way Considerations in the Transportation Facility Life Cycle

Given the close association of right-of-way with major capital projects affecting highway facilities, considerations of right-of-way and asset management can occur throughout the facility life cycle as described below.

Long-Range Planning

Long-range planning is the logical stage at which to evaluate strategic options and trade-offs among possible investments. Right-of-way considerations need to enter these deliberations in several ways:

- Projections of future growth and demographic shifts underlie the forecasts of changing demand for transportation services, and are an important component of long-range planning and of corridor studies. The links between these economic and social changes and land use values identify not only the locations where impacts of growth may be greatest, but also the potential new corridors in which right-of-way may need to be acquired for future system expansion.

- Corridor preservation strategies need to anticipate where areas of future growth will affect demand for highway access on existing facilities. Right-of-way information can provide input for determining the best locations for future highway access to serve this growth.

- Joint development opportunities that are identified at the planning stage can affect right-of-way requirements in several ways: e.g., the width of right-of-way that will be needed to accommodate utility placement or joint transportation development (such as highway and transit) along the length of a corridor; zoning requirements and adjacent land use at specific locations where joint development is proposed; and the dimensions and physical characteristics of right-of-way that may be needed to support development projects. These considerations may influence the locations of proposed

[5] FHWA Office of Real Estate Services, "An Assessment of the Effects of Public Project Acquisitions on Adjacent Business," summary of a study performed for FHWA by Economics Research Associates, October 1996; http://www.fhwa.dot.gov/realestate/adjhwy.htm.

transportation corridors and the costs of right-of-way acquisition (and thus total estimated project cost).

- By establishing a blueprint for future transportation development, long-range planning can guide strategic actions in right-of-way acquisition and disposal. The right-of-way unit can analyze proposed corridors to determine whether existing right-of-way holdings are sufficient to allow future construction to move ahead; gaps in existing holdings that require additional parcels to be acquired for continuity; proposed corridors for which few or no parcels are now held, and where advance acquisition may be a candidate; and parcels that are no longer needed.

Project Development

Project development advances the transportation investment strategies outlined in the long-range plan to consider project options in more detail. Two major analyses that may be conducted at this stage affect right-of-way directly.

- An alternatives analysis considers the relative costs and benefits of different project alignments and potential options in highway design within these alignments. Differences in respective right-of-way costs, including relocation requirements for residences and businesses, mitigation measures, and potential economic and community impacts, are key components of this analysis. Further refinements in alignment or design characteristics may be considered based on preliminary results. All of these options and refinements influence right-of-way requirements for the project, as well as associated costs and impacts to adjacent parcels.

- Environmental reviews consider the impacts of project alternatives on the social and economic conditions in the host community, air and water quality, noise, protection of endangered species and historical sites, and species habitats. Potential mitigation actions may entail the need for further right-of-way investments: e.g., to compensate for wetlands that have been eliminated by the project, to acquire additional right-of-way clearance to protect sensitive environmental areas, to replace lost social or cultural resources in a community, or to acquire additional right-of-way to maintain contiguous animal roaming ranges or habitat areas.

Project Programming/Resource Allocation

Agencies have different approaches to capital project programming and resource allocation. These approaches vary not only as a function of agency policies and priorities, but also in the degree of formality with which projects are defined and described. Differences also occur in the manner by which candidate projects are managed to control "scope creep" and associated increases in cost and schedule. From an asset management perspective, projects ideally are advanced based on the strategy recommended in the long-range plan and the results of alternatives analyses and environmental reviews. Projects are nominated – i.e., formally proposed by a project sponsor – with a description of their costs, benefits, and other impacts. This information, together with corresponding information developed for other project candidates, is used to rank or prioritize projects for funding.

The resource allocation process distributes the available funding among programs and projects that have been prioritized as the best use of the available investment dollars.

Many agencies organize project implementation within at least three distinct phases: preliminary engineering, right-of-way acquisition, and actual construction. These phases may either be funded together or separately. Funding individual phases separately is typically used to get projects underway when the allocation is not sufficient to fund the entire project all at once, or where the lead time prior to construction is likely to be long (e.g., for environmental reviews). Preliminary engineering and the acquisition of right-of-way (including relocation of residents and businesses, and any mitigation measures required) are likely to be the first phases funded in these cases because of the time needed to complete these activities.

It is important that right-of-way costs be estimated as accurately as possible in project nomination to avoid unexpected, significant increases in project financial requirements. Right-of-way costs that turn out to be substantially higher than estimates will reduce the funding available for other project phases (or for other projects). Periodic updates of right-of-way estimates throughout the planning and project development process are useful to identify potential changes in project costs as early as possible. Estimating right-of-way costs is particularly challenging because projects often occur in an atmosphere of rapidly changing property values, and the costs of relocation often are difficult to quantify accurately without substantial detailed information about the residents and businesses to be displaced. The field of right-of-way cost estimating still is evolving, with an emphasis on finding ways to achieve more accurate cost estimates early in the planning process. Today, estimates are developed primarily by using the experience gained with projects of similar nature and location.

Capital Project Delivery

With certain limited exceptions, right-of-way purchases must be complete, and any displaced persons relocated, before project construction actually gets underway. Right-of-way purchase and relocation assistance should be as carefully planned and scheduled as any other part of a project to allow sufficient time for completion before construction, and still occur within the timeframe of a well-defined project

Prior to obtaining final environmental approval, the state DOT may request FHWA agreement to provide reimbursement for advanced acquisition of a particular parcel, or limited number of parcels, to prevent imminent development and increased costs (protective buying), or to alleviate hardship to a property owner or owners on the preferred location (hardship acquisition). The use of these early acquisition techniques can be very effective if the qualifying conditions are met.

For protective buying, the state DOT must clearly demonstrate that development of the property is imminent and such development would limit future transportation choices. A significant increase in cost may be considered as an element justifying a protective purchase.

Hardship acquisitions are based on a finding that there is a hardship for health, safety or financial reasons, and that remaining in the property poses an undue hardship on the property owner compared to others. There also must be evidence that the property owner, because of the project, is unable to sell the property at fair market value, within a time period that is typical for properties not affected by the impending project.

More than 25 states are using innovative forms of project delivery, with design-build being a key example. Design-build entails a single procurement for both design and construction of a project by a contractor. Best-practice procedures have been developed by the FHWA to incorporate right-of-way activities within design-build contracts.[6]

Operations and Maintenance

Once projects are built, agencies continue to have responsibilities in operating the facility and maintaining the right-of-way for the safety, convenience, and comfort of motorists and the public living or working near the highway. Several strategies that already have been discussed are conducted in this phase:

- Maintenance of the integrity of the highway right-of-way to preserve its utility, continue protecting the environment, and remove hazards;
- Use of access management techniques to maintain traffic flow and safe operations, and to preserve intended design standards;
- Use of access management and joint use agreements to provide operations equipment infrastructure (signals, signage); and
- Continuing real property management to protect safety and reserve necessary parcels for future transportation needs. Real property management also extends to revenue generation where joint development is permitted and appropriate.

One issue that is increasing in importance is the potential commercialization of the right-of-way, a growing interest in broader, non-transportation uses within the right-of-way limits. While corporate logos and acknowledgment signs are permitted within the right-of-way as the result of public-private partnerships for maintaining roads and roadsides, the proliferation of such signs may have safety implications and affect the quality of the roadway as perceived by motorists. These current uses, as well as proposals for the expanding permissible advertising activities outside the right-of-way and allowing advertising within the right-of-way, raise issues that require further investigation and policy development.

[6] FHWA Office of Real Estate Services, "Design/Build Contracts and Right-of-Way Activities," http://www.fhwa.dot.gov/realestate/dbcrwa.htm.

2.4 Application of Asset Management Principles to Right-of-Way

The following sections describe examples of how asset management can influence right-of-way management.

