

**THEME 1**  
**PROBLEM STATEMENTS**

**Theme 1 – Use of Existing Technology and Tools**

Problem statements 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, and/or updating prior to their implementation.

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Best Practices for Pavement Management*

## II. RESEARCH PROBLEM STATEMENT

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 build upon the existing AASHTO *Pavement Management Guide* and include a broad range of topics that include (but are not limited to):

- **Asset Management Principles.** Asset management and pavement management procedures and benefits.
- **Referencing Systems.** Establishing and maintaining linear referencing system, merging several linear referencing methods into a single system, and addressing alignment and boundary changes.
- **Data Collection.** Type and extent of data; data collection procedures; data collection frequency; sampling rates; data needed for network-level, project-level, forensic investigations, and research; quality control/quality assurance procedures; equipment types and capabilities; equipment specifications; and equipment certification.
- **Data Storage and Integration.** Storage requirements, needed costs, maintenance issues related to storage, storage needs and formats to maximum integration, communication, data links, and technology/system availability.
- **Data Analysis.** Procedures and processes for analyzing data to meet agency needs.
- **Performance Modeling.** What level of detail is needed (both in data collection and model development), describe when model updates are necessary (e.g., due to improvements in measurement accuracy and changes in design principles, materials, or construction practices), quantify the impacts of measurement accuracy (e.g., windshield, automated, or semi-automated), how to conduct a sensitivity analysis on the model inputs and resulting performance prediction, catalog of available performance prediction models, and how to develop, calibrate/validate, implement, and maintain prediction models.
- **Treatment Selection.** Pavement preservation and rehabilitation treatments, benefits, and limitations.
- **Presenting and Communicating Results.** Discuss recommendations for presenting pavement management results and methodologies used for communicating pavement management data to stakeholders.
- **Supporting Agency Decisions.** Use of pavement management information to support planning activities (e.g., STIP and strategic planning), allocate resources, linking network and project-level treatment recommendations, identify organizational components that lead to successful pavement management, and provide recommendations for addressing barriers to the use of pavement management and improving agency business processes that are needed to support pavement management.

- **New Technologies.** Methodologies and procedures for evaluating and implementing emerging technologies, and coordination with and considering IT capabilities.

**Tasks:** The research will include the following tasks:

1. Literature search (domestic and international) on pavement management procedures and practices.
2. Develop detailed outline.
3. Develop pavement management best practices.

**Final Product:**

The final product of the research is a best practice guide for pavement management. Not only will this be a reference for all things related to pavement management, but it will also act as a “desk guide” for practitioners. To enhance access and implementation, it is envisioned that this guide will be developed and available through an electronic web-based format.

**III. RESEARCH OBJECTIVE**

The objective of this research is to provide a best practices guide for pavement management for reference, use, promotion, and to further the implementation of pavement management procedures.

**IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD**

**Estimated Budget:** \$500,000

**Estimated Project Duration:** 36 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Development of Pavement Distress Standards*

## II. RESEARCH PROBLEM STATEMENT

Pavement distresses are defined, measured, and categorized differently between many state highway agencies (possibly excluding IRI). Pavement condition standards would assist in improving data quality checks for comparing performance measures, and provide guidance to equipment manufacturers and data collection service providers. AASHTO has established a number of distress protocols, but the widespread use of these protocols is uncertain. 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 protocol for AASHTO balloting.

**Tasks:** The research will include the following tasks:

1. Survey and review current state highway agency (SHA) practices regarding pavement condition standards utilized.
2. Compare SHA pavement condition standards relative to AASHTO distress protocols.
3. Identify gaps in AASHTO protocols and draft provisional standard accordingly.
4. Develop guidelines for getting the most out of contracted pavement management systems.

### **Final Product:**

The final product of the research is a set of provisional AASHTO standards addressing SHA's needs regarding distress identification and measurement.

