A 10-YEAR PRIORITIZED ROADMAP FOR PAVEMENT MANAGEMENT

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ABSTRACT

The implementation and use of pavement management tools have progressed significantly over the last several decades. A number of transportation agencies have well established pavement management systems that are routinely used to estimate pavement needs, to summarize network conditions, to identify budgetary requirements, and to recommend pavement preservation and rehabilitation treatments. However, the degree to which pavement management information influences decisions varies widely among transportation agencies because of factors such as the reliability of the pavement condition data, the agency's philosophy for funding pavement improvements, and the agency's confidence in the pavement management models. Therefore, efforts to increase the use of pavement management information to support agency decisions are dependent on addressing any gaps that exist between the state of the practice and the state of the art.

As a means of addressing current gaps in the use of pavement management and to promote a more focused research effort, the FHWA sponsored the development of a "pavement management roadmap." The ultimate goal of this activity was to guide future research, development, and workforce development initiatives that will lead to improved approaches to pavement management. The roadmap was developed through a series of regional workshops attended by practitioners who helped identify the existing gaps and needs in pavement management.

The workshops produced a total of forty seven research, development, and technology transfer needs, which included twenty-three short-term needs (to be conducted within the next 5 years) and twenty-four long-term needs (that should be addressed in the next 6 to 10 years). The needs statements were later organized by the four theme areas listed below:

- Theme 1: Use of Existing Tools and Technology.

- Theme 2: Institutional and Organizational Issues.

- Theme 3: The Broad Role of Pavement Management.

- Theme 4: New Tools, Methodologies, and Technology.

This paper documents the process of developing the pavement management roadmap and presents the final list of prioritized short-term and long-term needs. In addition, the paper summarizes some of the recent initiatives that have been undertaken to advance the implementation of the roadmap through research, training, and other activities.

1.0 INTRODUCTION

Over the last few decades, transportation agencies have seen tremendous changes in the way business is conducted. For example, since the construction of the interstate highway system there has been an increased emphasis on performance monitoring and on the use of pavement management data to assist with the planning and programming of maintenance activities and capital improvements. Additionally, the methods used to assess pavement condition have evolved in conjunction with other technological advancements so that automated procedures are more commonly being utilized than in the past. Moreover, advancements in computer capabilities and their availability have resulted in a plethora of new tools for designing, analyzing, and managing pavements. Most recently, this has led to the development of new mechanistic-empirical pavement design procedures with significantly larger and more diverse data requirements than have been previously used.

In addition to technological changes, transportation agencies have seen adjustments in the way decisions are being made. Within the past 10 years there has been an increasing emphasis on asset management principles for resource allocation and utilization decisions that are based on system performance objectives. Under an asset management framework, investment decisions consider the trade-offs associated with different strategies and strive to align tactical improvement programs with the agency's strategic priorities. With asset management there is an increased focus on customer expectations and transparency in the decision process. The availability of quality data has a tremendous impact on an agency's ability to compare different investment options and to make sound business decisions that consider both engineering and economical factors.

Unfortunately, decreases in the purchasing power of available funding, coupled with reduced funding levels, have led to deteriorating network conditions within most transportation agencies at the same time that demand for these facilities is increasing. As a result, many transportation agencies are shifting their priorities from a focus on system expansion to an increasing focus on system preservation. In fact, a number of agencies have recognized the cost-effectiveness associated with the use of preventive maintenance treatments to slow the rate of deterioration and to postpone the need for most costly rehabilitation strategies.

As a result of these and other changes impacting transportation agencies, the role of pavement management is changing. In the past, pavement management was primarily considered to be used for assessing and reporting pavement conditions, prioritizing capital improvements, and estimating funding needs. Today, pavement management has the potential to fulfill a much broader (and more significant) role within a transportation agency. In addition to the more traditional roles it serves, pavement management can support an agency's asset management practices through the development of strategic performance objectives for the highway system. It can also provide a link to maintenance and operations through the analysis of pavement preservation options. And, it can provide the pavement performance data required to evaluate and calibrate the new mechanistic-design models for use within a specific transportation agency.