Policy-Driven

Specific goals and objectives for the right-of-way function are supportive of transportation goals and objectives and broader state government policies regarding, for example, economic development and environmental protection. Examples of how these policies may influence right-of-way include:

- Planning for and providing needed right-of-way for corridor development and project construction in a timely and cost-effective fashion;
- Minimizing costs and risks of right-of-way acquisition through an agreed-upon program of strategic and tactical purchases;
- Improving the integration of various functions, including right-of-way, to streamline the project planning and development processes;
- Ensuring full compensation is paid for all property acquired, and satisfaction of all relocation assistance requirements, in compliance with the Uniform Act[7] and applicable state law;
- Managing property holdings cost-effectively and with recognition of safety and environmental protection (by removing hazardous materials, protecting the natural environment, and preventing encroachments into the right-of-way to ensure public safety);
- Managing access to highway facilities to maintain mobility and safety;
- Ensuring that the disposal of property interests, whether under air space agreements or as transfers of excess properties no longer needed for transportation purposes, generates appropriate revenue;
- Encouraging economic development and, where appropriate, working with public and private partners to build needed facilities; and
- Enhancing the efficiency and consistency of right-of-way activities across state programs.

[7] Refer to Section 3.0 for more information on this Act.

While agencies must assess the implications of these policies and pursue right-of-way strategies that are consistent with and support these objectives, it also must be recognized that Federal law and regulations[8] specify requirements for real property acquisition, relocation assistance for displaced persons and businesses, and property management, which must be met if Federal funds are to participate in any part of the project.

Performance-Based

Performance monitoring and tracking are central to an asset management approach, regardless of the assets or functions involved. Measuring right-of-way program performance presents a challenge because requirements may appear to be contradictory. Right-of-way supports and is committed to rapid and efficient project delivery. Yet dealing with people and businesses, acquiring their real property and relocating them, requires services and other actions that are mandated by law and regulation. These activities often are time-consuming, and some have mandatory minimum notice periods. In addition, many of right-of-way's functions are heavily dependent upon the actions taken by other disciplines such as design and environment. For these reasons, it is difficult to identify objective measures for right-of-way activities. However, data can be gathered and used to identify trends that can provide information about the overall effectiveness of a right-of-way program. The following information, gathered over several years, may be useful to identify trends within a right-of-way program:

- Percentage of parcels acquired through negotiation (versus eminent domain);
- Length of property acquisition process, and the lead time required to close;
- Percentage of right-of-way costs spent on litigation,
- Percentage of construction costs associated with right-of-way acquisition, including environmental mitigation;
- Average time needed to relocate residents;
- Average time needed to relocate businesses; and
- Average payments: residential housing supplemental payments and moving costs, real property per parcel costs, administrative costs (absolute and/or per parcel).

In addition, internal and external customer satisfaction surveys can be used to measure success in the right-of-way program.

[8] The Uniform Act and regulations in 49 CFR Part 24 and 23 CFR Part 710 are pertinent. Refer to Section 3 for additional discussion of statutory requirements governing highway right-of-way.

Analysis of Options and Tradeoffs

Options and tradeoffs associated with locations of transportation corridors are evaluated as part of the overall transportation planning process, alternatives analysis, and project environmental reviews. Right-of-way functions can be integrated with other functions earlier in the project-development process to ensure that the potential costs of real property acquisition and of relocation of occupants are properly taken into account in the evaluation of alternatives.

Further options that directly affect the right-of-way function occur when implementing the real property acquisition and management required by the current and future transportation network. Agencies have choices in the following areas:

- Timing of property acquisition and disposal;
- Access management provisions (capacity versus operations/management);
- Corridor management and preservation techniques;
- Property management practices (e.g., maintenance and upkeep); and
- Property management revenue (e.g., joint development and shared-use agreements).

Decisions Based on Quality Information

Right-of-way holdings in a highway network are extensive and can be held for many years. Existing regulations[9] require that agencies keep records on property inventories and acquisitions, authorized uses of airspace, and other leases or agreements. However, acquisition of parcels prior to this regulation may not be documented as completely. For example, the recent financial reporting requirement for highway system assets by the Governmental Accounting Standards Board (GASB Statement 34) has highlighted gaps in the real property records of transportation agencies.

Agencies can improve on these shortcomings with the help of advances in information technology, such as enterprise databases and geographic information systems. These tools can support a number of asset management functions in addition to the GASB 34 reporting and the real property management functions of the right-of-way unit itself: e.g., access management, environmental stewardship, economic development, land use patterns, and forecasting of future development. Examples of the types of information that would be needed at a minimum include:

- Complete, accurate, current information on property holdings;
- Real property and relocation assistance costs by category of parcel, project type, and location;

[9] These regulations are in Chapter 23 of the Code of Federal Regulations, and are issued by the FHWA. Refer to Section 3 of this memo for additional information on FHWA's regulatory responsibilities and activities.

- Time requirements for different project phases by project type and location;
- Environmental characteristics of parcels, and potential or actual mitigation needed; and
- Project experience: success and risk factors actually encountered, and recommendations for addressing similar situations in the future.

Monitoring to Provide Clear Accountability and Feedback

The performance measures and information technology tools described above provide a basis for establishing clear management accountability for performance and feedback to improve future management and operations:

- "Lessons learned" are documented and used to establish best practice;
- Data on right-of-way costs are used to improve cost estimation methods; and
- Data on the time required to obtain parcels and relocate displaced persons and businesses are used to improve scheduling accuracy and statistics on project readiness.

Monitoring and feedback are particularly important when revising business processes and evaluating results. For example, if right-of-way activities are begun early in the project development cycle and integrated with other activities, monitoring and evaluation will document the effectiveness of this approach and its impacts on schedule and cost for future reference.

3.0 FHWA Office of Real Estate Services – Current and Future Activities Related to Asset Management

This section describes current activities of the FHWA Office of Real Estate Services (ORES) and the real estate staff in FHWA division offices that relate to asset management. It then identifies additional opportunities for implementing asset-management principles and techniques in the future.

3.1 Current and Planned Activities

Policy and Regulatory

ORES operates under several legal authorities in providing its services:

- Title 23, U.S.C.:[10] Highways, including the Highway Beautification Act;
- Title 42 U.S.C., Chapter 61: Uniform Relocation Assistance and Real Property Acquisition Policies for Federal and Federally Assisted Programs (the Uniform Act);
- Title 49 U.S.C.: Transportation;
- 23 CFR Part 710, Right-of-Way and Real Estate; and
- 49 CFR Part 24, regulations deriving from the Uniform Act.

ORES, representing FHWA and the U.S. DOT, is the lead agency for administering the Uniform Act through rule-making. These rules establish the real property acquisition and relocation assistance requirements that projects must follow to be eligible for Federal funds. Seventeen other Federal agencies currently have programs subject to the Uniform Act.

ORES develops, implements, and evaluates policies for acquisition, management, and disposal of real estate in connection with FHWA programs and provisions of 23 CFR, including the Highway Beautification Act. It issues guidelines for real property management, including air rights, leasing, disposal, and early acquisition. Updating these policies, regulations, and guidelines to reflect changes in statute is an ongoing activity within ORES. ORES and the FHWA division offices also administer the Highway Beautification program for controlling outdoor advertising along highways.

Technical Assistance and Information Dissemination

ORES provides assistance through the entire cycle of project delivery, including project planning, property appraisal and acquisition, relocation of affected residents and businesses, and post-project-property management. ORES recommends that operating agencies use a property inventory and maintenance system. The office issues a number of publications and guidebooks to assist state and local agencies in conducting and managing the right-of-way process. Guidelines also are given for leasing (interim and post-closeout) and property disposal. ORES staff participate in the AASHTO Utilities and Right-of-Way Subcommittee and the International Right-of-Way Association, and has formal partnering agreements with other Federal agencies, including FAA, FTA, and the Corps of Engineers. ORES historically has delivered training in relevant right-of-way functions and procedures, and is now investigating new, less staff-intensive ways to

[10] U.S.C. stands for United States Code; CFR stands for Code of Federal Regulations.

deliver this training: e.g., through partnering with other agencies (such as the Corps of Engineers) and through distance learning courses offered through the National Highway Institute (NHI).

In general, the FHWA provides policy guidance and technical assistance to state DOT partners and other Federal agencies in implementing the Uniform Act and 49 CFR requirements, but does not typically get involved in day-to-day project activities. Differences in state laws and agency practices require the development of adaptable analytic tools, and right-of-way issues change rapidly, particularly in fast growing areas of the country.

Research and Technology

ORES has sponsored or is now planning research in a number of subjects that contribute to better real property management. Several examples follow.

