Phase I Report

Task 3 of 3: Recommended Research Program

Prepared for:

National Cooperative Highway Research Program
Transportation Research Board
National Research Council

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February 2002

ACKNOWLEDGMENT

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

Foreword

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

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

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

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

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

The objectives of this study are to gather information on asset management practices in the U.S. and overseas, develop a framework for transportation asset management, and apply this framework to produce a ***Transportation Asset Management Guide.*** The study is organized in two phases:

- Phase I encompasses information gathering, framework development, and recommendation of a research program; and
- Phase II deals with production of the ***Guide***.

Work to date has completed Phase I. The products of Phase I have been issued in three separate volumes:

- Task 1: A synthesis of current information and practices in asset management;
- Task 2: A comprehensive framework for transportation asset management to provide the framework for development of the ***Guide***; and
- Task 3: A prioritized program of research in asset management.

This report constitutes the third volume above, addressing asset management research needs. Identification of areas ripe for research has been informed by a number of concurrent developments:

- The formulation of a conceptual framework for transportation asset management as documented in the first volume above;
- An understanding of the current state-of-practice in asset management among state DOTs as described in the second volume above;
- Tasks identified by the AASHTO Task Force on Transportation Asset Management in its ***Strategic Plan***; and
- Priority research needs in asset management and related fields that have been identified by knowledgeable transportation executives and managers.

The recommendations of this report focus on areas of research that reflect the strategic nature of asset-management business processes and information needs. Many of the topics proposed herein are not now widely addressed in existing research programs. Certainly, asset management will also benefit from a much wider sphere of research that

will continue to be carried out at many levels and by many groups in related fields such as pavement, bridge, and maintenance management; performance-based planning and budgeting; new engineering materials and technology; Intelligent Transportation Systems (ITS) hardware and software; and new methods of delivering an agency's projects, products, and services. A conscious effort has been made in this report, however, to identify research topics that will advance the more fundamental aspects of transportation asset management as a way of doing business by state DOTs.

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Summary

Transportation asset management represents a strategic approach to managing transportation infrastructure assets. It focuses on a department of transportation's (DOT's) business processes for resource allocation and utilization with the objective of better decisions based upon better information. Recognizing its growing importance to transportation agencies worldwide, the American Association of State Highway and Transportation Officials (AASHTO) in 1998 adopted asset management as a strategic initiative, and formed a task force to develop and implement a Strategic Plan for Transportation Asset Management.

Transportation asset management builds on a set of principles to promote new ways of doing business. Redesigned planning and programming processes, updated procedures, new analytic methods, improved management systems and data leading to better information, and more effective ways of communicating DOT needs, priorities, and accomplishments are all potential elements of departmental asset management plans. Research in how to develop and apply these innovations successfully can benefit DOTs in implementing their own asset management plans. A number of research topics were envisioned, for example, in the AASHTO ***Strategic Plan***.

This report presents a prioritized program of research that would help transportation agencies advance the state of current practice in asset management. It presents 31 projects totaling almost $28 million over a 10-year period. Several of these projects are based upon goals, strategies, and tasks outlined in the AASHTO ***Strategic Plan*** and in other sources. The proposed research topics are organized in five areas important to asset management:

- Area 1 – Policy and Institutional;
- Area 2 – Information, Analysis, and Technology;
- Area 3 – Planning, Program Development, and Delivery;
- Area 4 – Training and Information Sharing; and
- Area 5 – Academic Programs and Material.

For each research topic, the report describes a problem statement and proposed research, provides cost and duration estimates, and assigns a relative priority. The selection of topics and identification of priorities were informed by the study team's concurrent review of current asset management practices by transportation agencies in the U.S. and overseas, and the team's development of a framework for a future transportation asset management guide. All of the recommended topics are worthy of conduct, and many are derived from elements of the AASHTO ***Strategic Plan***. Priorities have been assigned to recognize the fact that research funding may be limited and only selected topics can be performed within a particular time period; priorities may also imply an order or sequence in which topics should be performed. The following factors were considered in assigning priorities:

- Topics are applicable to several cross-cutting asset management themes and principles;
- It is likely that a topic would be difficult to fund through other research mechanisms;
- Topics are broadly applicable to state DOTs and other transportation agencies;
- Topics have the potential to remove a critical bottleneck or fill a gap in asset management practice;
- The logical precedence that exists among topics that collectively would build the elements of an asset management practice, discipline, or curriculum; and
- The existence of particular time constraints or other unique circumstances that would affect the scheduling to perform a research topic.

This report can serve with other documents (such as the ***Strategic Plan***) as a guide to the AASHTO Task Force, AASHTO's Standing Committee on Research (SCOR), and other panels considering potential research in asset management. The research topics that are recommended in this report are intended to be updated periodically to reflect technological advances, changing organizational and institutional structures and relationships, and shifts in transportation policies and funding.

1.0 Introduction

1.1 Background

Transportation asset management drives a more strategic approach to resource allocation decisions across transportation infrastructure assets. It provides a framework for an agency to reach decisions on investments in new capacity, system improvements, system preservation, maintenance, and operations based on better information and in a more holistic and proactive way. Asset management helps build an awareness of the importance of transportation assets – financially, economically, societally, and technically. It embodies fundamental principles of good practice that can be applied by agencies across the country representing different organizational structures, management philosophies and culture, demographic and geographic influences on transportation demand, funding situations, and institutional relationships.

Recognizing its growing importance to transportation agencies worldwide, the American Association of State Highway and Transportation Officials (AASHTO) in 1998 adopted asset management as a critical initiative, and formed a Task Force to develop and carry out a ***Strategic Plan for Transportation Asset Management***. To complete the initial tasks called for in this ***Strategic Plan***, the National Cooperative Highway Research Program (NCHRP) awarded Project 20-24(11) to this Study Team. Phase I of this project has three major tasks:

1. To synthesize current practices in asset management among public- and private-sector organizations, and infer from this information a state-of-the-art approach;

2. To develop the framework of an asset management "system" – i.e., a discipline of good asset management practice comprising principles, procedures, and tools that will underlie development of an Asset Management Guide in Phase II of the study; and

3. To recommend a prioritized program of research to benefit agencies in moving from the state of current practice documented in Task 1 to improved practice as developed in Task 2.

This report is one of three documenting the findings of Phase I. It proposes the research program that is the subject of Task 3. While it builds upon the perspectives and proposed tasks outlined in the AASHTO Strategic Plan, it also encompasses a wider set of suggestions and perceptions that have been gathered throughout the course of this NCHRP transportation asset management study. Complementing this report on research recommendations are two companion reports documenting the findings of Task 1 and Task 2, respectively.

1.2 Methodology

Transportation asset management as a comprehensive "way of doing business" is in a nascent state of development in the United States. State DOTs have in place several important elements of asset management and are continuing to pursue additional improvements. However, these developments have preceded the definition of a comprehensive framework and approach to transportation asset management. To guide the direction of a proposed research program, we have therefore looked to the following recent developments that help shape a concept of what asset management entails and what research efforts might promote its application:

- AASHTO's ***Strategic Plan for Transportation Asset Management*** outlines a 10-year program of progressive development of asset management concepts and methods and the dissemination of information and techniques;

- The Transportation Asset Management framework developed in Task 2 of this NCHRP study embodies fundamental principles of good asset management and identifies characteristics and criteria of state-of-the-art methods applicable to U.S. transportation agencies;

- Suggestions of useful research topics in asset management have been proposed by state DOT line managers and research staff during interviews conducted in Task 1 of this NCHRP study;

- Several research statements following the CEO Workshop on Managing Change in State Departments of Transportation (Minneapolis, June 25-27, 2000) are relevant to asset management and have been reviewed as part of this task; and

- The research programs of agencies interested in asset management are a source of information on current and proposed work in the field that helps to round out the research recommendations. Information has been obtained from the National Cooperative Highway Research Program (NCHRP), other units of the Transportation Research Board (TRB), the Federal Highway Administration (FHWA), the Civil Engineering Research Foundation (CERF), the Partnership for the Advancement of Infrastructure and Its Renewal (PAIR), and the National Science and Technology Council (NSTC).

The following section presents summary information from these sources to give perspectives on asset management and suggest potential agendas for research.

2.0 Strategic Visions of Asset Management

2.1 AASHTO Strategic Plan

The Strategic Plan prepared by the AASHTO Task Force on Asset Management lays out a 10-year program to meet long-term goals through a series of strategies and tasks to be pursued through AASHTO, the FHWA, and NCHRP *(1)*. The following tables describe the strategies responding to each goal. A check mark ("√") indicates that work is in prog??ress. Research needs that have not yet been developed into projects are candidates for project topics to be considered in this report.

Table 2.1 Goal 1 – Develop Partnerships with Public and Private Entities Having an Interest in and Commitment to Asset Management

Strategy in AASHTO Strategic Plan on Asset Management		Ongoing?
Strategy 1-1.	Interact with and coordinate asset management activities with other organizations.	
Strategy 1-2.	Promote sustained support for the advancement of asset management activities and research in cooperation with other organizations.	
Strategy 1-3.	Jointly sponsor workshops and seminars through partnerships with other organizations engaged in asset management.	
Strategy 1-4.	Benchmark asset management measurement used by other organizations.	

Table 2.2 Goal 2 – Develop and Document an Understanding of Asset Management and How it can be used by Member States

Strategy in AASHTO Strategic Plan on Asset Management		Ongoing?
Strategy 2-1.	Identify and document the state-of-the-art in asset management, specifically applicable to state DOTs.	√
Strategy 2-2.	Identify and document the state-of-the-practice in asset management among the AASHTO member states.	√
Strategy 2-3.	Identify knowledge and technology gaps and future research projects.	√
Strategy 2-4.	Develop a framework for asset management.	√
Strategy 2-5.	Plan appropriate AASHTO/FHWA scanning tour(s).	
Strategy 2-6.	Develop an AASHTO Glossary for asset management.	
Strategy 2-7.	Coordinate ongoing benchmarking and reassessment of metrics.	

Table 2.3 Goal 3 – Promote the Development of Asset Management Tools, Analysis Methods, and Research Topics

Strategy in AASHTO Strategic Plan on Asset Management		Ongoing?
Strategy 3-1.	Promote the development and use of management systems for asset management.	
Strategy 3-2.	Evaluate and promote the use of innovative technologies.	
Strategy 3-3.	Promote relationships with academia to develop regional centers, courses, and Master's of Science degree programs in asset management.	
Strategy 3-4.	Explore, refine, and develop methods to value assets.	
Strategy 3-5.	Promote the development of methodologies and computer software for information management of agency databases.	
Strategy 3-6.	Incorporate risk analysis into asset management.	
Strategy 3-7.	Develop and administer a "laboratory" state model.	
Strategy 3-8.	Participate in an international conference on asset management.	