The successful transition of pavement management into these areas depends on a variety of factors, including the availability and accessibility of quality data to support an agency's decision processes, the agency's philosophy for funding pavement improvements, and the agency's confidence in the pavement management models. Therefore, efforts to increase the use of pavement management information to support agency decisions are dependent on addressing any gaps that exist between the state of the practice and the state of the art.

As a means of addressing current gaps in the use of pavement management and to promote a more focused research effort, the FHWA sponsored the development of a "pavement management roadmap." The ultimate goal of this activity was to guide future research, development, and workforce development initiatives that will lead to improved approaches to pavement management. The roadmap was developed through a series of Regional workshops attended by practitioners who helped identify both short- and long-term goals; to identify research, development, and technology transfer needs; and to anticipate any hurdles that need to be overcome to achieve the strategic objectives. The information presented in this paper is largely based on information presented in the final Roadmap published by the FHWA (FHWA 2010).

2.0 ROADMAP DEVELOPMENT
2.1 Stakeholder Involvement
From the beginning, the FHWA intended the development of the roadmap to be a collaborative process, involving representatives from each of the various stakeholder groups that either use pavement management data, support the use of pavement management concepts, or provide technical assistance or training to current or future pavement management practitioners. However, although participation from all of these stakeholders was desired, an emphasis was placed on the involvement of representatives from state and local transportation agencies.

Stakeholder input was obtained through facilitated break out groups at three regional workshops held in Phoenix, AZ; Dallas, TX; and McLean, VA. Approximately 150 invitations were extended to individuals working in pavement management in the hope that approximately 30 to 40 stakeholders would be able to attend each of the three workshops.

Through a contract agreement, FHWA provided funding for the participation of government representatives (excluding FHWA representatives) to help increase the likelihood of participation. A total of 88 participants accepted invitations to participate and were able to attend one of the three workshops. In addition to FHWA, the participants represented 31 SHA, 7 other government agencies (i.e., cities, counties, and Canadian government agencies), 13 private contractors, and 6 academic agencies. A Technical Panel consisting of pavement management practitioners from FHWA, SHA, and academia provided technical guidance throughout the development of the roadmap.

2.2 Identification of Focus Areas
To make the most efficient use of the participants' time at the regional workshops, it was important that everyone be familiar with the current state of the practice and have equal awareness with regard to the status of current initiatives in the area of pavement management. Therefore, the contractors performed a literature search to identify current practices, recent research initiatives, topics discussed at recent conferences, and other activities relevant to the practice of pavement management. The literature results were compiled into a summary report that identified 10 key focus areas that could set the stage for the discussions at the regional workshops. These focus areas represented topics that were identified as being important subjects within the pavement management community. For each focus area, the summary report included a synopsis of the current state of the practice and the challenges being faced by pavement management practitioners. Several thought provoking questions that could be used to start the facilitated discussions during the workshops were also included, as was a summary of recently completed or on-going research activities conducted by SHAs, the National Cooperative

Highway Research Program (NCHRP), or the FHWA. Finally, the perceived benefits of new research, development, and technology transfer opportunities in each focus area were provided.

The 10 focus areas selected for discussion are listed below.
1) Data collection techniques, equipment, and emerging needs.
2) Data quality.
3) Data storage integration.
4) Performance modeling.
5) Treatment selection.
6) Use of pavement management in the decision process.
7) Changing needs and emerging technology in data collection and analysis.
8) Quantifying the benefits of pavement management.
9) Integrating pavement preservation and pavement management strategies.
10) Institutional issues and other factors influencing the use of pavement management.

2.3 Regional Workshop Activities
Each of the regional workshops was structured in a way that subsets of the participants would discuss all ten of the focus area topics over a 2-day period. Participants were asked to identify topics of interest and were assigned to particular focus areas upon arrival at a workshop. By assigning participants to a focus area, the contractor was able to ensure that each focus area was attended by individuals with knowledge and/or experience in that area and that an adequate number of participants were in each of the breakout sessions. A facilitator was assigned to each of the breakout groups from the research team.