## III. RESEARCH OBJECTIVE

The primary objective of this research is to better address SHA's needs from standardized pavement condition protocols.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$350,000

**Estimated Project Duration:** 24 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Development of Improved Methodologies for Evaluating Data Quality*

## II. RESEARCH PROBLEM STATEMENT

Pavement management recommendations are impacted by the quality of the data collected. Most agencies have recognized this issue but struggle with the lack of sophisticated methodologies to effectively and efficiently evaluate data quality and the resulting impact on pavement management decisions. The objective of this study 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 will also demonstrate the use of the results to establish data collection guidelines (to specify required levels of accuracy) and to evaluate the impact of variability on pavement management recommendations.

**Tasks:** The research will include the following tasks:

1. Identify and evaluate quality control/quality assurance procedures for various pavement management data collection practices.
2. Define viable methodologies based on data precision and repeatability, collection efficiency, and cost effectiveness.
3. Develop guidelines so that an agency can apply viable methodologies into its pavement management system practices.

### **Final Product:**

The final product of the research is development of guidelines to improve data quality in terms of collection, processing, and reporting.

## III. RESEARCH OBJECTIVE

There are two specific objectives for this research. First, the research will develop standard quality control/quality assurance criteria for pavement management data collection practices. The second objective will determine how to incorporate QC/QA practices into pavement management systems.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$350,000

**Estimated Project Duration:** 24 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Establish and Develop Equipment Calibration Centers and Guidelines*

## II. RESEARCH PROBLEM STATEMENT

National calibration centers or well-established protocols or guidelines for calibrating profile, texture, noise, or ground penetrating radar (GPR) data collection are either limited or nonexistent. Strategically located calibration centers would allow for large-scale consistency in data collection and greatly improve reliability of data comparisons between equipment types and vehicles. This study will identify potential calibration sites (strategic locations and resources for establishment, maintenance, and operation), recommended equipment calibration frequencies, equipment calibration procedures, and precision and bias requirements. In the area of calibration centers, this study should reference the work and efforts developed for the FWD calibration centers.

**Tasks:** The research will include the following tasks:

1. Survey practitioners regarding current quality assurance/equipment calibration procedures.
2. Conduct sample size analyses to recommend how many test sections/regional test sites should be established.
3. Determine details of equipment calibration, operator certification, and amount of data to collect and review.
4. Develop practices/guidelines/specifications for equipment calibration and operator certification.

### **Final Product:**

The final product of the research is identifying the location of regional calibration centers, calibration procedures for data collection equipment, and an operator certification program.

## III. RESEARCH OBJECTIVE

There are two specific objectives for the research. First, the research will provide a synthesis of current quality assurance/equipment calibration procedures being used by practitioners in regards their data collection equipment. The second objective is establishing an equipment calibration and operator certification/training program.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$250,000

**Estimated Project Duration:** 12 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Comprehensive Study to Guide the Integration of Pavement Preservation and Pavement Management*

## II. RESEARCH PROBLEM STATEMENT

In most agencies, pavement management data collection and analysis tools were established before pavement preservation techniques were extensively used. As a result, the data that is currently collected and the project selection processes are not necessarily easily modified to include preventive maintenance treatments. However, the importance of tracking pavement preservation treatments is critical to predicting pavement performance, identifying needs, and establishing budgets. In addition, data related to pavement preservation treatments (e.g., pavement condition prior to treatment application, treatment type and thickness, and, if applicable, material type) is critical for developing performance prediction models for preservation treatments.

**Tasks:** The research will include the following tasks:

1. Conduct a survey of state agencies regarding best practices for integrating pavement preservation into pavement management.
2. Identify data needed to support the integration of pavement preservation into pavement management.
3. Identify levels of integration, including cost and benefits associated with each level.
4. Develop guidelines for integrating preventive maintenance into pavement management according to each level.

### **Final Product:**

The final product of the research is guidelines for adapting pavement management systems to fully support pavement preservation activities.