1. ORES has sponsored research and other activities that promote better program performance:
   - History and overview of the Federal Outdoor Advertising Control Program;
   - Assessment of the effects of public project acquisitions on adjacent business;
   - Scans of innovative U.S. practices;
   - European right-of-way and utilities best practices scan; and
   - A review of best-practice management approaches and systems used by right-of-way divisions in five surveyed states (Florida, Louisiana, Oregon, Pennsylvania, and Wisconsin).
     - Evaluation of state condemnation processes;
     - Report on design/build contracts and right-of-way activities;
     - Synthesis report on integrating and streamlining transportation development and decision-making;
     - A relocation retrospective study; and
     - Corridor preservation case studies.
2. ORES currently is funding research in the following topics, emphasizing greater use of technology:
   - Web-based annual acquisition and relocation statistics;
   - GIS implementation in right-of-way programs, including GIS and data management applications for local agencies;
   - Automated driveway access management with GIS 3-D imagery; and
   - Innovative (GIS) corridor assessment and land acquisition management tools.

Coordination

ORES is located within the Office of Planning, Environment, and Realty. It coordinates internally with sister Offices in Planning, Environment, and Realty, as well as with other major Offices such as Operations, and Infrastructure. It works through FHWA division offices to assist state DOTs in right-of-way matters throughout the project life cycle, including planning and NEPA review stages. As lead agency for implementing the Uniform Act and 49 CFR, ORES is routinely engaged in responding to operational questions from the 17 other Federal agencies that operate under the Uniform Act. ORES also coordinates with AASHTO and the International Right-of-Way Association.

The FHWA does not acquire right-of-way for Federal-aid highway projects. Instead, the FHWA makes Federal-aid funds available to the State transportation departments, mainly by statutory formula. State transportation officials work with local governments to determine which projects are funded. The States are responsible for acquisition of right-of-way, although local governments acquire the right-of-way in some cases. Approximately $1.5 billion is spent annually on acquisition and relocation activities for Federal-aid highway projects. The FHWA works with its partners during the acquisition process and, through them, assists other customers, such as nonprofit organizations, property owners and businesses, and individuals affected by transportation projects.

3.2 Potential Future Activities

The Office of Real Estate Services can build on its current activities and interactions with other FHWA offices to further strengthen the relationship between right-of-way management and asset management. Some of these activities include:

- Encouraging agencies to implement comprehensive right-of-way inventory databases and analytic techniques. FHWA currently encourages the use of property inventories, but there may be a need to develop or license versions to local agencies. A database could record all property and improvements for a particular project, tracking each required parcel and its associated land, structures, and equipment. Accounting, leasing, maintenance, and disposal functions also could be integrated. Performance measures and analytic techniques can be included to evaluate the most effective options in the pre-project and post-project phases.

- Developing flexible tools that can be tailored by each agency to evaluate the impact of right-of-way decisions. Tools are needed for both decisions within the right-of-way program itself, and for integrating right-of-way considerations with the long-range planning process. Within right-of-way, an analytic tool could help state and local agencies determine how much property is needed for rights-of-way, how much to dispose, and how far in advance to begin the acquisition process. A second tool could better integrate right-of-way in long-range planning by helping to anticipate long-range property needs, and assisting planners in evaluating the impacts of transportation decisions on surrounding communities.

- Working with other FHWA offices, and perhaps with a panel of states and AASHTO in a laboratory-state or lead-state arrangement, to achieve advances in a targeted objective: e.g., environmental management of right-of-way lands. This effort could extend ongoing work by NCHRP (e.g., Project 25-25), and focus on developing bodies of information that could be used throughout the facility life cycle: i.e., from long-range planning through operations and maintenance and, if needed, disposal.

- Supporting greater outreach and education, emphasizing pre-project and post-project right-of-way asset management opportunities. Instead of a static cost associated with new capacity projects, property can be actively managed to minimize acquisition cost, reduce community disruption, and generate revenue through shared use or leasing in appropriate situations. To communicate these potential benefits, FHWA could develop best practice case studies at both the project and state levels, while recognizing that there are differences in right-of-way regulations between states.

- Cost estimation for right-of-way is an emerging field, and additional work is needed to develop guidelines and procedures that could yield more accurate costs at the planning stage. Compilations of case studies, identifying factors that contribute to cost variability and the magnitude of divergences from estimates, offer one approach. A second is to work with agencies to develop more analytical procedures in producing estimates.

- The growing issue of commercialization of the right-of-way has been discussed in Section 2.3. Further work is needed to review the issue and to formulate consistent policies and approaches to commercialization Discussions on this topic are underway among the states and within AASHTO.

- ORES has identified future research needs in the following subjects:

  - FHWA stewardship practices;
  - Advance acquisition of right-of-way;
  - Right-of-way procedures that support innovative contracting practices;
  - Corridor preservation using tiered EISs;
  - Right-of-way performance measures;
  - Practices and issues related to commercial uses within rights-of-way;
  - Division interagency agreements and practices for interagency activities;
  - Right-of-way cost estimating;
  - Operational and safety effects of outdoor advertising on highway users;
  - Use of GIS in right-of-way and development of the business case for adopting GIS in right-of-way; and
  - Automated systems for residential and business valuation and for calculating relocation benefits.

FHWA White Paper: *Federal Lands Highway and Asset Management*

The purpose of this paper is to define the relationship between transportation asset management and transportation system planning and to describe the current, and potential future, activities of the FHWA Federal Lands Highway office that support the implementation of asset management. The paper is one of a set of seven papers exploring the relationship of asset management to each of FHWA's major program areas including planning, right-of-way, environment, infrastructure, safety, operations, and Federal lands.

Section 1.0 provides a general overview of asset management relevant to all program areas. Section 2.0 defines the relationship between Federal lands and asset management. Section 3.0 describes current, and potential future, activities of the Federal Lands Highway office that support asset management.

1.0 Overview of Transportation Asset Management

1.1 Definition of Asset Management

Transportation asset management is a set of guiding principles and best practice methods for making informed transportation resource allocation decisions, and improving accountability for these decisions. The term "resource allocation" covers not only allocation of money to program areas, projects, and activities but also covers deployment of other resources that add value (staff, equipment, materials, information, real estate, etc.). While several of these principles and practices were initially developed and applied within the domain of infrastructure preservation, most established definitions of asset management are considerably broader. The **Asset Management Guide**,[1] recently adopted by AASHTO defines asset management as:

[1] *Transportation Asset Management Guide*, prepared for the National Cooperative Highway Research Program (NCHRP) Project 20-24(11) by Cambridge Systematics, Inc. with Parsons Brinckerhoff Quade & Douglas, Inc., Roy Jorgensen Associates, Inc. and Paul D. Thompson, November 2002, AASHTO Publication RP-TAMG-1.

> *"… a strategic approach to managing transportation infrastructure. It focuses on…business processes for resource allocation and utilization with the objective of better decision-making based upon quality information and well-defined objectives."*

As Mary Peters, FHWA Administrator has frequently put it:

> *"If I have one additional dollar to spend on the transportation system, what is the most effective way to spend it?"*

The essence of asset management is answering that question.

Asset management is concerned with the entire life cycle of transportation decisions, including planning, programming, construction, maintenance, and operations. It emphasizes integration across these functions, reinforcing the fact that actions taken across this life cycle are interrelated. It also recognizes that investments in transportation assets must be made considering a broad set of objectives, including physical preservation, congestion relief, safety, security, economic productivity, and environmental stewardship.