The end product from each breakout session was a list of recommended needs and documentation describing each of the needs in detail. At the end of each day, all participants convened to discuss the findings and recommendations for that day.

2.4 Combining Similar Need Statements
Initial targets assumed that 3 to 5 needs would be identified in each focus area at each of the regional workshops. However, once all three of the regional workshops had been conducted a total of 242 research, technology, and workforce development needs were identified. Therefore, the contractor developed a combined list of recommendations, eliminating duplications or merging closely related ideas. A target of approximately 60 final research needs was established, assuming that 3 to 6 needs statements per focus area was a reasonable number.

The efforts to combine needs statements proved successful, reducing the 242 needs statements to 47. It became evident during this process that there were a number of problem statements that may have been suggested under multiple focus areas. For instance, a problem statement identifying the need for improved network-level pavement structural data was noted in focus areas 4, 5, 7 and 10. To address this issue, the combined needs statements were reorganized into theme areas rather than focus areas. This change allowed the contractor to group similar project statements that emerged from multiple focus areas and simplified the organization of the results. The following four theme areas quickly emerged when the combined needs statements were developed.
- Theme 1: Existing Technology and Tools. Problem statements in this area focused on techniques to improve the use of existing technology and tools through the development of best practice studies and guidelines.

- Theme 2: Institutional and Organizational Issues. Needs statements in this area focused on the development of methods for better communicating the benefits of pavement management and improving the skills of the workforce.
- Theme 3: Role of Pavement Management. Statements in this theme area focused on the changes needed for pavement management to continue to support agency decisions, such as its use to support innovative contracting and to analyze load impacts on pavement performance.
- Theme 4: New Tools, Methodologies, and Technology. These problem statements focused on the development of more advanced tools and techniques, such as the development of more automated condition data processing tools and the incorporation of design, climate, and construction characteristics into pavement management models.

During the activity of combining needs statements, it became evident that the majority of statements identified during the workshops had been identified as immediate, high-priority needs by the participants. In fact, only three of the needs statements described activities that were classified as long-term needs. Therefore, the Technical Panel was invited to identify additional long-term needs. Five additional needs statements were developed as a result of the Technical Panel meeting. Following the meeting, additional work was conducted to combine the problem statements and to move some of the needs into the long-term category. These efforts resulted in a final list of 23 short-term needs and 26 long-term needs in four theme areas.

2.5 Prioritization of Needs

The individuals who participated in the three regional workshops were invited to participate in a webinar in which the combined needs statements were presented. In addition, participants were asked to individually rank the short- and long-term needs in each theme area and to rank the four theme areas in terms of importance. This information provided the data needed to prioritize the short-term and long-term needs within each theme area and across theme areas. As a result, a roadmap containing a ranked listing of the research, technology, and workforce development needs to guide state and national research initiatives was produced.

3.0 10-YEAR ROADMAP FOR PAVEMENT MANAGEMENT
3.1 The Pavement Management Vision

The successful adoption of the Pavement Management Roadmap is expected to lead to the increased use, and improved applicability, of pavement management by eliminating the barriers or gaps that limit its effectiveness or hinder its acceptance within an agency. Through comprehensive and coordinated efforts to address both the short-term (i.e., less than 5 years) and long-term (i.e., 5 to 10 years) research, development, technology, and workforce development activities identified in the Roadmap, practitioners can foresee the following vision of pavement management in the year 2020.

The Vision for Pavement Management in 2020

Pavement management will make use of a new generation of technology so agencies are less dependent on manual labor for data collection. Pavement management tools will allow agencies to communicate effectively with stakeholders, using clear statements that are tied to agency goals and pavement worth. Within an asset management framework, pavement management will be used for investigating decisions and program options in both private and public sectors. A pavement management analysis will consider new materials and construction/design practices, as well as other factors that influence project and treatment selection, including safety, congestion, and sustainability. As a result of these changes, pavement management will be robust, comprehensive, and credible, and will address agency needs at the project, network, and strategic levels.