Table 2.4 Goal 4 – Communicate with and Inform Member States How to Utilize Asset Management

Strategy in AASHTO Strategic Plan on Asset Management		Ongoing?
Strategy 4-1.	Communicate and share information with member states and others interested in asset management.	
Strategy 4-2.	Continue to sponsor workshops and conferences that focus on "real life" examples of asset management.	√

Table 2.5 Goal 5 – Assist Member States in Assessing and Implementing Asset Management Principles

Strategy in AASHTO Strategic Plan on Asset Management		Ongoing?
Strategy 5-1.	Develop and maintain an AASHTO Asset Management Guide.	√
Strategy 5-2.	Develop and administer a lead-state/host-state model.	
Strategy 5-3.	Provide ongoing support for member states.	
Strategy 5-4.	Explore additional training opportunities.	

Strategies responding to Goals 2 and 5 that are marked as underway represent tasks of the current NCHRP Project 20-24(11) on transportation asset management. Other items in the tables above that require research study have been considered in the research program that is recommended in later sections.

2.2 Transportation Asset Management Framework

A conceptual framework for evaluating an agency's practices in asset management has been defined in work performed in Task 2 of this NCHRP Project 20-24(11) study. The principles, characteristics of departmental decision-making processes, and criteria for evaluation that are critical to effective asset management have been defined in four major areas of a department's management functions: policy goals and objectives, planning and programming, program delivery, and information and analyses. To establish points of reference, the state-of-the-art for each evaluation criterion has also been defined. A summary of these state-of-the-art practices is presented in Tables 2.6 through 2.9 to assist DOTs in improving their asset management practice.[1]

Tables 2.6 through 2.9 are each organized in three columns:

1. The first column identifies basic characteristics of good asset management practice applicable to U.S. transportation agencies. These have been kept to a small number in each matrix to focus on the most important.

2. The second column lists specific criteria by which these characteristics can be evaluated. They identify the likely places to look in determining whether the policy guidance, management procedures, and decision culture that drive investment choices, resource allocation, and program delivery conform to the characteristics of good asset management.

3. The third column describes the current state-of-the-art of transportation asset management in each criterion. These ideal practices define benchmarks that agencies can aim toward in seeking to improve their current approach.

The matrices below together define a framework for transportation asset management in the United States. This framework will be used to develop a Transportation Asset Management Guide in Phase II of this study.

[1] While this framework of transportation asset management may be updated during development of the Transportation Asset Management Guide in Phase II, Tables 2.6 through 2.9 nevertheless provide a useful basis for considering research needs at this stage of the study.

Table 2.6 Policy Goals and Objectives: Does Policy Guidance Encourage and Provide Incentives for Good Asset Management?

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

Table 2.7 Information and Analysis: Do Information Resources Effectively Support Asset Management Policies and Decisions?

Characteristics	Criteria	Benchmark: State-of-the-Art
1. The agency maintains high-quality information needed to support asset management.	• Asset Inventory	• The agency maintains an inventory of assets that is a complete, accurate, and current description of infrastructure for which the agency is responsible or in which it has a statewide transportation interest.
	• Asset Condition	• Asset condition data are updated on a periodic schedule sufficient to meet regulatory requirements (e.g., bridge inspection data) and to provide timely and accurate information on status and performance.
	• Customer Perceptions	• Information on customer perceptions is updated regularly through surveys, focus groups, complaint tracking, or other means, to gauge public perception of asset condition and agency performance, and to respond thereto.
	• Program outputs	• Information on actual costs and accomplishments by project, asset category, work type, and location are maintained in a form that can be utilized to track actual cost versus performance and improve cost-estimation techniques.
2. Agency collects and updates asset management data in a cost-effective manner.	• Data collection technology	• The agency applies the appropriate mix of data collection technology (e.g., visual, automated, remote sensing) to provide cost-effective coverage needed to maintain the quality information base discussed above.
	• Sampling methodology	• The sampling methodology is demonstrated to be appropriate in terms of network coverage, sample size, and frequency, and in the training and team assignments needed to ensure objectivity, consistency, and repeatability.

Table 2.7 Information and Analysis: Do Information Resources Effectively Support Asset Management Policies and Decisions? (continued)

Characteristics	Criteria	Benchmark: State-of-the-Art
3. Information is automated and on platforms accessible to those needing it – relates to both databases and systems.	• System technology and integration	• The agency's management systems and databases have been updated and integrated to overcome "stovepiping," enable consistent information on all asset categories to be accessible to multiple applications, and provide managers at various organizational levels the information and tools needed for effective asset management.
	• Data administration	• Information requirements and/or standards for asset management are in place to ensure that future system and database development efforts within the agency will integrate with existing systems and meet asset management information and analysis improvement needs.
	• Geo-referencing	• Systems and information are based upon a common geographic referencing system and a common map-based interface for analysis, display, and reporting.
4. Effective Decision Support Tools are available for Asset Management.	• Strategy Analysis	• The agency has decision support tools that facilitate exploration of capital versus maintenance tradeoffs for different asset classes.
	• Project Analysis	• The agency has tools that support consistent analysis of project costs and impacts, using a life-cycle cost perspective.
	• Program Analysis	• The agency has tools that provide an understanding of the system performance implications of a proposed program of projects.
	• Program Tradeoff Analysis	• The agency has tools to help explore the system performance implications of different levels or mixes of investments across program categories or subcategories.
5. Financial value of assets.	• Conformity with GASB Statement 34	• The agency reports the value and condition of its transportation capital assets in a manner that conforms to the modified approach specified in Governmental Accounting Standards Board (GASB) standards.
	• Information support for condition and financial reporting	• Information on asset condition and the level of expenditure needed to meet target condition is available from the agency's asset management systems.

Table 2.8 Planning and Programming: Do Resource Allocation Decisions Reflect Good Practice in Asset Management?

Characteristics	Criteria	Benchmark: State-of-the-Art
1. Planning and programming procedures and criteria are consistent and reinforce policy goals and objectives.	• Fiscally constrained planning	• Development of statewide and urban area long-range plans can be demonstrated to be consistent with policy goals and objectives and with realistic projections of future revenue.
	• Program prioritization	• Funding allocation and project prioritization criteria are consistent with and support the state's and the agency's policy goals and objectives.
	• Updates and revisions	• Updates and revisions to the planning and program development process are performed regularly to reflect changes affecting asset management priorities in the arenas of: – Policy (e.g., preserving existing investments, economic development); – Technology (e.g., new design procedures or materials); or – Emerging issues (e.g., updated environmental regulations; identification of potentially catastrophic risks to asset condition or performance).
2. Planning and program development consider a range of alternatives in addressing system deficiencies.	• Planning alternatives	• Long-range planning identifies and evaluates a range of program alternatives and, as appropriate, modal alternatives to meet present and future deficiencies.
	• Project scope, cost, benefits, impact on performance	• Program development, guided by adopted plans, formulates projects of appropriate scope and develops realistic estimates of their costs, benefits, and impacts on system performance.

Table 2.8 Planning and Programming: Do Resource Allocation Decisions Reflect Good Practice in Asset Management? (continued)

Characteristics	Criteria	Benchmark: State-of-the-Art
3. Performance-based concepts guide planning, program development, and system monitoring.	• Performance-based budgeting	• Recommended programs and budgets are tied to performance budgeting concepts entailing: – Structuring of costs by activity; and – Relationship of costs to levels of service or performance measures.
	• Benchmark achievement	• The planning and programming process generates the resources required to maintain existing assets at target performance levels and at least life-cycle cost.
	• System monitoring	• Performance measures or levels of service are defined and regularly applied to quantify the impacts of program decisions and actions and to provide feedback for future planning and program priorities.
	• Reporting	• Progress toward stated programmatic system performance targets is measured and reported regularly.
4. Resource allocations and program tradeoffs are based on relative merit and an understanding of comparative costs and consequences.	• Program building	• Organization of projects within programs (program building) results from statewide competition among projects based on objective criteria.
	• Consistency	• Projects being designed and built respond to, and are consistent with, overall policy guidance for system performance.
	• Program tradeoffs	• Tradeoffs between programs (e.g., Preservation versus Improvement, or System Expansion versus Operations) are based upon analyses of life-cycle benefits and costs, rather than arbitrary formulas or historical splits.
	• Communication	• The implications of more or less resources allocated to each program are clearly communicated in terms of selected performance measures.

Table 2.9 Program Delivery: Are Appropriate Oversight Techniques Reflecting Industry Good Practices Being Implemented?

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

2.3 Research Initiatives

Research programs and proposals relevant to transportation asset management are now underway or under discussion in several national organizations. The following sketches outline the kinds of topics that are now current as related to asset management. A more exhaustive presentation of these programs is available from the respective sources.

NCHRP

The National Cooperative Highway Research Program (NCHRP) has long sponsored research studies in topics relevant to improving asset management practice: e.g., transportation organization and management, engineering of transportation facilities, supporting analytic methods and tools, performance measures, performance-based planning and budgeting, program development methods and criteria, capital and maintenance program delivery, and regulatory impacts on transportation. In addition to research reports, NCHRP syntheses of current practice provide DOTs useful summaries of current peer agency solutions to problems and sources of relevant information.

Examples of recent NCHRP projects relevant to asset management include transportation system performance measurement (Project 20-24(6)A), maintenance quality assurance (14-12), maintenance benchmarking (14-13), and incorporation of customer perceptions into transportation decision-making (20-53). Recent syntheses of highway practice have addressed engineering and methodological topics, transportation planning, capital programming, performance measurement, organizational management, and construction and maintenance practices.

State DOT Input

The NCHRP program serves as an important mechanism for accomplishment of research recommendations by AASHTO member departments. State DOT input to the NCHRP program is provided through mechanisms such as AASHTO technical committees and subcommittees, and committees of the Transportation Research Board (TRB). Current recommendations by several of these groups have been reviewed by the Study Team in developing research recommendations. In addition, the Study Team has solicited suggestions for research from DOT managers who were interviewed during the visits to state transportation agencies conducted in Task 1 of this study.

Federal Highway Administration and Federal Transit Administration

The Federal Highway Administration (FHWA) has been very active through its Office of Asset Management in furthering U.S. practice in transportation asset management. It has worked with AASHTO in the sponsorship of three national workshops on the subject. It has also taken a leadership role in documenting asset management practice, first through a Primer on Asset Management *(2)*, and more recently in a Primer on Governmental

Accounting Standards Board Statement 34 (GASB 34) *(3)*. The FHWA participates in the AASHTO Task Force on Asset Management, and will oversee the accomplishment of selected strategies and tasks in AASHTO's Strategic Plan discussed earlier.

The FHWA also pursues asset management objectives through its own research program. One objective of FHWA's program is to develop concepts, methods, and data related to tunnel management, in cooperation with the Federal Transit Administration (FTA). A second is a pilot program to introduce states to an investment analysis tool, HERS/ST. This effort will explore the applicability of HERS/ST for statewide highway planning and to determine what engineering economic analysis tools and procedures would be useful to states in considering alternative highway system improvement strategies.

Discussions with the FHWA Office of Asset Management staff have suggested several research topics for consideration in the recommendations to be made by this NCHRP study:

- Educational initiatives and development of related materials by academic institutions, ranging from an introductory graduate-level course in asset management (not necessarily limited to transportation) to an interdisciplinary Master's degree program in the subject;

- Advancement of critical elements of asset management, particularly measures of system performance, benefits, and return on investment;

- Research on performance indicators to address questions such as: What are the appropriate indicators? How are they applied, and by whom? How should they be communicated to different audiences? and

- Research to establish better or new standards of measurement of asset condition and performance: e.g., AASHTO standards for measuring typical pavement conditions such as rutting.