## III. RESEARCH OBJECTIVE

There are three specific objectives for the research. First, the research will develop a synthesis of best practices regarding how agencies integrate preventive maintenance into pavement management, identifying successful case studies and lessons learned. The second objective is to define basic levels of integration according to the state of the practice in terms of both preventive maintenance activities and pavement management practices at an agency. The final research objective is to develop guidelines that transportation agencies can use to begin integrating their preventive maintenance and pavement preservation activities.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$350,000

**Estimated Project Duration:** 24 months



# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Independent Technical Assessments of Pavement Management*

## II. RESEARCH PROBLEM STATEMENT

The Federal Highway Association (FHWA) is a strong supporter of pavement management tools in SHAs, but the use of these tools is optional. Furthermore, there are diverse approaches being used for data collection, reporting, and analysis within those agencies using pavement management. There is also a lack of established appraisal methods for determining whether pavement management practices comply with “good practice.” At the same time, agencies are facing funding constraints that limit the resources available to support pavement management.

**Tasks:** The research will include the following tasks:

1. Identify baseline capabilities for pavement management.
2. Survey SHAs regarding their pavement management system practices. Determine whether the baseline capabilities are being met, and if not, how any deficiencies can be addressed.
3. Develop a framework for assessing pavement management practices, including development of means to assess risk associated with specific pavement management practices relative to best practices, and recommend funding needs to address pavement management deficiencies.

### **Final Product:**

The final product of the research is a framework for assessing pavement management practices according to an agency’s activities relative to best practices.

## III. RESEARCH OBJECTIVE

The primary objective of this research is to develop a means of assessing an agency’s pavement management practices relative to best practices, including assessing the risk associated with specific practices so as to communicate need for improvement where applicable.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$250,000

**Estimated Project Duration:** 12 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Pavement Management Clearinghouse*

## II. RESEARCH PROBLEM STATEMENT

Technology advances in pavement distress data collection are often difficult to for an agency to monitor, evaluate, and determine implementation appropriateness. In addition, there are many resources that are of value to pavement management practitioners, but a great deal of time can be spent trying to locate the information. It would also be beneficial for transportation agencies to have a readily available list of local, regional, and national contractors and their capability of constructing the vast array of pavement preservation and rehabilitation treatments. In this manner, an agency looking to apply a specific treatment (e.g., microsurfacing or hot in-place recycling) can access a web-based clearinghouse to determine contractor capabilities. A centralized repository of equipment availability, technology advancements, resources, and contractor availability and capability is necessary.

**Tasks:** The research will include the following tasks:

1. Survey SHAs, equipment suppliers, and contractors regarding distress data collection equipment, contractors/supplier capabilities, and prequalification procedures.
2. Prepare a synthesis of available data collection equipment and qualified contractors.
3. Survey equipment suppliers regarding equipment capabilities for accurately measuring pavement distress.
4. Survey qualified contractors regarding capabilities specific to common pavement preservation/rehabilitation treatments.
5. Develop an online database of contractors and capabilities, allowing for a sort of vetting process for new additions.

### **Final Product:**

The research will result in the development of an online database of equipment suppliers and treatment contractor capabilities, allowing for a sort of vetting process for new additions.

## III. RESEARCH OBJECTIVE

The primary objective of this research is to develop a central resource for SHAs regarding availability of pavement condition equipment and qualified contractors in relation to their capabilities specific to pavement preservation/rehabilitation applications.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$100,000

**Estimated Project Duration:** 12 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Synthesis of External Issues Driving Pavement Management*

## II. RESEARCH PROBLEM STATEMENT

There are many factors that impact pavement management that are beyond the control of agency staff or administrators. With changes in available transportation funds, agencies have to adapt to new approaches for funding, contracting, and/or project acceptance. These external forces have undoubtedly influenced pavement management needs and priorities.

**Tasks:** The research will include the following tasks:

1. Conduct a survey of pavement management practitioners to determine what factors have impacted pavement management practices, as well as if and how these factors have been addressed.
2. Identify SHAs to be case studies in a more detailed assessment.
3. Develop a synthesis of findings.