3.2 Prioritized Research, Development, and Technology Transfer Needs

The Pavement Management Roadmap prioritizes the urgency with which each of the recommended activities should be addressed, based on the importance and priority rankings provided by the participants. As such, the prioritized list of short-term and long-term needs represents the urgency with which the participating pavement management stakeholders would address these activities. The results are presented in a number of different formats to emphasize the priorities across theme areas, as well as within theme areas.

In total, the suggested initiatives represent over $14.5 million in funding, with approximately $6.5 million representing short-term needs over the next 5 years and $8 million representing long-term needs to be initiated within the next 5 to 10 years. By theme area, the funding is distributed in accordance with the figures shown in table 1.

Tables 2 and 3 present the prioritized listing of recommended needs to address the gaps in pavement management over the next 10 years, ignoring the four theme areas. Table 2 presents the prioritized listing of the short-term needs, and table 3 includes the prioritized listing of long-term needs.

Table 1: Funding needs by theme area.

Theme	Short-Term Needs (< 5 years)		Long-Term Needs (5 to 10 years)		Totals	
	# of Projects	Funding Requirements	# of Projects	Funding Requirements	# of Projects	Funding Requirements
1: Use of Existing Technology and Tools	8	$2,180,000	2	$850,000	10	$3,030,000
2: Institutional and Organizational Issues	5	$880,000	6	$780,000	11	$1,660,000
3: The Broad Role of Pavement Management	5	$1,550,000	5	$1,300,000	10	$2,850,000
4: New Tools, Methodologies, and Technologies	5	$1,930,000	11	$5,100,000	16	$7,030,000
Totals	*23*	*$6,540,000*	*24*	*$8,030,000*	*47*	*$14,570,000*

4.0 TOP TEN SHORT-TERM AND LONG-TERM NEEDS

4.1 Recommended Short-Term Needs by Theme Area

The regional workshops produced a total of twenty-three short-term research, development, and technology transfer needs to be addressed within the next 5 years to advance pavement management capabilities. To a significant degree, the problem statements emphasize the need for improved access to information about best practices, and better methods to communicate the importance of pavement management to transportation agencies. Additionally, stakeholders placed an emphasis on improving data quality and consistency. The top ten short-term research, development, and technology transfer needs are presented in table 4 and described in this section of the paper, by theme area.

Theme 1: Use of Existing Technology and Tools
Needs statements included in theme 1 include recommendations for technology and tools that can support traditional pavement management applications. In general, this theme includes technology and tools that are currently available today but are in need of additional review,

Table 2: Prioritized listing of short-term needs.

Priority Ranking	Title	Theme	Score
1	Communicating Pavement Management Information and Benefits	Inst & Org	2.18
2	Development and Use of Effective Performance Measures	Broad Role	2.16
3	Improving the Skills of Pavement Managers	Inst & Org	2.13
4	Development of Automated Condition Data Processing Tools	New Tools	1.85
5	Methods to Quantify the Benefits of Pavement Management	New Tools	1.85
6	Best Practices for Pavement Management	Existing Tools	1.65
7	Development of Pavement Distress Standards	Existing Tools	1.62
8	Development of Improved Methodologies for Evaluating Data Quality	Existing Tools	1.58
9	Improving Factors Considered in Project and Treatment Selection Decisions	New Tools	1.58
10	Establish and Develop Equipment Calibration Centers and Guidelines	Existing Tools	1.55
11	Comprehensive Study to Guide the Integration of Pavement Preservation and Pavement Management	Existing Tools	1.44
12	Pavement Management Data Mining: Improving Current Uses and Leveraging New Applications of Pavement Management Data	Broad Role	1.37
13	Analysis of Trade-Offs Associated with Alternate Methods of Data Collection	New Tools	1.33
14	Load Limit Impacts on Pavement Performance	Broad Role	1.19
15	Developing and Supporting a Pavement Management Business Plan	Broad Role	1.18
16	Use of Pavement Management Information for National Reporting	Broad Role	1.07
17	Annual Approval of SP&R Funding	Inst & Org	0.89
18	Framework for Minimizing the Delivery of Treatment Application	Inst & Org	0.89
19	Independent Technical Assessments of Pavement Management	Existing Tools	0.84
20	Pavement Management Clearinghouse	Existing Tools	0.80
21	Addressing Trade-offs, Metric Issues, and Purchasing Controls/Policies	Inst & Org	0.62
22	Synthesis of External Issues Driving Pavement Management	Existing Tools	0.60
23	Pavement Management in a Changing World	New Tools	0.49