The FTA is expressing interest in asset management in the transit industry, in addition to involvement in the tunnel management project cited above. An FTA representative serves as liaison on the panel for this transportation asset management study, NCHRP Project 20-24(11). Examples of research that could form the basis for broader asset management work in the transit industry for both infrastructure and fleets were presented at the 2001 Annual Meeting of the Transportation Research Board.

Research and Technology Forum

The Research and Technology (R&T) Forum is a cooperative effort organized by TRB, AASHTO, and the FHWA to provide "a new framework for coordinating highway research and technology activities among research sponsors, practitioners, researchers, and other stakeholders in highway transportation" *(4)*. The intent is not to duplicate existing mechanisms for conducting, managing, and disseminating research, but rather to provide a way to coordinate the investments in highway-related research, recognizing the numerous and diverse stakeholders in highway transportation. Goals of this effort

include more effective and efficient R&T investment, greater awareness of research underway, fostering of research partnerships, and demonstration of the needs and opportunities for research and the benefit and payoff therefrom.

The R&T Forum is still in its formative stages. Five Working Groups have been proposed as the Forum's operating units in the following areas: Safety, Infrastructure Renewal, Operations and Mobility, Planning and Environment, and Policy Analysis and System Monitoring. These groups will operate at a mid-level "Tier #2" between a high-level Research and Technology Coordinating Committee at Tier #1, and existing groups and committees with interests in the research areas addressed by the Working Groups.

CEO Workshop on Managing Change in DOTs

A workshop among CEOs and senior staff of state DOTs was held in Minneapolis, Minnesota, in June 2000 to discuss experiences in managing internal and external change. The workshop was held under the auspices of TRB's Committee on Strategic Management. The workshop yielded a number of research statements, of which the following bear most closely on asset management practice (codes in parentheses identify projects as listed in the research problem statements following the workshop) *(5)*:

- Synthesis of Best Practices in Performance Measurements for Strategic Management (A-1), six months, $60,000;
- Building Strong Legislative Support for Strategic Transportation Agendas (A-3), 12 months, $150,000;
- Effectively Marketing Transportation Departments' Products and Services (A-4), six months, $50,000;
- Linking Strategic Planning to Resource and Implementation Decisions (A-5), 27 months, $190,000 (includes three phases: a survey of DOTs and other private and public organizations, detailed case studies, and "research and development of new models and guidelines");
- Impacts of Technology and Information Needs for Changed Mission (B-2), 12 months, $100,000;
- Six projects, each of six-month duration and budgeted at $50,000 apiece, to address process and program delivery-driven research needs (C-1 through C-6). (Topics include the utilization of private sector resources, internal re-engineering of project and program delivery activities, streamlining conventional procurement methods, innovative contracting methods, cooperative relationships between DOTs and other public and private entities, and owner/vendor partnering. The scopes of the projects include scanning and summarizing current practices.);
- Cross-Jurisdictional Sharing of Services Between Transportation Providers (D-1), 12 months, $100,000; and

- GASB 34 Impacts on State DOT Infrastructure Asset Management and Finance (D-3), 18 months, $325,000 (two phases are envisioned: a scan of how state DOTs are proposing to respond to the GASB 34 standards, and a review and set of case studies to assess the impacts of GASB-related financial reporting of infrastructure condition and costs on agency practices in asset management and financing).

Civil Engineering Research Foundation

The Civil Engineering Research Foundation's (CERF's) goals are to help facilitate, coordinate, and integrate research results more quickly into practice, revitalize the deteriorating infrastructure, and enhance the environment *(6)*. It has established evaluation centers for highways, buildings, environmental, and public works technology and products. It has also sought to join in the national effort for more effective and proactive infrastructure repair and renewal through the PAIR initiative as described below.

National Science and Technology Council

The National Science and Technology Council (NSTC) has developed six high-priority research thrusts for transportation research and development *(7)*. One of these topics that most closely relates to asset management is entitled, Monitoring, Maintenance, and Rapid Renewal of the Physical Infrastructure. The purpose of this initiative is to accelerate the renewal and advancement of the Nation's infrastructure through research into superior materials, more cost-effective delivery systems, and reduced waste and pollution in the production of construction materials. The NSTC envisions this effort as a collaboration among federal, state, and local agencies, managed through the PAIR initiative described below.

Partnership for the Advancement of Infrastructure and Its Renewal

Partnership for the Advancement of Infrastructure and Its Renewal's (PAIR's) goal is to accelerate innovation in the construction, repair, and maintenance of the nation's infrastructure *(8)*. Within transportation specifically, a subsidiary effort referred to as PAIR-T is envisioned as a partnership of public and private organizations to undertake investigations that supplement, not supplant, research and development by others. Part of the effort will address non-technical barriers that slow the pace of innovation and discourage industry from commercializing promising technologies. A number of proposed areas of research along this line have been developed by the PAIR-T initiative, with preliminary funding plans. However, following a panel review of the effort in 1999, the program is now revisiting its agenda to develop a more specific direction and focus of attention.

3.0 Recommended Research Program

3.1 Topic Descriptions

The material described in Section 2.0 was reviewed to compile a recommended research program. This program is presented below in terms of a problem statement, proposed approach, estimated cost, projected duration, and priority for each proposed research topic. Certain research topics may have been developed in a previous source, typically the AASHTO Strategic Plan or the CEO Workshop. In these cases the source is cited by an identifying code: e.g., SP x-y, or CEO x-y, denoting recommended topic number x-y from the AASHTO Strategic Plan or the CEO Workshop Summary, respectively. Quotations cite material taken directly from the source document. The originally estimated cost and duration in the source document are also given. However, if the findings of this NCHRP study indicate a recommended change to the scope, cost, or duration of these studies, these proposed revisions are also provided and described in a follow-up section labeled "Recommendations or Additional Comments."

The research recommendations below focus on the strategic aspects of asset management. They address topics that are not ordinarily included in more technical or operational-level research programs. The recommendations below are thus meant to complement existing research efforts, not to substitute for them or duplicate them. They add a dimension to existing research that will assist DOTs to address the more holistic and long-term aspects of asset management. Many other research projects addressing, for example, specific engineering, analytic, management, or systems problems will also contribute to asset management – the program below is not an exhaustive one, and it is not meant to cover every aspect of asset management practice. What it does provide, however, is a basis for investigating the more strategic aspects of asset management as part of an agency's way of doing business.

The proposed research topics are organized in five areas:

- Area 1 – Policy and Institutional;
- Area 2 – Information, Analysis, and Technology;
- Area 3 – Planning, Program Development, and Delivery;
- Area 4 – Training and Information Sharing; and
- Area 5 – Academic Programs and Material.

Research topics described below may be implemented as a single research project or as multiple studies, concurrently or in sequence. For consistency with the AASHTO Strategic Plan, they are assumed to be part of a 10-year research plan.

Area 1 – Policy and Institutional

1.1 Benchmark Asset Management Used by Other Organizations (SP 1-4)

Problem Statement

Transportation agencies would benefit from a comprehensive understanding of the prog??ress made in asset management by other public agencies (non-AASHTO members) and by the private sector. Awareness of progress made by other organizations avoids the cost of unnecessary duplication and repetition, promotes learning from others, and helps identify useful benchmarks to gauge progress by state DOTs.

Proposed Research

SP 1-4: "Document the impact of asset management on cost effectiveness, efficiency, customer satisfaction, and life cycles as reported by other organizations."

Recommendations or Additional Comments

Supplement the statement of Proposed Research above with the following Approach:

Approach: Perform a literature review and establish contact with public and private organizations that have been developing or implementing asset management principles. Develop a synthesis of the state-of-the-practice in asset management throughout the public and private sectors. Where exemplary examples exist, document findings with case studies. The final report should summarize the results and evaluate the applicability of current practices to state DOTs.

Note: The AASHTO Strategic Plan envisions this research as focusing on organizations other than AASHTO members. Activities in asset management by state DOTs are covered in other Strategic Plan tasks: e.g., SP 2-7, addressed in topic 1.2 below.

Estimated Cost		Estimated Duration	
SP 1-4:	$20,000	SP 1-4:	12 months
Revised:	$50,000		

1.2 Effectiveness of Asset Management Implementation (SP 2-7)

Problem Statement

Agencies and their governing bodies need to understand the benefits of asset management and progress being made toward improved practices. The effectiveness of asset management implementation may be gauged by a series of metrics and benchmarks established for this purpose. These benchmarks and metrics need to be established and updated over time.

Proposed Research

SP 2-7: The Strategic Plan lists a number of research tasks to coordinate ongoing benchmarking, to assess available metrics, and to gauge the effectiveness of asset management implementation. Among these tasks are the following:

- 2-7-1: "Document the impact of asset management on the cost effectiveness of managing transportation assets";
- 2-7-2: "Document the value of national transportation assets as a benchmark against which efficiencies can be measured";
- 2-7-6: "Survey states on appropriate parameters and benchmarks for asset management" (build on NCHRP Project 14-13, Customer-Driven Benchmarking for Highway Maintenance Activities, and use results to establish benchmarking yardsticks);
- 2-7-7: Identify measures used to evaluate asset management progress within an agency, including those used to measure efficiency, effectiveness, life cycle, customer satisfaction, and other aspects;
- 2-7-8: Identify measures that facilitate the voluntary communication between agencies on topics such as the following: management systems, productivity, life cycles of system components, and other matters;
- 2-7-9: Develop a synthesis of measures being used and desirable measures that are not used because of the unavailability of software; and
- 2-7-10: Develop and maintain a database and the related software required to store and retrieve information on benchmarking activities, update the database with the results of the biennial synthesis.

Recommendations or Additional Comments

The findings of NCHRP Project 20-24(11) indicate that DOTs may differ substantially in the factors that affect their asset management implementation, due largely to organizational and institutional differences: e.g., the structure of funded programs, the relationship between the DOT and its governing body (legislative, executive, transportation commission), state policy goals, and organizational structure, roles, and responsibilities. These differences need to be accounted for in benchmarking. Furthermore, measures of asset management benefit and effectiveness may be qualitative as well as quantitative. Recognizing the complexity of these issues, the estimates of cost and time are increased to $350,000 and 36 months, respectively.

Estimated Cost		Estimated Duration	
SP 2-7:	$200,000	SP 2-7:	24 months
Revised:	$350,000	Revised:	36 months

1.3 Build Strong Legislative Support for Strategic Transportation Agendas (CEO A-3)

Problem Statement

CEO A-3: Transportation agencies must be effective in a number of dimensions to build a successful relationship with legislatures:

- Developing and sustaining legislative buy-in for programs and initiatives;
- Reconciling a comprehensive resource allocation strategy with the local objectives and priorities of legislators;
- Objectively reporting the effectiveness of new initiatives to legislators;
- "Determining techniques most effective for positioning legislative budget and funding proposals";
- Defining transportation's priority with respect to other statewide programs and initiatives; and
- Determining the most effective means of communication between DOTs and legislatures.