1.2 Asset Management Principles

The core principles of asset management are:

- **Policy-Driven –** Resource allocation decisions are based on a well-defined and explicitly stated set of policy goals and objectives. These objectives reflect desired system condition, level of service, and safety provided to customers, and typically are tied to economic, community and environmental goals as well;

- **Performance-Based –** Policy objectives are translated into system performance measures that are used for both day-to-day and strategic management;

- **Analysis of Options and Tradeoffs –** Decisions on how to allocate resources within and across different types of investments (e.g., preventive maintenance, rehabilitation, pavements, bridges, capacity expansion, operations, different modal mixes, safety, etc.) are based on an analysis of how different allocations will impact achievement of relevant policy objectives. Alternative methods for achieving a desired set of objectives are examined and evaluated. These options are not constrained by established organizational unit boundaries – for example solving a congestion problem could involve a capacity expansion or an operational improvement (e.g., signal coordination). The best method is selected considering the cost (both initial and long-term) and likely impacts on established performance measures. The limitations posed by realistic funding constraints must be reflected in the range of options and tradeoffs considered;

- **Decisions Based on Quality Information –** The merits of different options with respect to an agency's policy goals are evaluated using credible and current data. These data may apply to specific functions (e.g., pavement and bridge management,

traffic monitoring) or reflect a more integrated, corporate view. [2] Where appropriate, decision support tools are used to provide easy access to needed information, to assist with performance tracking and predictions, and to perform specialized analysis (e.g., optimization, real-time simulation, scenario analysis, life-cycle cost analysis, benefit/cost analysis); and

- **Monitoring to Provide Clear Accountability and Feedback –** Performance results are monitored and reported for both impacts and effectiveness. Feedback on actual performance may influence agency goals and objectives, as well as resource allocation and utilization decisions.

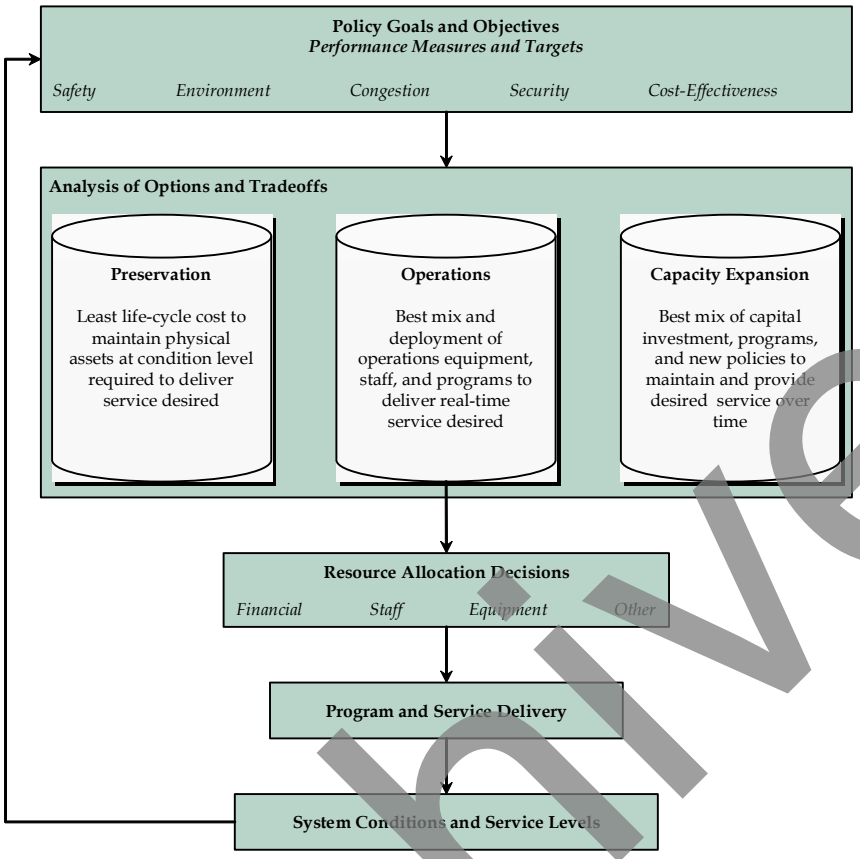
These principles are not unfamiliar, nor are they radical. Most transportation practitioners would agree that investment decisions should be based on weighing costs against likely outcomes, that a variety of options should be considered and evaluated, and that quality information is needed for decision-making. Many agencies are now pursuing performance-based approaches to planning and programming, monitoring system performance, and developing more integrated data and analysis tools to evaluate tradeoffs among capital expansion, operations, and preservation activities. Most agencies recognize that application of asset management principles is critical in times of constrained resources, when all investment and budget decisions are subject to increased public scrutiny.

1.3 Asset Management Practice

Figure 1 illustrates the strategic resource allocation process that embodies the asset management principles presented above.

[2] The FHWA plays a key role in standardizing the content and format of data that are mandated by federal law: e.g., the National Bridge Inventory (NBI) data that are reported by state DOTs.

Figure 1. Strategic Resource Allocation Process



The diagram includes the following elements:

- **Policy Goals and Objectives,** supported by performance measures are established through the policy and system planning process and used to guide the overall resource allocation process.

- **Analysis of Options and Tradeoffs** includes examination of options *within* each investment area, as well as tradeoffs *across* different investment areas. The definition of investment areas is flexible and can be tailored to how an individual agency does business. For example, an agency may have a separate safety investment area and also incorporate consideration of safety within system preservation, operations, and capacity expansion expenditures. Each option and tradeoff is evaluated with respect to established agency goals and performance objectives.

- **Resource Allocation Decisions** are based on the results of tradeoff analyses These decisions involve allocations of financial, staff, equipment, and other resources to the different investment areas and/or to different strategies, programs, projects, or asset classes within an individual investment area.

- **Program and Service Delivery** is accomplished in the most cost-effective manner which again involves consideration of different delivery options (e.g., use of contractors, interagency agreements), as well as a delivery tracking process involving recording of actions taken, costs, effectiveness, and lessons learned to guide future activity.

- **System Conditions and Service Levels** are tracked to see the extent to which established performance objectives are being addressed. This information is used to refine policy goals and priorities (e.g., put more emphasis on safety in response to an increase in crash rates).

1.4 Transportation Investment Categories

In Figure 1, the box labeled "Analysis of Options and Tradeoffs" shows three types of investment categories – preservation, operations, and capacity expansion. These are defined as follows:

1. **Preservation** encompasses work to extend the life of existing facilities (and associated hardware and equipment), or to repair damage that impedes mobility or safety. The purpose of system preservation is to retain the existing value of an asset and its ability to perform as designed. System preservation counters the wear and tear of physical infrastructure that occurs over time due to traffic loading, climate, crashes, and aging. It is accomplished through both capital projects and maintenance actions.

2. **Operations** focuses on the real-time service and operational efficiency provided by the transportation system for both people and freight movement on a day-to-day basis. Examples of operations actions include real-time traffic surveillance, monitoring, control, and response; intelligent transportation systems (ITS); signal phasing and real-time signal controllers at intersections; HOV lane monitoring and control; ramp metering; weigh-in-motion; road weather management; and traveler information systems. Although operations focuses on system management, the infrastructure needed to provide this capability may be substantial (e.g., traffic control centers; ITS hardware; environmental sensors and fire control systems in tunnels). Thus, an operations strategy requires capital and operating budget as well as substantial staff resources.

3. **Capacity expansion** focuses on the actions needed to expand the service provided by the existing system for both people and freight. Capacity expansion can be achieved either by adding physical capacity to an existing asset, or acquiring/constructing a new facility.

These three categories are defined in order to show that:

- Asset management is not just about preservation of highway network assets; it is about making investment decisions that address a wide range of policy goals.

- The three categories provide a simple, useful way for decision-makers to align program investment categories and priorities with key policy objectives. For example, many agencies establish a "preservation first" policy or favor maximizing efficiency of operations prior to investing in new capacity.

- The categories may present alternative ways of meeting a policy goal. For example, it may be appropriate to consider operational improvements to address a congestion problem as an alternative to adding a new lane.

- Decisions about the resources allocated to each category cannot be made independently. Meeting many policy goals (e.g., safety) may require a mix of investments across these categories. Similarly, an increase in capacity expansion investments may require increased operations and preservation expenditures at some point in time.

As noted above, tradeoff analysis may be done across *investment categories* as well as within them. An agency might wish to define investment areas coincident with the three categories discussed above (preservation, operations, capacity), or they may define a different set of categories. For example, a safety program could be defined as an investment category, with subareas for operational activities (e.g., signs, markings, signalization, channelization, etc.), preservation (replacement of guardrails), and capacity (project design features supporting safety, e.g., wide shoulders). This would provide the framework for understanding the best mix of complementary actions within the safety area as well as tradeoffs between safety and other objectives.