analysis, dissemination, and/or updating prior to their use. A total of $2,180,000 in funding is required to address these needs.

Theme 2: Institutional and Organizational Issues
The theme 2 needs statements relate to workforce development, communication, contracting, and organizational structure. The recommendations in this area are intended to address issues that include the impact pavement management on funding and how to determine, promote, and effectively communicate the use and the benefits of pavement management. A total of $880,000 in funding is required to address these needs.

Theme 3: The Broad Role of Pavement Management
Theme 3 includes needs statements that go beyond the standard functions of pavement management and include such areas as pavement design, impact of increasing load limits on pavement performance, and asset management. A total of $1,550,000 in funding is required to address these needs.

Table 3: Prioritized listing of long-term needs.

Priority Ranking	Title	Theme	Score
1	Methods of Defining and Calculating the Effect of Pavement Preservation Treatments on Pavement Life	Existing Tools	2.43
2	Impact of Pavement Management Investment Levels on Benefits	Inst & Org	2.26
3	Using Pavement Management Data to Support Design Activities	Broad Role	2.08
4	Performance Models that Consider Series of Treatments	New Tools	1.97
5	Method for Effectively Modeling Structural Condition	New Tools	1.91
6	Methods to Promote Pavement Management as a Management Tool	Inst & Org	1.82
7	Investigation into the Risk, Uncertainty, and Variability in Pavement Management Decisions	Existing Tools	1.45
8	Automation of Surface Texture Characteristics	New Tools	1.40
9	National Funding Allocations That Account for State Priorities	Broad Role	1.33
10	Identifying Strategies for Incorporating Emerging Technologies into the Pavement Management System	New Tools	1.23
11	Identify Data Needs to Support Other Processes	Broad Role	1.20
12	Quantifying the Cost of Pavement Use	New Tools	1.19
13	Recommended Methodology to Calculate Pavement Asset Value and Communicate to Stakeholders	Inst & Org	1.16
14	Methodologies to Reliably Support Innovative Contracting	Broad Role	1.13
15	Develop NDT for Measurement of In-Place Material Properties	New Tools	1.08
16	Suggested Topics for Pavement Management Into the Civil Engineering Curriculum	Inst & Org	1.03
17	Constant Funding for Pavement Management	Inst & Org	0.96
18	Identify IT Needs to Effectively Manage a Pavement Management System	Inst & Org	0.95
19	Quantifying the Benefits of Pavement Research	New Tools	0.78
20	Impact of Earmarks on Pavement Performance	Broad Role	0.70
21	Develop Default Models for Low-Volume Roads	New Tools	0.47
22	Impact of Climate Change on Performance Prediction	New Tools	0.39
23	Development and Integration of Wireless Sensors with PMS	New Tools	0.36
24	Use of Aerial Images for Distress Analysis	New Tools	0.29

Theme 4: New Tools, Methodologies, and Technologies

The problem statements in theme 4 are related to needs for research and development leading to new tools, methods, and technology to support pavement management. In general, needs statements included in this theme address concepts that are not readily available and will require a higher level of research, analysis, and development prior to implementation. A total of $1,930,000 in funding is required to address these needs.