Proposed Research

CEO A-3: Develop a synthesis of current practices by DOTs and other state agencies. The synthesis will describe successful approaches to interacting with legislatures and positioning priorities, summarize the outcomes, and identify keys to success. Compile a list of recommended approaches.

Recommendations and Additional Comments

This research topic should seek to identify those DOTs that have succeeded in improving relationships and communications with legislatures specifically through the application of principles of good asset management. One aspect of these principles entails the application of performance-based planning, program development, and resource allocation procedures, and the willingness of the agency to be held accountable for achieving stated targets. A second aspect is the capability of the DOT to provide the quality of information to the legislature that helps shape more effective asset management policy.

Estimated Cost		Estimated Duration	
CEO A-3:	$150,000	CEO A-3:	12 months

1.4 Improve Marketing of Transportation Asset Management (CEO A-4)

Problem Statement

CEO A-4: Transportation agencies have traditionally communicated and marketed their new initiatives and future vision ineffectively to the public. Specific issues include:

- Providing information customers need to best use the DOT's products and services;
- Increasing awareness and developing support for new initiatives;
- Improving accountability by demonstrating the value added by projects and programs;
- Communicating resource needs and proposed investments to the public; and
- Applying market research techniques to gain an understanding of customer needs in making decisions.

Proposed Research

CEO A-4:

- Summarize effective marketing techniques from public and private organizations;
- Identify and explain marketing concepts that are important to state DOTs;
- Recommend methods for DOTs to interpret customer input and apply it to decision-making processes;
- Define organizational structures that facilitate effective marketing; and
- Develop case studies illustrating the applicability of marketing to state DOTs.

Recommendations or Additional Comments

This item, as described in the CEO Workshop Summary, covers a broad range of topics. It is recommended that a portion of this project focus specifically on developing recommendations for the application of identified techniques to asset management. For example, customer feedback should be considered when determining the condition of assets. This additional scope is expected to add $25,000 to the estimated cost, bringing the total to $75,000 and extending project duration from six to nine months.

Estimated Cost		Estimated Duration	
CEO A-3:	$50,000	CEO A-3:	6 months
Revised:	$75,000	Revised:	9 months

1.5 Linking Strategic Planning to Resource and Implementation Decisions (CEO A-5)

Problem Statement

CEO A-5: Several state DOTs have initiated strategic planning initiatives. However, there has been difficulty linking these strategic plans to resource allocation and implementation decisions. Additional challenges include building in the flexibility for plans to change as needs evolve, and incorporating customer feedback into decisions.

Proposed Research

CEO A-5:

- Phase I: Survey public and private organizations to identify current practices;
- Phase II: Develop five or six case studies highlighting the most advanced organizations (studies will highlight keys to success and explore how obstacles were overcome); and
- Phase III: Develop a new model and set of guidelines to help DOTs link strategic planning to managerial resource and implementation decisions.

Estimated Cost		Estimated Duration	
CEO A-3:		CEO A-3:	
Phase I	$40,000	Phase I	6 months
Phase II	$50,000	Phase II	9 months
Phase III	$100,000	Phase III	12 months

1.6 Intergovernmental Roles in Asset Management and Coordination among State, County, and Local Agencies

Problem Statement

State DOTs have an interest in selected assets that are owned or maintained by county and local agencies. The success of a state's asset management efforts can be enhanced through more effective working relationships with local partners and exploration of a wider range of transportation solutions. One major issue is the degree to which statewide goals and objectives are reflected in local planning and programming processes. Another is the consistency of analytic models and data between state and local agencies.

Proposed Research

- Develop a synthesis of current practice and several detailed case studies highlighting successful intergovernmental arrangements in asset management. The case studies in

this topic will focus on planning and program development. Program delivery is addressed in topic 3.5.

- Evaluate each process in terms of efficiency, effectiveness, costs, and benefits. Describe the local organizational and institutional relationships and other factors affecting success.

- Develop a workshop for CEOs and upper management summarizing the findings and highlighting the implications of the recommendations.

Estimated Cost	Estimated Duration
$400,000	24 months

1.7 Updates of International Work in Asset Management

Problem Statement

Considerable international work is underway in asset management and valuation. An initial review of this work has been conducted in NCHRP Project 20-24(11). Updates of this review will keep the U.S. transportation community informed of new concepts and approaches recommended and implemented overseas. This review should also consider the local transportation organizational and institutional environment and its effect on the shaping and degree of success of the reviewed approaches.

Proposed Research

Develop a synthesis of international asset management developments, including reports and manuals of recommended asset management practice and documented implementation of specific approaches, their degree of success, factors contributing to that success, and potential for transfer to U.S. practice.

Estimated Cost	Estimated Duration
$100,000	12 months

1.8 Asset Management Implementation in Different Organizational and Institutional Settings

Problem Statement

Policies, regulations, practices, and organizational relationships established at federal, state, and local levels affect the ways in which transportation asset management can be implemented in a DOT, and may constrain an agency's latitude in making resource

allocation decisions. The organizational and institutional environments shaped by the convergence of these practices and relationships differ among agencies nationwide. A creative approach in which institutional constraints are recognized and accommodated within new procedures is typically required to achieve asset management objectives.

Proposed Research

This research will develop a set of case studies of agencies that represent different organizational and institutional environments, and that have begun to implement asset management. In each case the organizational and institutional background should be established: e.g., centralized or decentralized agency structure, relationship to executive and legislative governing bodies, program structure, funding situation, policies relating to transportation investment, partnerships with public and private groups, and so forth. The approach to asset management implementation should be explained in the context of these institutional factors: e.g., illustrating ways to promote cost-effective investment decisions given funding eligibility constraints or formula-based distributions.

Estimated Cost	Estimated Duration
$200,000	15 months

1.9 Improve Horizontal and Vertical Communication within Departments of Transportation through Managed Business Processes

Problem Statement

The need for managed business processes within state DOTs is crucial for the implementation of asset management. These processes would strengthen the use of information at key decision points and foster stronger horizontal and vertical communication throughout the organization. Horizontal communication enables a comprehensive approach that integrates data and needs across departmental functions and modes. Good vertical communication is required because senior and executive managers and political leaders need to understand and support the tactical perspective that drives work at the operational level. In turn, the field work force needs to understand the agency's mission and the decisions that dictate its actions.

Proposed Research

- Develop a synthesis of current practice and several detailed case studies highlighting communication needs and effective horizontal and vertical communication approaches within state DOTs. For example, when a state DOT begins a new initiative, such as the implementation of asset management, communication needs include increasing the key staff's understanding of the initiative and coordinating the implementation efforts of multiple department units. For example, PennDOT has demonstrated an effective horizontal integration approach during its development of an asset management strategic plan by holding a departmental vision workshop to review the proposed

framework, tasks, and intended benefits associated with the initiative. This vision workshop provided the benefit of both team-building and knowledge-building. While it succeeded in communicating the importance of asset management to the department, it also fostered the improved communication channels across departmental units that are needed for successful implementation of asset management.

- Develop a list of recommendations to fill the gaps between the identified needs and current approaches. For example, a common vertical communication issue at DOTs is a disjoint between the information needs of decision-makers (e.g., type, amount, and accuracy) and the needs assumed by the workers responsible for data collection. The design of departmental databases and management systems likewise can be improved to foster stronger communication.

- Develop a workshop for CEOs and upper management summarizing the findings and highlighting the implications of the recommendations.

Estimated Cost	Estimated Duration
$400,000	24 months

1.10 Policy Implications of GASB Statement 34 Reporting[2]

Problem Statement

GASB Statement 34 requires periodic financial reporting of the value, condition, and level of expenditure related to transportation and other infrastructure owned by state and local agencies. GASB allows agencies to use either a depreciation approach or a modified approach employing the agency's asset management systems as the basis of reporting. While GASB prescribes methodologically what is to be done if future expenditures are not sufficient to maintain transportation network condition to the target specified in the modified approach, the political implications of missed targets have not been explored. DOTs are also unsure of the most appropriate way to set the condition and the expenditure targets, and when they need to be set in relation to the reporting date.

Proposed Research

Most DOTs will begin data processing for GASB reporting beginning in June 2001. A meeting is planned in April 2001 under the auspices of AASHTO to discuss how states intend to meet these reporting standards. The proposed research is to conduct follow-up studies with those DOTs that employ the modified method, to determine and compare: 1) what policies are used to establish condition and associated expenditure targets; 2) how

[2]Statement 34, issued by the Governmental Accounting Standards Board (GASB), sets standards for financial reporting by state and local agencies. A change introduced by Statement 34 is to include information on the value, condition, and expenditures related to transportation and other infrastructure assets within these financial reports.

departmental information and management system analyses are used to support the establishment of these targets; 3) the degree of confidence that a department attaches to its ability to meet projected targets; and 4) what steps would be taken if the targets were not met over some extended time. This information will be gathered through interviews of agency personnel, summarized in a synthesis report, and presented at a workshop or other forum.

This topic should be coordinated with topic 3.4.

Estimated Cost	Estimated Duration
$300,000	18 months

1.11 Improve Public Relations and Understanding of Asset Management Efforts

Problem Statement

While undertaking asset management improvements will directly affect a DOT's business processes, the advantages may not be apparent to or easily understood by the public. Developing public buy-in and increasing the public's understanding of asset management will make implementation easier and improve the credibility and transparency of resource decisions.

Proposed Research

Develop a synthesis of current public relations, educational, and reporting policies at state DOTs. Use the synthesis and the results from topics 1.4 and 4.4 to develop a set of recommendations for improving the public's understanding of the strategic resource allocation process and educational material geared to non-technical audiences.

Estimated Cost	Estimated Duration
$125,000	9 months

Area 2 – Information, Analysis, and Technology

2.1 Evaluate and Promote Use of Innovative Technologies That Enhance Asset Management (SP 3-2)

Problem Statement

Technological advances have the potential to improve the efficiency and cost effectiveness of asset management if their applicability and expected benefits are recognized. Given the

tremendous pace of innovation, it is difficult for individual state DOTs to allocate the human and financial resources needed to evaluate currently available technology, let alone the technological advances that will become available in the near future.

Proposed Research

SP 3-2:

- SP 3-2-1: "Develop a synthesis of transportation technologies… These technologies should induce equipment, materials, and operation systems that are under development and will be most likely deployed within the next 10 years" ($300,000);
- SP 3-2-2: "Evaluate impact of innovative technologies on current facilities and evaluate their applicability and deployment within an asset management system" ($300,000); and
- SP 3-2-3: "Determine the use and capture of data resulting from emerging methods of measurement" ($300,000).

Recommendations or Additional Comments

Address SP 3-2-3 in topic 2.2, reducing the estimated cost of this topic by $300,000.

The scope of this topic should be expanded to include the analysis of technology in terms of potential implications to state DOT procedures or organizational roles and responsibilities (i.e., additional services that can be provided or improvements in quality or level of service provided). This analysis is expected to add $200,000 to the estimated cost.

Estimated Cost		Estimated Duration	
SP 3-2:	$900,000	SP 3-2:	72 months
Revised:	$800,000		

2.2 Incorporation of Field Sensing and Real-Time Information within Asset Management (Related to SP 3-2-3)

Problem Statement

A key component of asset management is the ability to monitor system performance and to apply these data to decisions on resource allocation. Agencies should apply the appropriate mix of data collection technology (e.g., visual, automated, remote sensing) to provide the cost-effective coverage needed to maintain the quality of this information. Improved collection procedures will have positive impacts on the time and money required to gather data and on the quality of the data collected.