1.5 Asset Management and the Transportation Planning Process

A common reaction to the broad description of asset management is "how is this different from the overall planning and programming process in an agency?" The response is that asset management is not a new kind of business process that replaces planning and programming. Rather, it should be viewed as a set of best practices to be employed within the established planning and programming framework. Existing regulations pertaining to the planning process, together with statutes related to specific funding programs and their allocation criteria, and the body of environmental regulations affecting transportation planning – provide the context within which asset management practice occurs. In terms of Figure 1, transportation regulations and statutes impact establishment of policy objectives, the manner in which options are generated and evaluated, and they also provide certain constraints on resource allocation (based on Federal and state funding eligibility restrictions). Many of the core principles of asset management are embodied in the existing planning regulations (e.g., consideration of alternatives). Examining the planning process using the lens of asset management

provides an opportunity to explore ways to continue to strengthen the mission of transportation planning – for example:

- How to improve connections between long-range planning and resource allocation;
- How to strengthen agency and public consideration of preservation and operations investments within the long-range planning process;
- How to better integrate environmental considerations throughout the transportation planning and decision-making process – across capacity, operational and preservation investments; and
- How to provide a common information resource base to serve multiple activities across the transportation asset life cycle – long-range planning, corridor studies, safety studies, environmental assessments, multi-year capital programming, project development, preventive maintenance and system operations.

While asset management is closely associated with planning and programming activities, asset management best practices are also integral to design, construction, routine and preventive maintenance and operations activities. For example:

- Application of life-cycle cost analysis in the facility design process;
- Analysis of alternative construction materials and methods;
- Tradeoffs across different maintenance activities based on level of service and extended facility life provided to customers;
- Developing an appropriate mix of operations expenditures on technology upgrades, hardware/infrastructure maintenance and replacement, and skilled personnel;
- Evaluation of delivery options (e.g., design-build, use of private contractors for maintenance and operations, inter-agency agreements, etc.).

1.6 Key Opportunities

Despite the support for taking an asset management approach, many agencies face very real organizational, institutional, and technical challenges to making further progress in asset management. Each one of these challenges represents a potential opportunity for FHWA to work with its partners to encourage broader implementation of asset management principles. For example:

- Top management needs to set an organization-wide direction and framework for decision-making and to ensure that all parts of the organization are working together in a coordinated fashion. Maintaining continuity in leadership direction and understanding of key asset management principles can be particularly challenging with frequent turnover in agency executives;

- Clear roles for each organizational unit must be established to solve common problems or meet common objectives. Differences in perspectives and approaches, lack of established procedures, or turf battles must be reconciled;

- Established resource allocation methods, often constrained by externally imposed restrictions, historical allocations or formulas, or delicate and difficult political negotiations may restrict the range of options and tradeoffs that can be considered;

- Staff resource constraints together with a constant "fire-fighting" mode of operation also may restrict the amount of time and effort that can be spent on analyzing options;

- Developing a comprehensive set of reliable methods, data and tools to evaluate performance tradeoffs among the full set of investment options will take a sustained, multi-year effort;

- Establishing a causal link between an investment or action and a performance indicator of interest, due to the presence of external factors influencing performance (e.g., gas prices, vehicle fleet changes, growth patterns, etc.) may require additional research in some cases;

- Coordination among multiple agencies to achieve established objectives in areas such as operations and safety adds complexity to the decision-making process and program implementation efforts; and

- External and internal agency culture based on "bottom-up" decision-making, with a focus on specific projects rather than on broader system performance and outcomes.

While it is relatively straightforward to implement asset management within a well-defined area of the agency (a pavement management unit, for example), the issues identified above illustrate why it is much more challenging to implement it more fully within an agency, or across multiple agencies.

However, the need to allocate scarce resources as effectively as possible and demonstrate results and performance to the customers of the transportation system provides strong motivation and support for overcoming these challenges. A comprehensive, performance-based approach to transportation investment decisions will be essential to meeting the increasingly complex set of transportation needs of the 21st century.

2.0 Federal Lands Highway and Transportation Asset Management

The Federal Lands Highway Program (FLHP) was created by the Surface Transportation Assistance Act of 1982 to provide a coordinated program of public roads and intermodal facilities serving Federal and tribal lands. This program services recreational travel and

tourism, protects and enhances natural resources, provides sustained economic development in rural areas, and provides needed transportation for Native Americans. The Federal Lands Highway office at FHWA works with numerous Federal partners including: the National Park Service, U.S. Forest Service, Bureau of Indian Affairs, Department of Defense, and Bureau of Land Management. In 1999, a Refuge Roads program serving the U.S. Fish and Wildlife Service was initiated.

Federal Lands Highway serves over 384 park units, 175 national forests and grasslands, some 564 Federally recognized Native American tribes, close to 10,000 bridges, and nearly 98,000 road miles. Additionally, FLH co-manages the Defense Access Road Program with the Military Surface Deployment and Distribution Command and coordinates the design, construction and maintenance of access roads to military reservations and sites.

Federal Lands Highway is actively involved in planning activities with all its Federal partners including current and long range strategic planning, project planning, and technical assistance. Additionally, FLH acts as a liaison between its land management agency partners and state departments of transportation (DOTs), Metropolitan Planning Organizations (MPOs), rural planning organizations, and local gateway communities. As a result, there are significant organizational complexities to consider for transportation planning and program development within Federal Lands.

Section 2.1 describes the types of activities conducted by Federal Lands Highway, emphasizing the areas where asset management principles are likely to have the most impact. Section 2.2 relates Federal Lands Highway's mission and activities to the three major transportation investment categories previously defined. Finally, Section 2.3 will describe how each of the key asset management principles can be applied to FLH.

2.1 Overview of Federal Lands Highway Activities

Over thirty percent of the United States consists of Federally or tribally owned land, including the National Parks, National Forests and Grasslands, National Wildlife Refuges, and Indian reservations. More than 900 million people visit these areas each year. To fulfill the Federal Government's responsibility to provide transportation within and serving these Federally owned lands, Federal Lands Highway is charged with administering the funding to maintain and improve access to and within these areas.

In addition to administering funding for the Federal Lands Highway Program, FLH also provides comprehensive transportation planning and highway engineering services for its partners, including plan preparation, contracts, and project supervision. Headquartered in Washington, D.C., Federal Lands Highway (FLH) has three divisions in Vancouver, Washington (Western FLH Division), Lakewood, Colorado (Central FLH Division), and Sterling, Virginia (Eastern FLH Division). The FLH divisions provide program planning, design, and construction project and program services to its partners, similar to the functions performed by the FHWA Division Offices for the Federal-aid program. Specific activities carried out by FLH include:

- **Providing funding for public roads, transit, and other modes providing access to or within Federal and tribal lands that are not a state or local government responsibility.** In providing transportation access for Federal and tribal lands, the Transportation Equity Act for the 21st Century (TEA-21) defined five programs as funding categories:

  - Indian Reservation Roads (IRR) funding can be used by the Bureau of Indian Affairs (BIA) and tribal governments for transportation facilities (roads, transit, bicycle/pedestrian, etc.) providing access to or within tribal lands. The IRR system consists of approximately 25,000 miles owned by the BIA and tribal governments, and approximately 31,000 miles owned by State or local governments. Authorized annual funding in TEA-21 was $275 million, with $13 million as a set-aside for IRR bridges.
  - Forest Highways (FH) funding can be used for transportation facilities (roads, transit, bicycle/pedestrian, etc.) to provide access to National Forests and Grasslands. The internal National Forest roads and bridges are the responsibility of the U.S. Forest Service, and are not eligible under the Federal Lands Highway Program. The Forest Highways system consists of approximately 29,200 miles owned primarily by State and local governments. Authorized annual funding in TEA-21 was $162.4 million.
  - Park Roads and Parkways (PRP) funding can be used for transportation facilities (roads, transit, bicycle/pedestrian, etc.) providing access to or within the National Park System. The PRP system consists of nearly 8,500 miles owned by the National Park Service. Authorized annual funding in TEA-21 was $165 million.
  - Refuge Roads (RR) funding can be used for transportation facilities (roads, transit, bicycle/pedestrian, etc.) providing access to or within the National Wildlife Refuge System. The RR system consists of approximately 4,800 miles owned by the U.S. Fish and Wildlife Service. Authorized annual funding in TEA-21 was $165 million.
  - Public Lands Highway Discretionary (PLHD) funding can be used for select transportation projects providing access to or within Federal and tribal lands. No legislative formula was established for allocating funds. Funds are allocated by the Federal Highway Administrator, who selects projects based on need, but also gives preference to projects that are significantly impacted by Federal land and resource management activities, or are proposed by States which have three percent or more of the total Federal lands in the nation. Authorized annual funding in TEA-21 was $83.6 million. In FY 2002, the Congress designated a total of $127.5 million in PLHD funds for 69 specific projects.