### **Final Product:**

The final product of the research is development of a synthesis of factors that impact pavement management practices, including case studies that demonstrate how state agencies have been able to address these impacts.

## III. RESEARCH OBJECTIVE

Research objectives include identification of factors that impact pavement management practices at various levels (e.g., municipal, county, and state), and identification of how, and how well, these impacts are being addressed by practitioners.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$30,000

**Estimated Project Duration:** 9 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Methods of Defining and Calculating the Effect of Pavement Preservation Treatments on Pavement Life*

## II. RESEARCH PROBLEM STATEMENT

There is little information available to assist pavement managers with quantifying the effect of pavement preservation treatments on pavement life. This is especially true in light of the fact that the same treatment can be used in a preventive manner or as a stop-gap treatment. The extent of existing pavement distress, traffic level, climatic condition, treatment type, materials, and other factors can significantly impact treatment performance.

**Tasks:** The research will include the following tasks:

1. Conduct a survey of state of the practice regarding quantifying pavement preservation impacts on pavement life.
2. Identify roadway sections that have historical data concerning pretreatment conditions (e.g., pavement condition, pavement structure, and traffic levels), as well as construction and condition information regarding treatment type.
3. Develop pavement condition performance according to existing condition, treatment type, climate, traffic levels, and other factors.
4. Prepare a report detailing treatment performance.

### **Final Product:**

The final product of this research will be a report documenting research findings.

## III. RESEARCH OBJECTIVE

The research will quantify the impacts that pavement preservation treatments have on pavement performance, using measured field data from various geographic regions of the country.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$500,000

**Estimated Project Duration:** 36 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Investigation into the Risk, Uncertainty, and Variability in Pavement Management Decisions*

## II. RESEARCH PROBLEM STATEMENT

Pavement management systems are based on collected data (e.g., condition data, traffic data, existing layer types and thickness, and past preservation and rehabilitation treatments) that have the potential for associated errors. The analysis methods themselves are conducted using performance models that also have an associated error. Yet results of these analyses do not usually estimate the errors associated with data collection and performance prediction. The impact (or risk) associated with errors in the data collection and performance prediction processes are not well quantified. Procedures are needed to help agencies determine the amount of data needed to provide credible recommendations and to determine what level of risk (or uncertainty) is considered acceptable, in an attempt to improve levels of accountability and confidence in the performance prediction outputs from the pavement management system.

**Tasks:** The research will include the following tasks:

1. Identify the critical pavement management system outputs (e.g., network condition, program recommendations, and so on) that impact performance prediction.
2. Determine data and analysis needs to improve performance prediction. Identify the associated risk based on data availability and steps needed to reduce the potential of data error.
3. Develop guidelines for data collection needs and analysis for improving performance prediction.
4. Develop software tools to assess errors in the data collection and analysis procedures.

### **Final Product:**

The final product of the research includes guidelines and software tools for assessing data quality and improving the reliability of pavement management outputs and recommendations.

## III. RESEARCH OBJECTIVE

The objective of this research is to investigate the various forms of variability affecting pavement management recommendations and to develop a process for evaluating this impact and the overall effectiveness of pavement management recommendations.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$350,000

**Estimated Project Duration:** 24 months

**THEME 2**  
**PROBLEM STATEMENTS**

## **Theme 2 – Institutional and Organizational Issues**

The theme 2 problem 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 of pavement management on funding and how to determine, promote, and effectively communicate the use and the benefits of pavement management.

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Communicating Pavement Management Information and Benefits*

## II. RESEARCH PROBLEM STATEMENT

An important part of establishing credibility in a pavement management system is presenting recommendations in a way that resonates with the audience. Historically, pavement managers have not been effective in "telling their story" in a way that influences the decisions of executives, the public, and other external stakeholders.