Proposed Research

Develop a synthesis of current data collection techniques. Define unmet needs. Identify technologies that are currently available or scheduled to be available within the next 10 years. Analyze the applicability of these technologies to asset management and their costs and benefits. Based on the findings, develop a guideline for improving the efficiency and cost effectiveness of data collection and monitoring. The findings should also include a section that defines the scope for product development initiatives necessary to address monitoring needs related to the management of transportation systems.

Estimated Cost	Estimated Duration
$300,000	24 months

2.3 Information Quality Assurance Program

Problem Statement

Every area of effective asset management should be supported by good information. Currently, many state DOTs store data on transportation system inventory, condition, performance, and use in several locations and assign various parties the responsibility for its management. In addition, several collection methodologies (i.e., procedures, timing, and sampling techniques) are used. Decisions based on a collection of data are only as good as the data subset of the lowest quality. A quality assurance program that is flexible across several collection technologies and that recognizes the different management needs to which information on the transportation system is applied would standardize data management procedures, assure the completeness, accuracy, and timeliness of needed information, provide greater data integrity, and promote cost effectiveness by reducing duplication and encouraging more efficient collection procedures.

Proposed Research

Develop a quality assurance framework applicable to asset management based on a literature review and a synthesis of current practice by transportation agencies, other public agencies, and the private sector. Take into account the auditing of information and management system applications that may be conducted to ensure compliance with the modified approach allowed by GASB Statement 34. Design a workshop based on the framework that can be given to state information officers and managers.

Estimated Cost	Estimated Duration
$400,000	24 months

2.4 *Management System Enhancements for Asset Management (SP 3-1)*

Problem Statement

The decision-support capabilities needed to support good asset management require strengthened management and information systems, information reporting, and analytical tools. While DOTs have made great strides in developing and implementing management systems in the past 40 years, these systems are directed toward specific, individual asset classes or departmental functions. The strategic premise of asset management and its need for improved communication in decision-making require a more integrated approach, and the creation of new tools to fill gaps in current departmental analytic capabilities.

Proposed Research

SP 3-1: The Strategic Plan includes three tasks in this research topic:

- SP 3-1-1 explores "integrating the management systems into a cohesive transportation asset management system"; this task entails reviewing current analytical tools, evaluating the potential and applicability of integration, and developing recommended tools and software ($400,000);

- SP 3-1-2 involves "the development of individual management systems where none currently exist or where they are rudimentary"; this task entails identifying gaps in the systems currently in use or under development, and developing software to fill these gaps ($265,000, revised to $500,000); and

- SP 2-1-3 promotes "the development of tools to support coordination between the modal systems" within and between transportation agencies; again, gaps should be identified, and tools should be developed to fill these gaps ($2,000,000).

Recommendations or Additional Comments

It is recommended that the scope of this research topic be broadened to include two additional tasks.

- The first is the investigation and description of successful approaches to adapt and incorporate existing legacy systems within a modern asset management system framework. Case studies of successful initiatives will serve as the foundation for a set of recommendations ($500,000); and

- The second deals with the need to develop additional management system reports for decision-making, particularly for executives and for communication with an agency's governing bodies. Because the specifics of such reports will vary by state, the objective should be a guide to the type of information, suggested formats, and useful comparisons that can be included in such reports, and the technology available to produce them ($200,000).

These additions and revisions above bring the total estimated cost of this research topic to $3,600,000. Estimated duration is extended to five years.

Estimated Cost		Estimated Duration	
SP 3-1:	$2,665,000	SP 3-1:	36 months
Revised:	$3,600,000	Revised:	60 months

2.5 Databases and Information Management (SP 3-5)

Problem Statement

An underlying theme in asset management is that policy formulation, resource allocation, and management accountability are supported by current, accurate, and useful data. Surveys of how management systems and information are used at different organizational levels of transportation agencies suggest that timely and effective information is not always available to support these decisions and processes, particularly at executive management levels.

Proposed Research

SP 3-5: The topic encompasses two research tasks:

- SP 3-5-1: "To evaluate data management needs, methods, and software to support asset management activities" by analyzing the applicability of existing asset management systems and synthesizing database systems currently used by member agencies; this effort will lead to the definition of a software development project ($300,000); and

- SP 3-5-2: To develop the software package that has been recommended; the final product will than be marketed as AASHTOWare ($700,000).

Recommendations or Additional Comments

This research is directly tied to the work proposed in topic 2.4. Coordination is necessary to insure that all tools and systems are compatible with each other and with a common database. Specific issues that should be addressed include data warehousing that enables parties to have access to all required data, and a common linear- or geo-referencing system.

Database development involves significant design, production, testing, documentation, and implementation, and may entail appointment of a task force to oversee the process. The budget for this item is therefore increased to $3,000,000.

Estimated Cost		Estimated Duration	
SP 3-5:	$1,000,000	SP 3-5:	60 months
Revised:	$3,000,000		

2.6 *Engineering/Economic Analysis Methods and Tools (SP 3-6)*

Problem Statement

There is a need to develop and promote new and existing optimization and analysis tools that are compatible with, and complement the capabilities of, legacy management systems. These tools would enable engineering-economic analyses of investment options, impacts of deferred maintenance, capital-maintenance tradeoffs, relationships among costs, benefits, and system performance, and analyses of risk. They would supplement and strengthen decision-support capabilities in an agency's existing management systems.

Proposed Research

SP 3-6:

- SP 3-6-1: "Review current methods used by states to perform economic evaluations"; describe useful methods and identify tools that need to be developed ($300,000); and
- SP 3-6-2: "Develop engineering/economic tools (e.g., benefit/cost, Life-Cycle Cost Analysis (LCCA), risk analysis)"; create a how-to manual and a training course for the tools ($1,100,000).

Recommendations or Additional Comments

The scope of the research topic described in the AASHTO Strategic Plan should be expanded to include the development of promotional material for tools that are currently available, yet under-utilized. It is estimated that this item would add $50,000 to the estimated cost of this research topic. In addition, it is noted that these tools should all be developed to be compatible with systems improved and developed through work in topics 2.4 and 2.5.

Software development involves significant design, production, testing, documentation, and implementation, and may entail appointment of a task force to oversee the process. The budget for this item is therefore increased to $5,000,000.

Estimated Cost		Estimated Duration	
SP 3-6:	$1,400,000	SP 3-6:	72 months
Revised:	$5,000,000		

2.7 *Impacts of Changed Mission on Technology and Information Needs (CEO B-2)*

Problem Statement

CEO B-2: A state DOT's IT strategy should complement its overall mission and reflect its organizational goals and responsibilities. As missions evolve, IT requirements change.

There is a need to improve the management of IT-related issues (i.e., system development and resource allocation) created by movement in new directions by transportation agencies.

Proposed Research

CEO B-2: Develop four to six case studies highlighting successful efforts of planning for and managing the impacts of mission changes on IT budgets and personnel, and on the structure of organizations.

Recommendations or Additional Comments

This item, as described in the synthesis of the CEO Workshop, covers several issues. However, it is recommended that a subset of the project (three to four case studies) be funded to address specifically the impacts on IT strategies of changes driven by asset management as an agency priority. It is estimated that this focused effort will itself require $70,000 in a 12-month period.

Estimated Cost		Estimated Duration	
CEO B-2:	$100,000	CEO B-2:	12 months
Revised:	$70,000		

Area 3 – Planning, Program Development, and Delivery

3.1 Transportation Performance Measures for Asset Management

Problem Statement

Many transportation agencies have developed system performance measures to help track the impacts of program investments, maintenance, and operations improvements. These performance measures are usually technical in nature, capturing an engineering or operational attribute of the transportation system. A review of these measures is needed to assess their usefulness for asset management: e.g., their application in tradeoff analyses.

Proposed Research

Develop a synthesis of current transportation performance measures. Analyze the usefulness and effectiveness of these measures as a basis for identifying needs in planning, as expressions of program objectives or targets, in program tradeoff analyses, as a basis for performance budgeting, in communicating outcomes of investment levels, for monitoring system performance, and other applications of asset management. As a separate study component, identify high-level performance measures that have been defined specifically for executives and political leadership. These high-level measures may be non-technical, and express trends in program accomplishment (i.e., Is the program meeting its targets?

How does this year compare to last year?) rather than capturing an engineering level of performance.

Recommendations or Additional Comments

This topic was suggested by a research project proposed at the CEO Workshop and applies it specifically to asset management. For reference, the original CEO Workshop recommendation is summarized as follows:

CEO A-1 Problem Statement: State DOTs currently rely on performance monitoring in varying degrees to aid decision-makers at the operational and programmatic levels. Selected agencies have recently attempted to develop and implement measures for strategic planning and management initiatives. There is a need to consolidate the lessons learned from these states.

CEO A-1 Proposed Research: Develop a synthesis of current performance monitoring practices at the strategic level. The synthesis will identify:

- The purpose of measurement systems;
- The measurements being monitored and their relation to performance;
- The targeted audience; and
- Methodologies for utilizing the data to improve the effectiveness of the DOT.

The CEO Workshop recommended funding of $60,000 for a six-month study. The cost and duration recommended for the asset management study are as indicated below.

Estimated Cost	Estimated Duration
$150,000	12 months

3.2 Methods to Establish Transportation Performance Targets

Problem Statement

Certain state DOTs define targets to which current conditions can be objectively compared to determine whether the transportation system is performing acceptably. The basis on which these targets are set varies by DOT, and there is no universally accepted methodology for establishing these. Guidance in establishing such targets would also assist agencies using the modified method for GASB financial reporting of transportation infrastructure assets.

Proposed Research

The research proposed for this topic is an extension of the work in topic 3.1. It includes developing a framework for establishing performance targets, recognizing that these

targets will vary among states and by management judgment. Rather than recommend specific target values, the framework will establish a methodology for addressing targets among key performance measures and offer a range of alternatives as guidance. The recommendations should be derived from a synthesis of current practice and a literature review.

Estimated Cost	Estimated Duration
$300,000	24 months

3.3 Models to Analyze Multimodal Tradeoffs

Problem Statement

NCHRP Project 8-36A (Task 7) will develop a framework for analyzing multimodal tradeoffs for planning and program development. There are several situations in which such a framework can assist in asset management decisions: e.g., in evaluating competing modal projects for system expansion or improvement, and in assessing modal impacts (as on transit) of choices between system improvement/expansion and system preservation. This multimodal framework is also consistent with the more "strategic" or "corridor-based" view of projects now being adopted by several DOTs. The methodology for analyzing multimodal tradeoffs is one of the specialized analytic procedures that agencies will maintain in their toolkit to conduct more effective asset management.

Proposed Research

Identify three DOTs to serve as candidates for trial applications of the multimodal tradeoff methodology within an asset management context. Within each selected agency, develop the multimodal framework into a workable, practical procedure by defining models and parameter values appropriate to the agency's transportation system, economic and demographic characteristics, policies and levels of service, and program and funding structure. Develop case studies illustrating the application of the approach to tradeoff analyses and decisions in asset management. Seek a variety of modes to be addressed across the several agencies participating. Document the several case studies in a report.