- **Providing emergency financial assistance for transportation facilities providing access to or within Federal and tribal lands**. Under the Emergency Relief for Federally Owned Roads (ERFO) program, Federal Lands Highway administers funds to repair and reconstruct eligible transportation facilities damaged by a natural disaster or other catastrophic failure. The intent is to supplement resources provided by other Federal agencies to help pay for unusually heavy expenses caused by extraordinary events.

- **Providing funding for Defense Access Roads (DAR).** Funds for access to military bases are provided by Congress after requests are made through the Military Surface Deployment and Distribution Command (SDDC). The funds are transferred to Federal Lands Highway and allocated to the proper agency.

- **Providing funding for technology development through the Coordinated Federal Lands Highway Technology Implementation Program (CTIP).** The CTIP is a cooperative technology development program between Federal Lands Highway and its partner Federal land management agencies, including the U.S. Forest Service, the Bureau of Indian Affairs, the National Park Service, and the U.S. Fish & Wildlife Service. Examples of funded projects have included a software update for field personnel to evaluate fish migration through culverts, and an evaluation of the durability, effectiveness, and maintenance cost-savings for avalanche resistant guard-walls. The partners who participate in management of the CTIP program, but do not vote on policy issues and proposals, include the Military Surface Deployment and Distribution Command, the U.S. Army Corps of Engineers, and the Bureau of Land Management.

- **Providing comprehensive program and project services to partners.** The Federal Lands Highway headquarters and divisions offer a range of program and project services to its partners, including:
  - Transportation planning;
  - Highway and bridge designs, plans, specifications, and estimates;
  - Contract procurement;
  - Construction management;
  - Road/bridge inventories, inspections, and condition ratings;
  - New technology support; and
  - Training of engineers, planners, environmental specialists, project managers, and others.

While asset management principles potentially could be integrated into all of the above FLH activities, they are likely to have the most impact when implemented at the partner Federal land management agencies in program development and project prioritization. The land management agencies and Federal Lands Highway work together in transportation planning, programming, and project selection, the results of which are approved and funded by FLH.

2.2 Relationship to Transportation Investment Areas

In terms of the strategic resource allocation process described in Section 1.3, the Federal Lands Highway offices, as administrators of a Federal-aid program, focus on resource allocation decisions, program and service delivery, and system conditions for its partners. FLH's partners share responsibility for long-range transportation planning and the

analysis of options and tradeoffs in developing programs and generating a prioritized project list submitted to FLH for approval. FLH is involved to varying degrees with each of the partners, depending on the specific inter-agency agreements. Recognizing that FLH generally provides stewardship and oversight for transportation on Federal lands, but share responsibility for program development, FLH is already encouraging its partners to implement asset management principles in their planning and programming processes.

Preservation

For preservation projects, the eligibility for each FLH funding area differs slightly, but in general FLH administers funds for the maintenance and repair of roads, bridges, transit, pedestrian, and bicycle facilities serving Federal and tribal lands, including preservation actions to improve safety. For Refuge Roads, funds can also be used for the maintenance of vehicular parking areas and roadside rest areas. Project candidates are developed and submitted to FLH by the partner Federal land management agencies.

Quality information on the importance of life-cycle costs in preserving facility investments is crucial to adopting a programmatic approach to maintenance and preservation actions. Adopting an asset management approach that balances preservation with operations and capacity expansion would enable partners to recognize how regular and scheduled maintenance actions can extend the service life of a facility and save resources in the long term. Implementation of management systems and analysis tools through existing regulations will also allow partners to understand the tradeoffs and allow them to meet commonly agreed-upon facility and service targets though a programmatically balanced approach.

Operations

Compared to preservation and capacity expansion, FLH conducts relatively fewer activities in the area of operations, though FLH funds can generally be used for planning studies on operational issues (for example, the U.S. Forest Service and National Park Service studies on alternative transportation systems and transit). There are traffic management measures in place at spot locations. In addition, the Western FLH Division is working with the National Park Service to develop a congestion level of service measure for use in implementation of a congestion management system.

As increasing pressures are placed on the nation's public places, especially the national parks, and resources continue to be focused on maximizing the use of existing infrastructure, the area of operations will be an increasingly important future area of coordination and funding need.

Capacity Expansion

FLH's mission is to provide access to and within Federal and tribal lands. Key components in achieving this is to expand capacity by constructing new roadways, bridges and transit services, widening existing roadways and bridges, and expanding

transit service to areas that are not adequately served by transportation facilities. FLH funds can also generally be used to expand the capacity of pedestrian and bicycle facilities. An asset management approach allows the partners to evaluate the relative long-term facility and service impacts of investing in capacity expansion and to develop programs that balance those system expansion investments against activities that preserve infrastructure, make better use of the existing transportation assets, or provide intermodal transportation options.

2.3 Application of Asset Management Principles to Federal Lands Highway

This section describes how each of the asset management principles outlined in Section 1.2 can be applied to setting transportation priorities for Federal and tribal lands. The relationship with FLH's partner land management agencies will also be discussed, since the partners share responsibility for program development and project selection. This sharing of responsibilities creates challenges for FLH in encouraging a consistent asset management approach among its partners, but also allows FLH to revisit the current program development process and determine opportunities for a more focused investment approach.

Policy-Driven

In its strategic planning process, FLH has adopted the FHWA Vital Few goals of safety, environmental stewardship and streamlining, and congestion mitigation. To support the achievement of these goals, the FLH 2003-2007 Business Plan identifies four business improvement initiatives to:

- Improve the safety of transportation on Federal and tribal lands;
- Streamline the environmental process;
- Work with Federal Land Management Agencies to ensure that transportation planning is an integral part of their planning processes; and to
- Improve the accountability of all parties involved in project management.

To implement these initiatives, the specific performance goals are to:

- Increase satisfaction of FLH partners and customers;
- Increase job satisfaction of FLH employees;
- Minimize project delivery costs;
- Maximize amount of capital improvement with public funds;

- Improve stability of the multi-year program;
- Improve delivery of FLH environmental compliance services to partners, regulatory agencies and interest groups; and
- Deploy technologies to improve processes and results within FLH and with FLH partners.

Performance-Based

Consistent with asset management principles, FLH has identified specific performance measures for each policy objective in order to monitor goal achievement over time and to communicate the impacts and implications of different plan alternatives. Performance measures also provide a mechanism during resource allocation for setting system condition and service targets and for balancing tradeoffs between program categories. The notion that at its essence asset management is really "total performance management" derives from the critical role that performance measurement plays in implementing the concepts of asset management. Performance-based planning and programming are essential components of asset management and rely on specification of performance measures that reflect key policy goals.

FLH has specified six key performance measures, along with baselines and targets, that are directly tied to its goals in its FY 2003-2007 business plan. These performance measures are:

- Project development customer satisfaction;
- Completed project customer satisfaction;
- Program administration customer satisfaction;
- FLH employee survey results;
- Program delivery costs; and
- Percent of funds obligated.

Federal Lands Highway also monitors the condition of roads and bridges for the Park Roads and Parkways, Forest Highways, Refuge Roads, and Indian Reservation Roads. These condition assessments are used for program decision-making and for reports to Congress.

Analysis of Options and Tradeoffs

The essence of good resource allocation is the analysis of options and tradeoffs. At the strategic resource allocation level, this analysis needs to consider prioritizing and balancing tradeoffs across all major investment categories including preservation,

operations, and capacity expansion, while balancing transportation needs with the natural and cultural resource values of the agencies. Under the current processes, this analysis is conducted in partnership with the National Park Service, U.S. Forest Service, U.S. Fish and Wildlife, and the Bureau of Indian Affairs on behalf of Indian tribal governments.