4.2 Recommended Long-Term Needs by Theme Area
The regional workshops produced a total of twenty-four long-term research, development, and technology transfer needs to be addressed within the next 5 to 10 years to advance pavement management capabilities. As opposed to the short-term needs, this list includes activities that will require research to develop methods to improve existing practices. The highest ranked needs indicate that efforts are needed to define and calculate the impact of pavement preservation treatments, and to determine the impact of different investment levels on pavement management

Table 4: Top ten listing of short-term needs statements by theme.

Theme 1: Use of Existing Technology and Tools

Needs Statement	Description	Funding
Best Practices for Pavement Management	There is a significant need to assemble and prepare a best practices document for the operational and functional aspects of pavement management. This guide will include a broad range of topics, such as benefits and limitations of data collection equipment and procedures, processes for developing and implementing a linear referencing system and addressing data integration issues, guidelines for developing and updating performance modeling, methods for using pavement management to support agency decisions and allocated funds, and methods for communicating pavement management data to stakeholders.	$500,000
Development of Pavement Distress Standards	This study will identify distress to be measured, review current state practice, compare state procedures to current AASHTO protocols, identify areas not currently covered by an AASHTO protocol, develop preliminary protocols, conduct webinars or workshops to obtain state buy-in, and finalize the protocol for AASHTO balloting.	$350,000
Development of Improved Methodologies for Evaluating Data Quality	This study's objective is to develop a standard methodology that can be applied to a wide range of pavement condition data to assess quality in terms of accuracy and repeatability. The study results will establish data collection guidelines and evaluate the impact of variability. A product will be the development of guidelines to improve data quality in terms of collection, processing, and reporting.	$350,000
Establish and Develop Equipment Calibration Centers and Guidelines	This study will identify potential calibration sites, recommended calibration frequencies, and calibration procedures.	$250,000

Theme 2: Institutional and Organizational Issues

Needs Statement	Description	Funding
Communicating Pavement Management Information and Benefits	This study will investigate how highway agencies have successfully gained buy-in from decision makers that have led to increased use of pavement management information. The products will include guidelines for making these types of presentations, and a collection of effective presentations that can be used as templates.	$250,000
Improving the Skills of Pavement Managers	This initiative will provide guidance to help agencies evaluate the economic/organizational impacts of workforce development. This study will develop training guides, a web clearinghouse for resources, and information on pavement management careers.	$250,000

Theme 3: The Broad Role of Pavement Management

Needs Statement	Description	Funding
Development and Use of Effective Performance Measures	Under this study, examples of effective links between strategic and operational performance measures will be conducted, and guidelines on the use of pavement management measures to support strategic initiatives will be developed.	$250,000

Theme 4: New Tools, Methodologies, and Technologies

Needs Statement	Description	Funding
Development of Automated Condition Data Processing Tools	Improvements to current tools for automating the processing of some measures of pavement evaluation are needed to accelerate the rate which survey results become available and improve the consistency and reliability of the information. Improvements are needed to the processing of surface distress data, GPR, and rutting.	$800,000
Methods to Quantify the Benefits of Pavement Management	This is a synthesis study in which practices in public and private agencies may be explored to determine current practice. The end product is the identification of effective methodologies that can be used to quantify benefits associated with pavement management.	$30,000
Improving Factors Considered in Project and Treatment Selection Decisions	The study must provide guidance for addressing agency challenges that influence the use of this information. The product of this research will be a process for evaluating the decision factors used in the pavement management treatment selection process and guidelines for addressing any existing gaps in the criterion.	$250,000

Table 5: Top ten listing of long-term needs statements by theme.