**Tasks:** The research will include the following tasks:

1. Identify current practices incorporating pavement management with strategic planning.
2. Develop criteria for determining best practices regarding incorporating pavement management analyses into business and strategic processes.
3. Identify best practices and case studies suitable to illustrate how to successfully tie network- and project-level decisions/goals.
4. Develop guidelines documenting recommendations for using pavement management analysis results to provide meaningful planning decisions.

### **Final Product:**

The products of the study include templates, sample PowerPoint presentations, webcasts of successful approaches, and/or guidelines for using these strategies.

## III. RESEARCH OBJECTIVE

Investigate how highway agencies have successfully gained buy-in from decision makers that have led to increased use of pavement management information, investigate strategies for effectively communicating pavement management information (including the benefits of preservation), provide guidance for pavement managers responsible for making these types of presentations, and explore current methods of communication (e.g., Twitter, Facebook, and Wikipedia).

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$250,000

**Estimated Project Duration:** 12 months



# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Improving the Skills of Pavement Managers*

## II. RESEARCH PROBLEM STATEMENT

An effective pavement manager must have both technical and social skills to be most successful; skill levels affect the final output, which in turn affects credibility and buy-in. Some of the technical skills are taught in college or through on-the-job training, such as management skills (people skills) and understanding organizational behavior. However, some aspects of a pavement manager's job are not covered in a traditional civil engineering curriculum. Agencies have three options for addressing this shortcoming; they can contract for the services needed, provide the training needed, and/or allow untrained staff to perform the activities. Furthermore, although pavement management documentation is prolific, it has not been organized in a way that is effective in training or improving pavement management operations.

**Tasks:** The research will include the following tasks:

1. Develop an online clearinghouse for pavement management resources, including plan documentation, case studies, open-source software, training materials, and others.
2. Define appropriate levels of training and/or aptitude for personnel working with pavement management systems.
3. Identify inexpensive, yet effective, training alternatives when funding for professional development is limited.
4. Develop guidelines for getting the most out of contracted pavement management systems.

### **Final Product:**

The research will result in training guides to help agencies in the evaluation of fiscal and organizational impacts associated with workforce development, an online clearinghouse of useful resources, and information on career paths in pavement management.

## III. RESEARCH OBJECTIVE

There are three specific objectives for the research. First, the research will develop an online clearinghouse for pavement management resources. The second objective is to define basic levels of aptitude concerning pavement management systems. The final research objective is to develop guidelines that transportation agencies can use to ensure an outsourced pavement management system meets an agency's needs.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$250,000

**Estimated Project Duration:** 12 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Annual Approval of State Planning and Research (SP&R) Program Funding*

## II. RESEARCH PROBLEM STATEMENT

The annual approval of SP&R funding does not currently match the timing of data collection and processing for most state highway agencies. When SP&R funds are available for use, they expire at the end of the year making it difficult for the SHA to expend the approved funds. This study will identify the SP&R funding restrictions, identify solutions that will meet FHWA and SHA requirements, determine recommended solutions, and suggest policy changes.

**Tasks:** The research will include the following tasks:

1. Identify source(s) and reason(s) for SP&R funding restrictions.
2. Identify possible resolutions for getting the most out of SP&R funds.
3. Recommend policy revisions and such to implement solutions.

### **Final Product:**

The final product of the research is a set of recommendations for revising policy to better utilize SP&R funds in the timeframe allowed.

## III. RESEARCH OBJECTIVE

The primary objective of this research is to reconcile the timeframe of agency practices with the availability of SP&R funds.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$100,000

**Estimated Project Duration:** 12 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Framework for Minimizing the Delivery of Treatment Application*

## II. RESEARCH PROBLEM STATEMENT

Often, pavement preservation/rehabilitation projects are delayed due to plan preparation, advertising, and letting. This lag time between project selection and construction may render the selected treatment ineffective due to the continued advancement or acceleration of pavement distress. There is a need to develop a process for reducing the timing between project selection and treatment application to ensure proper treatment application, maximize performance life, and reduce overall life-cycle cost.