Estimated Cost	Estimated Duration
$300,000	24 months

3.4 Impacts of GASB 34 Standards on Asset Management and Valuation (SP 3-4, CEO D-3)

Problem Statement

CEO D-3: Significant uncertainties exist among state DOTs and local agencies regarding the requirements of GASB Statement 34. For example, it is unclear if there is a best approach and if the end results will be consistent or useful. In addition, work in this area is being done in isolation on a state-by-state basis. This lack of coordination will likely increase the costs and decrease the consistency of responses. Failure to meet the requirements of Statement 34 may result in an increase in the cost of borrowing funds for transportation projects and programs.

Proposed Research

CEO D-3: There are two phases to this topic.

- Phase I consists of a quick scan to determine how states are planning to address GASB-34 requirements ($75,000); and

- Phase II entails developing a synthesis of current valuation, reporting, and financing strategies based on the results of a written survey and literature review. Innovative strategies would be examined in more detail through case studies. The impacts on state DOTs that have adopted these approaches would be compared to the status quo to determine the net effects of these initiatives ($150,000).

SP 3-4:

- Summarize current valuation practices and recommend alternatives for valuing assets ($200,000); and

- "Research the economic issues involved with valuing assets from a transportation system perspective." Develop a practical methodology and "publish a guide for the economic evaluation of the transportation system" ($400,000).

Recommendations or Additional Comments

The studies described, respectively, in the Strategic Plan and the CEO Workshop Summary overlap. They should be combined into one research topic that includes the following steps.

- Perform a quick scan of the valuation methods proposed by state DOTs ($50,000);

- Draft a more detailed synthesis and in depth case studies of successful strategies for meeting GASB standards ($150,000);

- Develop a valuation framework and a practical guide for state DOTs that encompasses the modified and the depreciation methods, illustrates how agency information and

management systems can be applied to meeting GASB reporting, and describes how financial reports meeting GASB standards can be applied to asset management ($100,000); and

- Design a workshop that summarizes the findings and can be given to agency executives and financial managers ($50,000).

The estimated cost of this revised scope is $350,000. The expected duration is two years. This topic should be coordinated with topic 1.10.

Estimated Cost		Estimated Duration	
SP 3-4:	$600,000	SP 3-4:	36 months
CEO D-3:		CEO D-3:	
Phase I	$75,000	Phase I	6 months
Phase II	$150,000	Phase II	12 months
Revised:	$350,000	Revised:	24 months

3.5 Cross-Jurisdictional Sharing of Services between Transportation Providers (CEO D-1)

Problem Statement

CEO D-1: Several state DOTs have developed cross-jurisdictional relationships with local transportation agencies to share resources and responsibilities. However, this work is being done largely in isolation and there is no means of sharing information and lessons learned with other states. The result is the potential loss of savings by agencies that are unaware of these opportunities.

Proposed Research

CEO D-1 Summary: Identify ongoing cross-jurisdictional transportation agreements and programs. Examples include arrangements for maintenance services, signal management, pavement markings, ITS services and facilities, and video conferencing networks. Evaluate each program in terms of costs, benefits, and implementation challenges. Develop a synthesis and objective evaluation of the identified programs.

Recommendations or Additional Comments

Sharing services between transportation providers is addressed in this document because the asset management framework includes project delivery. In addition, coordination among service providers is complementary to a creating and sustaining a comprehensive view of resource allocation. This proposed scope of this item covers a small portion of the much broader objective established in topic 1.6.

Estimated Cost		Estimated Duration	
CEO D-1:	$100,000	CEO D-1:	12 months

Area 4 – Training and Information Sharing

4.1 Develop a Glossary for Asset Management (SP 2-6)

Problem Statement

As states begin to share information on asset management and fund related research proj??ects collectively, a standard terminology related to the field is necessary. Without a common language, agencies will continue to develop state-specific terms that impede the progress of such collaborative efforts.

Proposed Research

SP 2-6: Develop and publish a glossary of asset management terminology. The glossary will be derived from a literature review of both the public and private sectors and the results of NCHRP Project 20-24(11).

Recommendations or Additional Comments

The glossary should draw from usage in AASHTO, TRB, Strategic Highway Research Program (SHRP), or other recognized, standardized references to establish a common understanding of terms. Because state-specific usage may be embedded in definitions of programs, capital or maintenance activities, state statute, union agreements, and so forth, it may be difficult to establish a common nomenclature in practice. However, the glossary could be used as a basis for cross-referencing state-specific terms to the glossary.

Estimated Cost		Estimated Duration	
SP 2-6:	$60,000	SP 2-6:	12 months

4.2 Share Information with Member States and Others Interested in Asset Management (SP 4-1)

Problem Statement

There is no means for state DOTs to communicate their advances, challenges, and lessons learned in asset management with one another on an as needed basis. The result is frequent duplication of efforts and a general unawareness of potential opportunities.

Proposed Research

SP 4-1: Several tasks are included in the Strategic Plan: e.g., develop a web site, educational brochures, a quarterly newsletter, a set of standard presentations, and videos that promote asset management principles and advances. The material should target various audiences, such as CEOs, legislators, and the general public.

Estimated Cost		Estimated Duration	
SP 4-1:	$720,000	SP 4-1:	60 months

4.3 Maintain the AASHTO Asset Management Guide (SP 5-1-2)

Problem Statement

The initial development of the Guide will be a product of Phase II of NCHRP Project 20-24(11). Maintenance and updating of the Guide thereafter should be performed periodically.

Proposed Research

SP 5-1-2: A Task Force Subcommittee will monitor developments in asset management and determine whether updates to the Guide are needed, and if so, how they should be accomplished. The Guide will be updated as needed, and revisions published and distributed.

Recommendations or Additional Comments

The Asset Management Guide developed in Phase II of NCHRP Project 20-24(11) will likely evolve to a web site accessed via the Internet. Future updates to the Guide may therefore encompass the following types of projects:

- Initial development of the web site and establishment of linkages to related sites.
- Periodic updates of Guide content, format, and linkages to address advances in asset management process and tools and progress in the implementation of asset management by state DOTs. The study team envisions two major overhauls of the Asset Management Guide content to be conducted at 24- to 30-month intervals.
- General web site maintenance and customer support of the web site, including minor updates to the site to accommodate findings from future asset management studies, adding and deleting links to outside documents, and revising the format of the Guide in response to new requirements of the hosting server.

These may be accomplished in conjunction with revisions to, or reissue of, the printed version of the Guide, depending upon perceived need and the desired medium for distribution of the Guide among members of the transportation community.

Estimated Cost		Estimated Duration	
SP 5-1-2:	$800,000	SP 5-1-2:	60 months

4.4 Develop and Administer a "Laboratory" State Model (SP 3-7)

Problem Statement

As the coordination of asset management efforts evolves, it is important to create a "laboratory" state model that facilities the experimental implementation of frameworks and methodologies and evaluates their effectiveness. Lessons learned from test runs have great potential to save other agencies time and money, as approaches can be modified before wide spread implementation.

Proposed Research

SP 3-7:

- SP 3-7-1: "Appoint a task force subcommittee to seek volunteer state(s) to work with the task force on utilizing promising asset management approaches and evaluating their effectiveness" ($50,000);
- SP 3-7-2: "Publish reports and results in a format that provides other agencies with the methods to replicate the asset management approaches utilized" ($100,000); and
- SP 3-7-3: "Integrate the most promising outcomes into a lead-state program" ($2,000,000).

Recommendations or Additional Comments

Effective sharing of information will be important in this topic, because the success of particular approaches in an agency may depend upon the management philosophy and culture, funding and program structure, policy goals and objectives, and other factors local to that agency. It will therefore be useful to consider a number of case studies, and to discuss results at a workshop as part of the transition of successful strategies to a lead-state program.

Estimated Cost		Estimated Duration	
SP 3-7:	$2,150,000	SP 3-7:	102 months

4.5 Develop and Administer a Lead-State/Host-State Model (SP 5-2)

Problem Statement

Promising strategies for asset management need to be "pilot tested" in a "lead state" to identify practical factors affecting implementation, and to develop "know-how" that can be shared with other states in a region to promote more widespread and efficient implementation among many states.

Proposed Research

SP 5-2: "Solicit one or more volunteer states per AASHTO region to be lead states for specific task areas, such as pavement management, congestion, safety, and testing models." Coordinate communication between lead state and other states in that region, and between lead states to share insight, lessons learned, and "how-to" information to other states in the region.

Recommendations or Additional Comments

Asset management promotes a more holistic, long-term view of managing transportation infrastructure. In lieu of lead-state focus on specific technical areas such as pavement management, congestion, and so forth, it is recommended that lead-state efforts focus on more fundamental decision processes and resource allocation issues: e.g., capital-maintenance tradeoffs in preserving the transportation system; performance measures best suited to tracking customer impacts of investment, maintenance, and operating decisions; and packaging of information most useful to agency executives and to governing bodies. These efforts should be focused, and completed within a shorter period of time than initially recommended to allow for evaluation and mid-course correction. Follow-up efforts, if needed, can be identified and funded based upon the results of this topic.

Estimated Cost		Estimated Duration	
SP 5-2:	$720,000	SP 5-2:	90 months
Revised:	$500,000	Revised:	60 months

4.6 Explore Additional Training Opportunities (SP 5-4)

Problem Statement

As progress in asset management research is made, an effective training program is needed to facilitate the transition from study recommendations and a conceptual framework to actual implementation by state DOTs.

Proposed Research

SP 5-4: Develop and maintain an asset management training program. Distribute the program to the National Highway Institute (NHI), AASHTO members, FHWA, academia, and others. Conduct surveys every two to three years to monitory the training needs of state DOTs. Revise the training program periodically in response to the survey results and as research results become available.

Recommendations or Additional Comments

It is assumed that when individual deliverables are taken as a collective body of training material, information on some aspects of asset management will overlap, and that the relationships between certain sets of recommendations will be unclear or appear to be inconsistent. This topic coordinates in a clear and practical manner the considerable material that will result from other research topics.

Estimated Cost		Estimated Duration	
SP 5-4:	$520,000	SP 5-4:	93 months

Area 5 – Academic Programs and Material

5.1 Promote Relationship with Academia to Develop Courses and Degree Programs (SP 3-3)

Problem Statement

Asset management represents a strategic commitment by transportation agencies to improved business processes, procedures, information, and management. Young professionals who in the future will be serving in transportation agencies, or in public or private organizations that interact with DOTs, may wish to make transportation asset management a focus of their academic preparation, or to participate in educational or programs reflecting an asset management perspective.

Proposed Research

SP 3-3: This topic investigates mechanisms to promote relationships between the transportation and the academic communities:

- SP 3-3-1: "Identify the formal education needs of practitioner that can be met by academia," including specific courses, degree programs, and work/study programs ($10,000);

- SP 3-3-2: Asses the need for academic centers to evaluate application tools, develop management strategies, establish the relationship between materials selection and

life-cycle costs, and identify the impact of new hardware and materials on asset management ($20,000); and

- SP 3-3-3: "Meet with interested academic institutions to establish appropriate programs to advance asset management goals" ($20,000).