FLH has encouraged these agencies to think more broadly and long-term about transportation issues. Efforts in recent years have focused on improving partner transportation planning capacity to include thinking about long-term needs, recognizing relationships with host or gateway communities, looking at alternative modes for transportation solutions, and using asset management systems for transportation assets as well as other facilities and equipment.

Typical transportation tradeoffs considered by partner land management agencies might include:

- Balancing preservation, operations, and capacity expansion expenditures and programs for achieving appropriate system performance among all objectives;
- Decisions between modal and intermodal options, where appropriate;
- Tradeoffs among pavement and bridge projects to achieve a desired level of service over time (Indian Reservation Roads are currently the only program with a set-aside for bridges – for all other programs, bridge improvements are included with the associated road improvements);
- Balancing funding among different geographic areas, within the constraints of predefined legislative allocations; and
- Balancing access and mobility objectives with environmental and cultural protection.

The National Park Service has made significant progress in understanding the tradeoffs between preservation, operations, and capacity expansion expenditures, as well as considering modal and intermodal tradeoffs. Because transportation needs must be balanced with natural resource conservation, in many cases it is highly undesirable to widen roads or build additional parking lots in the national parks. As a result, the NPS routinely considers Intelligent Transportation Systems (ITS) solutions and transit options during program development and project prioritization, using the Choosing by Advantages process[3].

In 1998, the NPS developed the Alternative Transportation Program (ATP) to coordinate policy guidance and planning activities regarding intermodal transportation solutions for the national parks. The ATP enables the NPS to balance intermodal options with traditional road improvements. These intermodal options include bicycle, bus, boat, ferry,

[3] Additional detail on the National Park Service transportation planning process is available at: http://www.nps.gov/transportation/alt/guidebook/transplan.pdf

train, and trolley service. Since its inception, nearly $40 million has been allocated to develop and implement alternative transportation systems at national parks, thereby improving the visitor experience while protecting natural and cultural resources. There are currently around one hundred national parks in the United States providing some form of alternative transportation system.

Building on the example of the NPS, the other land management agency partners are making significant progress in considering multimodal solutions in their transportation planning. Over the past three years, Federal Lands Highway and the Federal Transit Administration have jointly evaluated alternative transportation needs on Federal lands. In 2001, the agencies submitted a report to Congress, as required by TEA-21, identifying significant transit needs at sites managed by the National Park Service, the Bureau of Land Management, and the U.S. Fish and Wildlife Service. Of the 207 sites evaluated, total 20-year needs of $1.7 billion were identified at 118 of 169 NPS sites, 6 of 15 BLM sites, and 13 of 23 FWS sites. In 2004, the agencies completed a supplement to the previous study that identified $698 million in alternative transportation needs at 30 U.S. Forest Service sites. As the planning, programming, and implementation of alternative transportation projects continues, the analysis of intermodal options and tradeoffs central to good asset management practice will become increasingly important to meet transportation needs on Federal lands.

Decisions Based on Quality Information

A key element in supporting the analysis of options and tradeoffs described above is the collection, management, and integration of quality information and data into the long term asset management process. The types of transportation data relevant to FLH activities include:

- Condition data for transportation facilities, including pavement, bridge, and transit infrastructure;
- Inventory data;
- Safety data on crashes, injuries, and fatalities; and
- Traffic data.

For the National Park Service, FLH collects inventory and condition data through the NPS Road Inventory Program (RIP) and Bridge Inspection Program (BIP). FLH also recently completed the first condition assessment of roads and bridges on the Refuge Road system for the U.S. Fish and Wildlife Service. For most of the Forest Highways, the Eastern FLH and Central FLH divisions conduct the inventory and condition assessments for pavement and bridges. The Western FLH division relies largely on data collection by the States, supplemented when necessary by manual data collection. Because Forest Highways are mostly State highways, there may be opportunities for Federal Lands Highway to coordinate data sharing with the States and to improve the data collection process.

Inventory and condition data for Indian Reservation Roads is collected by the Bureau of Indian Affairs, and FLH and the BIA are working together to improve data collection in support of asset management systems. A joint Steering Committee has been established to determine the process for developing implementation plans for nationwide pavement, bridge, and safety management systems. In addition, the BIA is undertaking an effort to augment and improve the data collected under the Bureau's Road and Bridge Inventories, since the data is critical in determining the funding allocation to the tribes.

The Central FLH division is working to develop pavement and bridge management systems for the Refuge Road system. The Eastern FLH division is working with the National Park Service to develop a pavement management system integrated with the existing NPS facility management system. The Eastern FLH division also maintains the bridge inventory database, using the Pontis bridge management system, on behalf of over a dozen Federal agencies including the National Park Service.

Safety and traffic data are both limited and may not be consistently collected and reported from partner to partner. The present FHWA initiative with all states to develop focused safety plans to reduce fatal accidents nationwide, and which emphasizes better and consistent data collection processes, presents an opportunity to improve this area. The Central FLH division has also been working with the partner agencies to develop safety management systems.

Monitoring to Provide Clear Accountability and Feedback

Monitoring and reporting on system performance and conditions over time is essential for implementing transportation asset management. For basic preservation, operations, and capacity expansion decisions, condition data can be used to assess facility condition, predict long-term preservation needs, and estimate maintenance and repair schedules. Safety data can be used to identify and correct high accident locations, and traffic data can be used to predict long-term capacity needs. System performance data for transit services will become increasingly important as the partner land management agencies invest resources in alternative transportation systems. For Federal Lands Highway, as administrators of a Federal-aid program, performance monitoring also provides verification that allocated funds are being spent appropriately.

Federal Lands Highway also tracks comprehensive performance measures that are tied to its business plan goals and objectives. These yearly reports provide decision-makers with an understanding of whether current investment strategies are achieving the long-term goals and performance targets identified in the business plan.

In addition to objective "operational" data on system condition and performance, Federal Lands Highway has also conducted surveys to assess public "customer" perception of transportation serving Federal and tribal lands. In 2001, FLH published results from the "Federal Lands Highway Public Survey" that assessed customer satisfaction with:

- Access to destination

- Road surface conditions
- Safety of driving conditions
- Visual appeal
- Preservation of natural resources
- Traffic flow
- Bridge conditions
- Direction and information signs
- Shuttle bus system (where applicable)

Results from this survey were crucial in providing public feedback on FLH and partner investment strategies and in guiding future goal-setting and program development activities.

3.0 Federal Lands Highway- Current and Future Activities in Support of Asset Management

The purpose of this section is to describe current activities of Federal Lands Highway that are supportive of asset management, and identify potential additional opportunities for the future.

3.1 Current and Planned Activities

Federal Lands Highway is already conducting or planning several activities that reflect the asset management principles discussed throughout this paper. The following sections highlight the key asset management activities in the areas of policy, technical assistance, research and technology, and coordination.

Policy and Regulatory

A range of efforts are being undertaken by FLH to provide policy and regulatory guidance for asset management and general transportation planning, including:

- FLH provides policy guidance for its partners in conducting transportation planning processes consistent with Federal regulations, particularly concerning the Transportation Improvement Program, public involvement process, and coordination with State DOTs, Metropolitan Planning Organizations (MPOs), and other partners.

FLH facilitates coordination between these partners and participates in all aspects of program development and project selection, including guidance on alternatives analysis, environmental coordination, public participation, and coordination with the TIP/STIP.

- FLH provided final rules in February 2004 for its partners (National Park Service, U.S. Forest Service, U.S. Fish and Wildlife, and the Bureau of Indian Affairs) to develop and implement safety, bridge, pavement, and congestion management systems (23 CFR 970-973). These management systems will collect, organize, and analyze data in order to understand current conditions and make better investment decisions at a program level. Management systems provide a strategic approach to transportation planning, program development, and project prioritization and selection. FLH will be working with the divisions and partners to develop implementation plans for these systems or continue activities already underway. For example, work is already underway for pavement and bridge management systems for the National Park Service and the U.S. Fish and Wildlife Service, safety management systems for the National Park Service, U.S. Fish and Wildlife Service, and U.S. Forest Service, and a congestion performance measure for the National Park Service.