**Tasks:** The research will include the following tasks:

1. Survey SHAs regarding planning and programming procedures.
2. Identify or develop procedures for reducing the time between treatment selection and application.
3. Conduct case studies to verify recommendations using data provided by SHAs.
4. Develop best practices for timely planning and programming of preservation and rehabilitation treatments.

### **Final Product:**

The research will result in the development of best practices for the timely planning and programming of pavement preservation/rehabilitation applications.

## III. RESEARCH OBJECTIVE

The primary objective of this research is to develop a best practices guide for improving the efficiency and timeliness of planning and programming operations regarding implementing pavement management recommendations, particularly with respect to pavement preservation/rehabilitation treatment applications.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$250,000

**Estimated Project Duration:** 12 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Addressing Trade-Offs, Metric Issues, and Purchasing Controls/Policies*

## II. RESEARCH PROBLEM STATEMENT

Political and organizational issues and organizational inertia can frequently impede the incorporation of improved and beneficial analysis and technological advancements into the pavement management process. In order to overcome this challenge, key issues related to the trade-offs, metric terms/issues, policies, and purchasing controls need to be determined, quantified, and presented so that more educated decisions can be made.

**Tasks:** The research will include the following tasks:

1. Survey practitioners regarding implementation of pavement management activities with respect to political and/or organizational encumbrances.
2. Identify common critical issues impacting implementation, especially with respect to acquiring new technology or analysis procedures and deployment of such.
3. Identify common critical issues regarding defining performance metrics and measures to meet the needs of practitioners and decision-makers.
4. Prepare a synthesis of findings.

### **Final Product:**

The final product of the research is a synthesis of common issues encountered in pavement management with respect to political and/or organizational impacts on policy, performance measures, implementation of new practices and activities, and so on.

## III. RESEARCH OBJECTIVE

The primary objective of this research is to understand the common critical issues surrounding political and/or organizational change on pavement management policy.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$30,000

**Estimated Project Duration:** 9 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Impact of Pavement Management Investment Levels on Benefits*

## II. RESEARCH PROBLEM STATEMENT

As agency budgets tighten, pavement management data collection activities (which typically represent the largest part of the budget for pavement management activities) are at risk of budget cuts. However, since the relationship between expenditures for data collection and analysis tools and pavement management outputs is not well understood, the financial impact and/or risk of budget cuts cannot be communicated. For example, if an agency cuts the data collection budget by 50 percent, an agency could respond by extending the frequency with which data are collected or be reducing the amount of data collected in each cycle. The consequences associated with each of these options are not well understood and there is no known basis for deciding how to address this challenge.

**Tasks:** The research will include the following tasks:

1. Survey practitioners for information regarding funding levels for pavement management data collection, number of network miles, and budget for preservation, rehabilitation, and reconstruction.
2. Analyze survey results to determine if any trends exist between funding for pavement management and funding for pavement preservation/rehabilitation/reconstruction.
3. Conduct risk analyses for cost effectiveness of perceived trends.
4. Develop guidelines allowing practitioners to illustrate how funding levels impact pavement management and its practices.

### **Final Product:**

The final product of the research is a set of guidelines for determining how funding impacts pavement management practices, illustrating the risks or benefits associated with changes in levels of funds allocated to pavement management/preservation activities.

## III. RESEARCH OBJECTIVE

There are three specific objectives for the research. First, the research will determine the relationship between agency funding and pavement management practices. The second objective is to define the risk or benefit associated with whether adequate funding is provided to conduct pavement management/preservation work. The final research objective is to develop guidelines that will illustrate for practitioners how pavement management is affected by funding and the impact such effects can have.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$350,000

**Estimated Project Duration:** 24 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Methods to Promote Pavement Management as a Management Tool*

## II. RESEARCH PROBLEM STATEMENT

Pavement management is an important tool to help agencies keep a long-term perspective when managing assets. It can be used to show impacts of different strategies, estimate needs, set and monitor performance targets, and evaluate changes in design, materials, or construction. But its value to agencies is not always well understood, especially among executives and elected officials with short-term positions. Therefore, what is needed is a public relations campaign that raises the profile of pavement management and communicates the wide-ranging benefits it provides an agency.