Recommendations or Additional Comments

This topic addresses only the establishment of a dialogue with academic institutions to identify potential scholastic contributions to asset management. It does not include specific educational or research projects.

Estimated Cost		Estimated Duration	
SP 3-3:	$50,000	SP 3-3:	12 months

5.2 Support the Development of Asset Management Curricula and Stipends

Problem Statement

The breadth of asset management moves the subject beyond traditional academic programs in, for example, engineering or management. New undergraduate and graduate offerings would strengthen academic curricula dealing with asset management, and would complement existing courses in engineering, management, economics, analytic methods, and information processing.

Proposed Research

A task force subcommittee will work with the academic community, based upon findings of topic 5.1, to select specific asset management initiatives and to recommend the necessary funding thereof. These initiatives will include the following:

- Identify appropriate methods to fund asset management initiatives at academic institutions. These methods may include, but are not limited to, curriculum development grants, faculty stipends for case study development, and student fellowships and assistantships;

- Develop new undergraduate and graduate courses that build upon existing course offerings to provide an overview of asset management, to illustrate the broad nature of resource allocation decisions across capital, maintenance, and operating programs, to consider different types of assets within a unified framework, to illustrate the value of good information at all stages of asset management, and to build a solid understanding of performance-based planning, program development, and budgeting; and

- Investigate the demand for, and feasibility of, an interdisciplinary, graduate-level program in asset management, and if indications are positive, promote development of this program. While the outline of this program remains to be determined, it is

envisioned to incorporate graduate-level subjects from several disciplines relevant to asset management: e.g., transportation infrastructure performance, public sector management and finance, microeconomics and life-cycle cost applications, analytic methods for decision-making and statistical sampling, performance-based planning and budgeting, and information processing for executives. Funding for development of new courses can be considered as noted in the preceding bullet.

Estimated Cost	Estimated Duration
$6,000,000	96 months

3.2 Prioritized Program

The following matrices indicate the relative priority of each topic on a scale of one to five, with five being the highest priority. Priorities were based upon the relative importance to asset management within the framework described in Section 2.2, relative urgency of the topic, and the perceived relevance to state transportation agencies across the country. The recommended costs and durations from Section 3.1 are also included.

1. Policy and Institutional

Research Topic (Reference to Source)	Priority	Estimated Cost ($000)	Estimated Duration (months)
1.1 Benchmark asset management used by other organizations *(SP 1-4)*.	2	50	12
1.2 Effectiveness of asset management implementation *(SP 2-7)*.	4	300	36
1.3 Build strong legislative support for strategic transportation agendas *(CEO A-3)*.	3	150	12
1.4 Improve marketing of transportation asset management *(CEO A-4)*.	2	75	9
1.5 Linking strategic planning to resource and implementation decisions *(CEO A-5)*.	3	190	27
1.6 Intergovernmental roles in asset management and coordination among state, county, and local agencies.	4	400	24
1.7 Updates of international work in asset management.	1	100	12

1. Policy and Institutional (continued)

Research Topic (Reference to Source)	Priority	Estimated Cost ($000)	Estimated Duration (months)
1.8 Asset management implementation in different organizational and institutional settings.	5	200	15
1.9 Improve horizontal and vertical communication within departments of transportation.	4	400	24
1.10 Policy implications of GASB Statement 34 reporting.	4	300	18
1.11 Improve public relations and understanding of asset management efforts.	2	125	9

2. Information, Analysis, and Technology

Research Topic (Reference to Source)	Priority	Estimated Cost ($000)	Estimated Duration (months)
2.1 Evaluate and promote use of innovative technologies that enhance asset management *(SP 3-2)*.	3	800	72
2.2 Incorporation of field sensing and real-time information within asset management *(SP 3-2-3)*.	4	250	12
2.3 Information quality assurance program.	3	400	24
2.4 Management system enhancements for asset management *(SP 3-1)*.	5	3,600	60
2.5 Databases and information management *(SP 3-5)*.	4	3,000	60
2.6 Engineering/economic analysis methods and tools *(SP 3-6)*.	5	5,000	72
2.7 Impacts of changed mission on technology and information needs *(CEO B-2)*.	3	70	12

3. Program Development and Delivery

Research Topic (Reference to Source)	Priority	Estimated Cost ($000)	Estimated Duration (months)
3.1 Transportation performance measures for asset management.	4	150	12
3.2 Methods to establish transportation performance targets.	3	300	24
3.3 Models to analyze multimodal tradeoffs.	4	300	24
3.4 Impacts of GASB 34 standards on asset management and valuation methods *(SP 3-4, CEO D-3)*.	5	350	24
3.5 Cross-jurisdictional sharing of services between transportation providers (*CEO D-1)*.	3	100	12

4. Training and Information Sharing

Research Topic (Reference to Source)	Priority	Estimated Cost ($000)	Estimated Duration (months)
4.1 Develop a glossary for asset management *(SP 2-6)*.	1	60	12
4.2 Share information with member states and others interested in asset management *(SP 4-1)*.	2	720	60
4.3 Maintain the AASHTO Asset Management Guide *(SP 5-1-2)*.	3	800	60
4.4 Develop and administer a "laboratory" state model *(SP 3-7)*.	4	2,150	102
4.5 Develop and administer a lead-state/host-state model *(SP 5-2)*.	3	500	60
4.6 Explore additional training opportunities *(SP 5-4)*.	4	520	93

5. Academic Programs and Material

Research Topic (Reference to Source)	Priority	Estimated Cost ($000)	Estimated Duration (months)
5.1 Promote relationship with academia to develop courses and degree programs *(SP 3-3)*.	5	50	12
5.2 Support the development of asset management curricula and stipends.	4	6,000	96

3.3 Summary of Deliverables

The following matrices summarize the deliverables proposed for each item. Considering only the columns in which bullets may be entered:

- A bullet in the first column indicates a synthesis of current practice or a more detailed case study;
- A bullet in the second column indicates a report, brochure, or other written product;
- A bullet in the third column indicates production of an information technology product: e.g., database, computerized analytic tool, management system, etc.;
- A bullet in the fourth column indicates development of training material, conduct of a workshop, or participation in a workshop or conference with prepared material on the asset management topic; and
- A bullet in the last column indicates work on academic material: e.g., course syllabus, outline, and lecture notes; case studies to be used in a course; or definition of an academic program.

1. Policy and Institutional

Research Topic	Case Studies or Synthesis	Report	Software or IT Product	Training Material or Workshop	Academic Material
1.1 Benchmark asset management used by other organizations *(SP 1-4)*.	●				
1.2 Effectiveness of asset management implementation *(SP 2-7)*.	●	●	●		
1.3 Build strong legislative support for strategic transportation agendas *(CEO A-3)*.	●	●			
1.4 Improve marketing of transportation asset management *(CEO A-4)*.	●	●			
1.5 Linking strategic planning to resource and implementation decisions *(CEO A-5)*.	●	●			
1.6 Intergovernmental roles in asset management and coordination among state, county, and local agencies.	●	●		●	
1.7 Updates of international work in asset management.	●				
1.8 Asset management implementation in different organizational and institutional settings.	●				
1.9 Improve horizontal and vertical communication within departments of transportation.	●	●		●	
1.10 Policy implications of GASB Statement 34 reporting.	●			●	
1.11 Improve public relations and understanding of asset management efforts.	●	●			

2. Information, Analysis, and Technology

Research Topic	Case Studies or Synthesis	Report	Software or IT Product	Training Material or Workshop	Academic Material
2.1 Evaluate and promote use of innovative technologies that enhance asset management *(SP 3-2)*.	●	●			
2.2 Incorporation of field sensing and real-time information within asset management *(SP 3-2-3)*.	●	●			
2.3 Information quality assurance program.	●	●		●	
2.4 Management system enhancements for asset management *(SP 3-1)*.	●	●	●		
2.5 Databases and information management *(SP 3-5)*.	●	●	●		
2.6 Engineering/economic analysis methods and tools *(SP 3-6)*.	●	●	●		
2.7 Impacts of changed mission on technology and information needs *(CEO B-2)*.	●				

3. Program Development and Delivery

Research Topic	Case Studies or Synthesis	Report	Software or IT Product	Training Material or Workshop	Academic Material
3.1 Transportation performance measures for asset management.	●				
3.2 Methods to establish transportation performance targets.	●	●			
3.3 Models to analyze multimodal tradeoffs.	●	●			
3.4 Impacts of GASB 34 standards on asset management and valuation methods *(SP 3-4, CEO D-3)*.	●	●		●	
3.5 Cross-jurisdictional sharing of services between transportation providers (*CEO D-1)*.	●				

4. Training and Information Sharing

Research Topic	Case Studies or Synthesis	Report	Software or IT Product	Training Material or Workshop	Academic Material
4.1 Develop a glossary for asset management *(SP 2-6)*.		●			
4.2 Share information with member states and others interested in asset management *(SP 4-1)*.		●	●	●	
4.3 Maintain the AASHTO Asset Management Guide *(SP 5-1-2)*.		●			
4.4 Develop and administer a "laboratory" state model *(SP 3-7)*.	●	●			
4.5 Develop and administer a lead-state/host-state model *(SP 5-2)*.	●	●			
4.6 Explore additional training opportunities *(SP 5-4)*.				●	

5. Academic Programs and Material

Research Topic	Case Studies or Synthesis	Report	Software or IT Product	Training Material or Workshop	Academic Material
5.1 Promote relationship with academia to develop courses and degree programs *(SP 3-3)*.					●
5.2 Support the development of asset management curricula and stipends.					●

4.0 Conclusion

4.1 Summary of Recommended Program

The recommended research program developed in Chapter 3.0 is summarized in Table 4.1. The recommended research budget totals almost $28 million over a 10-year period, divided among five areas of inquiry that reflect both the goals of the AASHTO ***Strategic Plan*** and the framework and state-of-practice of asset management that have been described in other tasks of this study. The organization of Table 4.1 is helpful in understanding the range of subject matter that is proposed, and the distribution of proposed funding. However, it is important to see the program in its entirety, rather than simply by individual topic area.