Theme 1: Use of Existing Technology and Tools

Needs Statement	Description	Funding
Methods of Defining and Calculating the Effect of Pavement Preservation Treatments on Pavement Life	This study will quantify the impacts that pavement preservation treatments have on pavement performance, using measured field data from various geographic regions of the country.	$500,000
Investigation into the Risk, Uncertainty, and Variability in Pavement Management Decisions	The objective of this research is to investigate the various forms of variability affecting pavement management recommendations and to develop a process for evaluating its impact and the overall effectiveness of pavement management recommendations. The results are expected to be able to help agencies determine the amount of data needed to provide credible recommendations and to determine what level of risk is considered acceptable, thereby improving levels of accountability and confidence in pavement management.	$350,000

Theme 2: Institutional and Organizational Issues

Needs Statement	Description	Funding
Impact of Pavement Management Investment Levels on Benefits	A product of this study is the development of an analysis approach that determines the relationship between funding expenditures, data reliability, and system outputs. Another product will be the development of a methodology for analyzing these relationships.	$350,000
Methods to Promote Pavement Management as a Management Tool	Pavement management's value to is not always well understood, especially among executives and elected officials with short-term positions. Public relations is needed to raise the profile of pavement management and communicate its wide-ranging benefits. Research is needed to know how to be most effective with audiences.	$100,000

Theme 3: The Broad Role of Pavement Management

Needs Statement	Description	Funding
Using Pavement management Data to Support Design Activities	This study will develop a methodology to enhance the sophistication of pavement performance modeling, determine the availability of data fields for both pavement management and pavement design, determine the compatibility of MEPDG and pavement management prediction, enhance DARWin-ME or develop a stand-alone tool, and recommend adjustments to calibrate one or both models.	$350,000
National Funding Allocations That Account for State Priorities	This study will result in the development of a methodology for comparing pavement performance that accounts for the differences in state priorities and objectives.	$250,000

Theme 4: New Tools, Methodologies, and Technologies

Needs Statement	Description	Funding
Performance Models That Consider a Series of Treatments	This study will include a literature search on the pavement performance impacts of a series of treatments; development of a strategy for evaluating treatments in a series; collection of sufficient data from state agencies to develop, analyze, and validate performance curves; and the creation of guidelines on how to develop performance curves for a series of treatments.	$500,000
Method for Effectively Modeling Structural Condition	This study will quantify the cost/benefit of network-level deflection testing. The researcher will conduct a survey of practice, validate testing with other static devices, determine precision and bias statements, conduct pilot studies, and develop guidelines.	$350,000
Automation of Surface Texture Characteristics	This study will identify surface characteristics that can be identified and quantified using existing high-speed data collection equipment potential methodologies for quantifying distress; equipment and analysis gaps; and software and equipment modifications.	$500,000
Identifying Strategies for Incorporating Emerging Technologies into the Pavement Management System	The main research objective is to develop a framework for identifying/evaluating the changes that impact pavement management decisions. The framework should be applicable to a wide range of situations and be demonstrated using data provided by state highway agencies. The final product is a set of guidelines for identifying and evaluating factors that influence the recommendations produced by the pavement management system. A clearinghouse for reporting the evaluation of technology may also be a product	$350,000

capabilities. Additional efforts address the need to better support pavement design activities with pavement management, including the need to effectively model structural condition and series of treatments over a pavement life cycle. The top ten long-term research, development, and technology transfer needs are presented in table 5 and described in this section of the paper, by theme area.

Theme 1: Use of Existing Technology and Tools
Need statements included in theme 1 include recommendations for technology and tools that can support traditional pavement management applications. In general, this theme includes technology and tools that are currently available today, but are in need of additional review, analysis, dissemination, and/or updating prior to their use. A total of $850,000 in funding is required to address these needs.

Theme 2: Institutional and Organizational Issues
The theme 2 needs statements presented in this section of the report relate to workforce development, communication, contracting, and organizational structure. The recommendations in this area are intended to address issues that include the impact pavement management on funding and how to determine, promote, and effectively communicate the use and the benefits of pavement management. A total of $780,000 in funding is required to address these needs.

Theme 3: The Broad Role of Pavement Management
Theme 3 includes needs statements that go beyond the standard functions of pavement management and include such areas as pavement design, impact of increasing load limits on pavement performance, and asset management. A total of $1,300,000 in funding is required to address these needs.