- FLH is heavily involved with the National Park Service and the U.S. Forest Service on nationwide implementation of regional and systemwide strategic long-term transportation planning. As a result of FLH's efforts, several of the parks are beginning to implement regional planning activities with their neighbors. Because many national parks are bounded by Forest Service lands, this planning effort highlights an opportunity for a cross-agency asset management system to be strengthened and used by different partners. The National Park Service is currently developing a service-wide long-range strategic plan to guide transportation planning at the regional and park unit levels. The U.S. Forest Service emphasizes community partnerships in its transportation planning guidebook developed in partnership with FLH, "Innovative Approaches to Transportation"[4].

- FLH has worked with the U.S. Fish and Wildlife Service to develop a draft 20-year transportation plan that incorporates the core principles of asset management including long-range goals and the importance of quality condition data. The plan also defines the importance of transportation asset management as part of the agency's comprehensive asset management plans, and identifies the need for project selection criteria.

- In 1999, FLH published "Transportation Planning Procedures and Guidelines" for the Indian Reservation Roads program[5]. These guidelines are available to assist Indian tribes and the Bureau of Indian Affairs in performance-based transportation planning. Comprehensive guidance on long-range transportation planning, funding,

[4] This document is accessible at: http://www.fs.fed.us/eng/pubs/pdf/01771806.pdf

[5] This document is accessible at: http://www.fhwa.dot.gov/flh/reports/indian/intro.htm

transportation improvement programs, and roles and responsibilities are documented. These guidelines are also used by FHWA as part of the State's regular planning certification process review as required by Federal law.

Technical Assistance and Information Dissemination

A number of activities are conducted by FLH to provide technical assistance and information directly related to asset management, including:

- FLH collects and maintains the pavement and bridge inventory and condition data for the National Park Service, U.S. Fish and Wildlife Service, and most Forest Highways (Western FLH relies on data collection by the States). FLH uses the ERES system for pavement management and the Pontis system for bridge management, which are databases and tools that could be used for modeling and tradeoff analysis by the partners. The National Park Service also has its own facility management system which could be integrated with ERES and Pontis.

- FLH has a database for safety and recently reinstituted the collection of crash data. One challenge is that historically, each of the partners has collected crash data differently, and there are problems with consistent location referencing and with lack of reporting. FLH is encouraging the National Park Service and U.S. Fish and Wildlife Service to report crashes comprehensively using standard faxed forms provided by FLH. However, state and local governments do not uniformly collect or report safety data for the Forest Highways. For Indian Reservation Roads, certain tribes may have safety data, but there is no comprehensive nationwide system.

Research & Technology

In the area of research and technology, FLH is conducting research and working with its partners to develop the technology necessary to support a more integrated transportation planning process. FLH is helping its partners develop processes that better reflect the asset management approach to transportation planning. The recently issued management system rules will likely require research into data integration and systems development.

Asset management-related research conducted by the Turner-Fairbank Highway Research Center could potentially be applied to Federal lands transportation in addition to the traditional Federal-aid highway program.

Coordination

Coordination with the Federal land management agencies is critical to the success of the Federal Lands Highway program. FLH has a unique partnership arrangement with each of the agencies and fulfills multiple roles that involve program planning, administration, and project delivery. These multiple roles require a high degree of coordination that involve almost constant communication to deliver a high quality program. For example, FLH has tri-party partnerships with the U.S. Forest Service and State DOTs in 41 states to

program and implement projects. Other land management agencies develop programs in coordination with FLH. For example, the U.S. Fish and Wildlife Service and FLH have jointly developed a comprehensive multi-year construction plan to address road, parking lot, and bridge deficiencies.

Transportation planning for the Indian Reservation Roads presents an opportunity and a challenge for FLH to coordinate with the Bureau of Indian Affairs, local tribal governments, State DOTs, the Federal Transit Administration, and numerous other partners. These coordination activities are critical in developing transportation plans and programs that address tribal transportation needs. While the Bureau of Indian Affairs has primary responsibility for program development and project selection, FLH plays a key role in reviewing plans, approving programs, and providing technical assistance and training.

FLH participates regularly in nationwide and regional program coordination meetings of the Bureau of Indian Affairs, U.S. Forest Service, U.S. Fish and Wildlife Service, and the National Park Service. At a minimum, these meetings are held twice a year, and most often occur more frequently. From time to time, FLH participates in more specialized meetings with the partners focused on enhancing a particular area of program delivery such as transportation planning, contract management, management systems, or alternative modes of transportation.

In recent years, FLH has participated in transportation planning conferences sponsored by the U.S. Forest Service and the National Park Service. For the Bureau of Indian Affairs, FLH provides financial, technical, and program support for seven Tribal Technical Assistance Program (TTAP) centers throughout the country that provide education and training to tribal communities regarding transportation.

FLH also coordinates internally within the U.S. DOT as needed. There has been interaction with the Federal Transit Administration on alternative transportation systems, and also with FHWA's Office of Planning and Office of Safety.

3.2 Potential Future Activities

Building on the activities that are already underway, FLH can take a number of steps to further promote asset management. In the short-term, some of these activities include:

- Assisting FLH partners with implementing the new management systems rules and providing assistance in using the systems for program development and project prioritization. As part of this process, FLH may need to modify and enhance some existing tools for modeling transportation system impacts and performance of investment decisions for tradeoff analysis activities. An important part of the implementation will be a discussion of data requirements and identification of agency roles and responsibilities. The National Park Service, for example, already has a facility management system that could be integrated with FLH's pavement and bridge management systems. Other partners, however, may want FLH to maintain the data

instead of managing it themselves. This may be more appropriate for the relatively decentralized partners like the tribal governments for Indian Reservation Roads and the state and local governments for Forest Highways.

- Continuing FLH efforts to improve inventory and condition data collection for all transportation facilities covered by the Federal Lands Highway Program, particularly for facilities not owned by the Federal government. Although Federal Lands Highway already collects, or has access to, some inventory and condition data on pavement and bridges for Indian Reservation Roads and Forest Highways, the implementation of the management system rules will improve this data collection process. The goal is to complete a full assessment within the next five years. As transit and other modal options become more widely used within Federal and tribal lands, FLH will also need to develop methods for storing inventory and condition data for other modes, as well as developing tools for data analysis and modeling.

- Coordinating with the FHWA Office of Asset Management for support in developing and implementing policies and processes that reflect the asset management approach. Use of the NHI training course on Asset Management to reach out to Federal Lands Highway divisions and partners is another method to encourage the use of asset management concepts. The annual Department of Interior Facilities and Asset Management Conference might be an opportunity to offer training courses or other workshops on various aspects of asset management. An asset management liaison or staff position in Federal Lands Highway headquarters may also be an appropriate approach to promoting best practice.

In the longer-term, some potential activities include:

- Strengthening program reviews and performance monitoring to establish feedback on program development and project prioritization. FLH has made good progress with program review and data collection for the National Park Service and the U.S. Fish and Wildlife Service, but might investigate how to better monitor system performance on the Indian Reservation Roads and Forest Highways. As an additional method of monitoring performance, FLH might consider updating and conducting the "Federal Lands Highway Public Survey" at regular intervals (annual or biannual) to determine how customers perceive transportation as a result of investment strategies and priorities.

- Publicizing more widely the tri-party partnerships FLH has in 41 states would market what has often been cited as Federal Lands Highway's best example of outstanding partnerships. Through these partnerships that address interjurisdictional issues, FLH can improve information sharing and coordination among all stakeholders, and extend this concept to the other Federal land management agencies. These partnerships provide an excellent opportunity to work with state DOTs and division personnel to address needed coordination issues.

- Developing a program to encourage greater adoption of asset management concepts for tribal lands. Planning for these facilities can be challenging since there are

numerous partners. A Tribal Technical Assistance Program (TTAP) training course on asset management could be an opportunity to assist tribes and the BIA in performance-based planning. Another strategy for encouraging good asset management practice for these facilities might be to communicate benefits through best practice case studies. For example, a tribe in Wisconsin has created an innovative safety management system in collaboration with the Wisconsin Department of Transportation.

- Publishing materials that highlight Federal Lands Highway's work in asset management; for example, a video on asset management best practices among the Bureau of Indian Affairs, Bureau of Land Management, U.S. Forest Service, U.S. Fish and Wildlife Service, National Park Service, and tribal governments that can be distributed to various partners.