Table 4.1 Summary of Research Recommendations by Topic Area

Topic Number	Research Topic	Estimated Cost and Duration	Priority (5=High) (1=Low)
Area 1	*Policy and Institutional*		
1.1	Benchmark asset management used by other organizations (SP 1-4)	$50,000, 12 months	2
1.2	Effectiveness of asset management implementation (SP 2-7)	$350,000, 36 months	4
1.3	Build strong legislative support for strategic transportation agendas (CEO A-3)	$150,000, 12 months	3
1.4	Improve marketing of transportation asset management (CEO A-4)	$75,000, 9 months	2
1.5	Linking strategic planning to resource and implementation decisions (CEO A-5)	$190,000, 27 months	3
1.6	Intergovernmental roles in asset management and coordination among state, county, and local agencies	$400,000, 24 months	4
1.7	Updates of international work in asset management	$100,000, 12 months	1
1.8	Asset management implementation in different organizational and institutional settings	$200,000, 15 months	5
1.9	Improve horizontal and vertical communication within departments of transportation	$400,000, 24 months	4
1.10	Policy implications of GASB Statement 34 reporting (coordinate with 3.4)	$300,000, 18 months	4

Table 4.1 Summary of Research Recommendations by Topic Area (continued)

Topic Number	Research Topic	Estimated Cost and Duration	Priority (5=High) (1=Low)
Area 1	***Policy and Institutional (continued)***		
1.11	Improve public relations and understanding of asset management efforts	$125,000, 9 months	2
	Area 1 Estimated Cost	**$2,340,000**	
Area 2	***Information, Analytic Tools, and Technology***		
2.1	Evaluate and promote use of innovative technologies that enhance asset management (SP 3-2)	$800,000, 72 months	3
2.2	Incorporation of field sensing and real-time information within asset management (SP 3-2-3)	$250,000, 12 months	4
2.3	Information quality assurance program	$400,000, 24 months	3
2.4	Management system enhancements for asset management (SP 3-1)	$3,600,000, 60 months	5
2.5	Databases and information management (SP 3-5)	$3,000,000, 60 months	4
2.6	Engineering/economic analysis methods and tools (SP 3-6)	$5,000,000, 72 months	5
2.7	Impacts of changed mission on technology and information needs (CEO B-2)	$70,000, 12 months	3
	Area 2 Estimated Cost	**$13,120,000**	
Area 3	***Planning, Program Development and Delivery***		
3.1	Transportation performance measures for asset management	$150,000, 12 months	4
3.2	Methods to establish transportation performance targets	$300,000, 24 months	3
3.3	Models to analyze multi-modal tradeoffs	$300,000, 24 months	4
3.4	Impacts of GASB 34 standards on asset management and valuation (SP 3-4, CEO D-3) (coordinate with 1.10)	$350,000, 24 months	5
3.5	Cross-jurisdictional sharing of services between transportation providers (CEO D-1)	$100,000, 12 months	3
	Area 3 Estimated Cost	**$1,200,000**	

Table 4.1 Summary of Research Recommendations by Topic Area (continued)

Topic Number	Research Topic	Estimated Cost and Duration	Priority (5=High) (1=Low)
Area 4	*Training and Information Sharing*		
4.1	Develop a glossary for asset management (SP 2-6)	$60,000, 12 months	1
4.2	Share information with member states and others interested in asset management (SP 4-1)	$720,000, 60 months	2
4.3	Maintain the AASHTO Asset Management Guide (SP 5-1-2)	$800,000, 60 months	3
4.4	Develop and administer a "laboratory" state model (SP 3-7)	$2,150,000, 102 months	4
4.5	Develop and administer a lead state/host state model (SP 5-2)	$500,000, 60 months	3
4.6	Explore additional training opportunities (SP 5-4)	$520,000, 93 months	4
	Area 4 Estimated Cost	**$4,750,000**	
Area 5	*Academic Programs and Material*		
5.1	Promote relationship with academia to develop courses and degree programs (SP 3-3)	$50,000, 12 months	5
5.2	Support the development of asset management curricula and stipends	$6,000,000, 96 months	4
	Area 5 Estimated Cost	**$6,050,000**	
	TOTAL ALL AREAS	**$27,460,000**	

For example, the area with the largest recommended research budget is Area 2, dealing with Information, Analytic Tools, and Technology. This relatively large amount of funding recognizes the difficulty and expense of information technology development and integration and the associated need for acceptance testing, demonstration, implementation support plus training, and dissemination of product information. It necessarily deals with projects that may be difficult for individual DOTs to undertake on their own. However, it is important to understand that this magnitude of funding does not mean that asset management is seen as primarily an exercise in information technology. On the contrary, the purpose of improving information technology and analytic tools is to inform and support an agency's asset management business processes – i.e., policy formulation, institutional relationships, planning, program development, program delivery, and system monitoring. Similarly, the major funding of academic programs indicated in Table 4.1 is intended as part of a long-term strategy to build greater understanding of the broad themes of asset management. This appreciation is to be gained through an understanding of the engineering, economic, financial, management, political, analytic, and technological

principles inherent in the asset management framework proposed by this study. The result of these academic programs will be seen in enhanced organizational capabilities and new institutional relationships that incorporate asset management within an agency's business philosophy and practices.

Another way to visualize the research program is by priority, as presented in Table 4.2. Table 4.2 includes the same list of research topics as presented in Table 4.1, but organized by recommended priority, beginning with the highest-rated research topics. Since the assigned priorities are based upon professional judgment, it is helpful to view these assignments broadly – e.g., high-priority topics are those rated 5 or 4 – rather than to attribute too strict a distinction among them. Highly-ranked research topics cut across the several topic areas, indicating that a cross-section of professional and academic activities should be undertaken to begin accomplishing the objectives of the AASHTO ***Strategic Plan*** and of the management framework that will be incorporated into the future ***Transportation Asset Management Guide***. In this context the assigned priorities may be interpreted as recommendations on the sequencing of research topics as well as on the allocation of limited research funds in each time period.

Table 4.2 Summary of Research Recommendations by Priority

Topic Number	Research Topic	Estimated Cost and Duration	Priority (5=High) (1=Low)
	Priority 5 (Highest)		
1.8	Asset management implementation in different organizational and institutional settings	$200,000, 15 months	5
2.4	Management system enhancements for asset management (SP 3-1)	$3,600,000, 60 months	5
2.6	Engineering/economic analysis methods and tools (SP 3-6)	$5,000,000, 72 months	5
3.4	Impacts of GASB 34 standards on asset management and valuation (SP 3-4, CEO D-3) (coordinate with 1.10)	$350,000, 24 months	5
5.1	Promote relationship with academia to develop courses and degree programs (SP 3-3)	$50,000, 12 months	5
	Priority 5 Estimated Cost	**$9,200,000**	
	Priority 4		
1.2	Effectiveness of asset management implementation (SP 2-7)	$350,000, 36 months	4
1.6	Intergovernmental roles in asset management and coordination among state, county, and local agencies	$400,000, 24 months	4
1.9	Improve horizontal and vertical communication within departments of transportation	$400,000, 24 months	4
1.10	Policy implications of GASB Statement 34 reporting (coordinate with 3.4)	$300,000, 18 months	4

Table 4.2 Summary of Research Recommendations by Priority (continued)

Topic Number	Research Topic	Estimated Cost and Duration	Priority (5=High) (1=Low)
	Priority 4 (continued)		
2.2	Incorporation of field sensing and real-time information within asset management (SP 3-2-3)	$250,000, 12 months	4
2.5	Databases and information management (SP 3-5)	$3,000,000, 60 months	4
3.1	Transportation performance measures for asset management	$150,000, 12 months	4
3.3	Models to analyze multi-modal tradeoffs	$300,000, 24 months	4
4.4	Develop and administer a "laboratory" state model (SP 3-7)	$2,150,000, 102 months	4
4.6	Explore additional training opportunities (SP 5-4)	$520,000, 93 months	4
5.2	Support the development of asset management curricula and stipends	$6,000,000, 96 months	4
	Priority 4 Estimated Cost	**$13,820,000**	
	Priority 3		
1.3	Build strong legislative support for strategic transportation agendas (CEO A-3)	$150,000, 12 months	3
1.5	Linking strategic planning to resource and implementation decisions (CEO A-5)	$190,000, 27 months	3
2.1	Evaluate and promote use of innovative technologies that enhance asset management (SP 3-2)	$800,000, 72 months	3
2.3	Information quality assurance program	$400,000, 24 months	3
2.7	Impacts of changed mission on technology and information needs (CEO B-2)	$70,000, 12 months	3
3.2	Methods to establish transportation performance targets	$300,000, 24 months	3
3.5	Cross-jurisdictional sharing of services between transportation providers (CEO D-1)	$100,000, 12 months	3
4.3	Maintain the AASHTO Asset Management Guide (SP 5-1-2)	$800,000, 60 months	3
4.5	Develop and administer a lead state/host state model (SP 5-2)	$500,000, 60 months	3
	Priority 3 Estimated Cost	**$3,310,000**	

Table 4.2 Summary of Research Recommendations by Priority (continued)

Topic Number	Research Topic	Estimated Cost and Duration	Priority (5=High) (1=Low)
	Priority 2		
1.1	Benchmark asset management used by other organizations (SP 1-4)	$50,000, 12 months	2
1.4	Improve marketing of transportation asset management (CEO A-4)	$75,000, 9 months	2
1.11	Improve public relations and understanding of asset management efforts	$125,000, 9 months	2
4.2	Share information with member states and others interested in asset management (SP 4-1)	$720,000, 60 months	2
	Priority 2 Estimated Cost	**$970,000**	
	Priority 1		
1.7	Updates of international work in asset management	$100,000, 12 months	1
4.1	Develop a glossary for asset management (SP 2-6)	$60,000, 12 months	1
	Priority 1 Estimated Cost	**$160,000**	
	TOTAL ALL PRIORITIES	**$27,460,000**	

A comprehensive agenda of high-priority topics promotes a strong, broad-based start in asset management research. It builds initial findings in each of the respective topic areas, laying a foundation for subsequent research in more advanced topics. While it encourages simultaneous efforts among professional and academic teams, it also entails the need for the several areas of inquiry to inform one another. Coordination among multiple lines of research can be maintained through exchanges of working papers, collaboration on demonstration projects and in implementing research findings, and periodic workshops and conference presentations. Continual review of progress on the ***Strategic Plan*** by the AASHTO Task Force will provide a clearinghouse for assessing research findings, suggesting additional mechanisms for coordination and implementation, revising the research plan when needed, and promoting dissemination of results.

4.2 Future Updates of Recommendations

The research recommendations summarized in Tables 4.1 and 4.2 are intended to be dynamic. New or revised research topics, updates of priorities, and even redirection of the goals of the research program may become desirable over time due to several causes:

- Pending and subsequent reauthorization of federal transportation legislation and other statutory and regulatory changes may introduce new transportation policies that have important implications for asset management needs and priorities.

- DOTs may undergo organizational change or face new institutional environments that require new business models and managed business processes for asset management.

- New methods of program delivery in construction, maintenance, and operations may be needed to gain cost and time efficiencies and take full advantage of public-private partnerships.

- As DOTs and other agencies apply asset management more extensively, advances in asset management techniques, business models, analytic methods, management systems, and database tools may push research needs to more advanced topics or suggest mid-course adjustments in research objectives.

- Technological advances may enable new management procedures affecting transportation system operation and monitoring, periodic and real-time data collection, and long-term system performance.

- Documented case studies and examples of asset management implementation by state DOTs and other agencies may suggest new avenues of research.

AASHTO, the U.S. DOT, and others will likely influence the priorities for research in the future through mechanisms such as the AASHTO Transportation Asset Management Task Force. Through its periodic consideration of the ***Strategic Plan*** in conjunction with this report, the Task Force can play an important role in shaping the ongoing research effort and identifying funding sources to support a broad-based research program. The AASHTO ***Strategic Plan*** is at the heart of many of the research recommendations in this NCHRP report, and updates to the ***Strategic Plan*** will have a natural ripple effect on these research recommendations.

References

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6. Civil Engineering Research Foundation, web site, www.cerf.org.

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