**Tasks:** The research will include the following tasks:

1. Identify various internal and external audiences—considering both marketing and engineering perspectives—affected by pavement management.
2. Survey practitioners regarding how pavement management is promoted internally and externally.
3. Identify effective ways of promoting pavement management to garner internal, public, and official buy-in and support.
4. Develop a marketing/public relations campaign(s) to raise the profile of pavement management activities and their associated benefits to the public, officials, and the practicing agency.

### **Final Product:**

The research will result in marketing materials that can be used to demonstrate the benefits of pavement management to all stakeholders.

## III. RESEARCH OBJECTIVE

There are two specific objectives for the research. First, the research will identify effective ways of promoting pavement management practices internally and externally to an agency. The second objective is developing a marketing/public relations campaign to encourage pavement management activities by an agency.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$100,000

**Estimated Project Duration:** 12 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Recommended Methodology to Calculate Pavement Asset Value and Communicate to Stakeholders*

## II. RESEARCH PROBLEM STATEMENT

Asset management systems have traditionally been required to answer the following fundamental questions: What assets do we have? Where are they? What condition are they in? A fourth, but equally fundamental, question now also exists: What is the value of our assets both today and expected over the life cycle? This fourth question has become particularly relevant with the advent of Government Accounting Standards Board Statement 34 (GASB 34), which is a past based approach, as compared to current and future based approaches. GASB 34 uses historical data to calculate asset value, and if this is not available, current replacement costs are “deflated” using a construction price index to estimate historic cost. Current based methods include replacement cost, written down replacement cost and net salvage value. Future based methods require performance models and include productivity realized value, salvage value, and market value. Application to real networks has been limited but indicates substantial differences in calculated asset value, depending on method, age of the asset, predicted performance, and various other factors. Agencies who track and report asset value over time do not have consistent, understandable, and widely accepted methodology.

**Tasks:** The research will include the following tasks:

1. Carry out a review of existing literature, national and international, on asset valuation methodology for civil infrastructure and particularly how it has been applied to pavements at the strategic, network and project levels.
2. Identify the positive features and the shortcomings of these methodologies.
3. Review the (full accrual accounting) requirements of GASB 34, and the various ways in which GASB 34 can be reported.
4. Prepare recommendations for a consistent, understandable and acceptable methodology for pavement asset valuation which can be used for reporting under GASB 34, but can also have wider application or use by stakeholders if possible.

### **Final Product:**

The final product of this study is a methodology for assessing pavement value for reporting to GASB 34.

## III. RESEARCH OBJECTIVE

The objective of this study will be to develop an asset valuation methodology for civil infrastructure, particularly on how it applies to pavements at the strategic, network, and project level.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$100,000

**Estimated Project Duration:** 12 months



# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Suggested Topics for Pavement Management into the Civil Engineering Curriculum*

## II. RESEARCH PROBLEM STATEMENT

There is not sufficient emphasis on pavement management in civil engineering curricula. As a result, there is a steep learning curve for new practitioners. Therefore, there is a need to raise the awareness of pavement management concepts in the existing college curricula.

**Tasks:** The research will include the following tasks:

1. Survey and create a synthesis of current college curricula regarding transportation engineering and management.
2. Survey practitioners' needs in regards to new employee knowledge and skills.
3. Develop teaching/learning resources to increase the level of awareness among instructors and students.

### **Final Product:**

The final product of the research is a set of instructors' resources for incorporating pavement management principles and concepts into college curricula.