Theme 4: New Tools, Methodologies, and Technologies
The problem statements in theme 4 are related to needs for research and development leading to new tools, methods, and technology to support pavement management. In general, needs statements included in this theme address concepts that are not readily available and will require a higher level of research, analysis, and development prior to implementation. A total of $5,100,000 in funding is required to address these needs.

5.0 IMPLEMENTATION

The stakeholders involved in the development of the Pavement Management Roadmap identified a plethora of research, development, and technology transfer needs that are required to solidify the role of pavement management in transportation agencies today, and to help ensure its applicability to the needs of transportation agencies in the future. As outlined in the Roadmap, this will require a coordinated plan that:
- Enhances the skills of pavement managers.
- Improves the use of existing technology and tools.
- Promotes the concepts of pavement management among decision makers and the public.
- Expands the data considered in a pavement management analysis.
- Explores the use of new tools and technology to improve the current approaches to data collection and analysis.

The Roadmap presents both the short-term and long-term priorities that will enable the pavement management community to accomplish these objectives. In total, the needs identified in the Roadmap will require $14.57 million in funding to achieve the stated goal. This amount of money is clearly beyond the capabilities of any single organization within the transportation community. Therefore, the successful implementation of the Roadmap demands a focused, cooperative approach among national and international organizations that are in a position to fund and support these types of research and outreach activities, including the FHWA, AASHTO, the National Research Academy and the Transportation Research Board (TRB), state highway agency research departments, and other industry representatives. This approach demands that:

- Funding to support pavement management initiatives is increased to meet the needs of stakeholders at all levels.
- Agencies work together to secure the necessary funding for the highest priority items.
- The pavement management community embraces the Roadmap and supports its implementation.
- Effective strategies for implementing the activities developed under this Roadmap are incorporated into each study.
- Responsibility for tracking accomplishments and pushing forward the remaining needs is assigned to a central organization.

6.0 CONCLUSION

The completion of the Pavement Management Roadmap represents the end of the collaborative process that was followed to identify and prioritize the needs of a diverse set of stakeholders who are involved in the use of pavement management data and analysis tools to support the cost-effective management of the nation's pavement infrastructure. As documented in this paper, the implementation of the Pavement Management Roadmap will rely on the creativity and resourcefulness of all those working in the pavement management community. No matter how they are connected to pavement management, stakeholders must get involved in supporting the activities outlined in the Pavement Management Roadmap if the community is to reach the vision for pavement management over the next 10 years. This will require a dedicated effort to assign responsibility for managing the Roadmap to a steering committee, to fund research efforts each year, and to provide the training necessary to address the institutional training and technology transfer initiatives included in the Roadmap. The FHWA is currently moving in this direction with the award of a contract to develop an implementation plan for the Roadmap.

The completion of the project provides an opportunity to review the process that was used in developing the roadmap and to recommend any adjustments to the process that might benefit the development of future roadmaps. The authors offer the following suggestions to improve the development process in the future:

1. The participants in the roadmap development had a hard time identifying needs beyond the short term. Therefore, it is important that sessions concentrate exclusively on long-term strategies to get a more comprehensive summary of needs.
2. The current Roadmap identifies needs, but does not show the relationships between recommended activities. In other words, if one activity requires another to be completed

before it can begin, this relationship is not spelled out. Depending on the types of needs identified, it may be important for these relationships to be mapped.
3. It is also important that ownership of the Roadmap and its contents is assigned to an organization early in the process. The FHWA Roadmap has found a home in a Transportation Research Board committee, but there were no assurances early in the process of the committee's participation. The American Association of State Highway and Transportation Officials' Joint Technical Committee on Pavements has also embraced the Roadmap and is promoting its recommendations for research funding.
4. Involve as many stakeholders as possible to build buy-in and support for the findings. The process used in the development of the FHWA Roadmap embraced a diverse group of stakeholders, which benefitted the process tremendously.

6.0 REFERNCES

Federal Highway Administration. 2010. *Pavement Management Roadmap*. Report No. FHWA-HIF-11-011. Federal Highway Administration, Washington, DC.