## III. RESEARCH OBJECTIVE

There are two specific objectives for the research. First, the research will determine what level of education regarding pavement management practices and principles would be beneficial to new employees. The second objective is developing resources instructors can use to incorporate pavement management-related education into their syllabi.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$100,000

**Estimated Project Duration:** 12 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Constant Funding for Pavement Management*

## II. RESEARCH PROBLEM STATEMENT

Inconsistent levels of funding make it difficult for pavement management staff to keep pavement conditions at a consistent level and predict future needs (e.g., pavement preservation, rehabilitation, and reconstruction) of the system. Additionally, it is difficult to maintain a consistent level of work for designers and contractors.

**Tasks:** The research will include the following tasks:

1. Survey SHAs regarding approaches used for fund allocation.
2. Summarize the advantages/disadvantages of each approach.
3. Quantify the impacts of suboptimal allocations.
4. Identify the monetary needs for a consistent pavement management work program to allow agencies to optimize pavement treatments and funding.
5. Develop best practices guidelines and recommendations.

### **Final Product:**

The research will result in the development of guidelines for recommending allocation of funds according to objective pavement management data.

## III. RESEARCH OBJECTIVE

The primary objective of this study is to develop a synthesis of practice for allocating funds for pavement preservation and pavement rehabilitation.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$100,000

**Estimated Project Duration:** 12 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Identify Information Technology (IT) Needs to Effectively Manage a Pavement Management System*

## II. RESEARCH PROBLEM STATEMENT

As agencies seek to achieve efficiencies in information technology practices, users of advancing technologies are experiencing challenges for accessing, manipulating, and using technology associated with internal IT departments. Often, technology advancements to address pavement management needs are impeded due to potential limitations in network capabilities, IT personnel understanding of the issues, or pavement managers' lack of knowledge on IT limitations, procedures, and roles.

**Tasks:** The research will include the following tasks:

1. Survey practitioners regarding the role IT departments play in acquiring, implementing, and deploying new pavement management information technology.
2. Identify common goals, needs, and gaps between pavement managers and IT managers.
3. Develop synthesis for coordinating IT needs and addressing common obstacles to satisfy both pavement management needs and IT management.

### **Final Product:**

The final product of the research is a synthesis that identifies common critical issues encountered when acquiring, implementing, and deploying new pavement management information technology, and how to work with IT management to more effectively communicate needs.

## III. RESEARCH OBJECTIVE

The primary objective of this research is to identify and address common issues encountered between IT management and pavement management as it pertains to effectively meeting the goals and objectives of pavement management policy and practice.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$30,000

**Estimated Project Duration:** 9 months

**THEME 3**  
**PROBLEM STATEMENTS**

### **Theme 3 – The Broad Role of Pavement Management**

Theme 3 includes problem 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.

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Development and Use of Effective Performance Measures*

## II. RESEARCH PROBLEM STATEMENT

To be most effective, pavement management should exist within an asset management framework that supports the integrated analysis of project needs and investment decisions. Agencies that have adopted asset management principles rely on performance management as a way of communicating needs, setting performance targets, and reporting progress. To date, a disconnect exists between performance measures used for strategic purposes and those that are reported in a pavement management system (e.g., IRI). In addition, many pavement management systems do not currently include measures needed to support the selection of pavement preservation treatments or the documentation of benefits for use in a pavement management cost/benefit analysis. Such measures might include maintenance patching or the consideration that pavement preservation might defer the need to patch. In some cases, existing performance measures are negatively impacted by the application of pavement preservation activities, such as an increase in roughness associated with the use of chip seals, so guidance must be provided on how to handle these instances.

**Tasks:** The research will include the following tasks:

1. Perform a literature review and survey of SHAs to synthesize performance measure terminology and targets, as well as thresholds and triggers.
2. Develop guidelines for determining effective performance measures and how to report measures according to the goals perceived by the target audience (e.g., technical, nontechnical, departmental, and political).
3. Perform a gap analysis of typical components and needs of pavement management systems compared to those of asset management practices, and identify strategies for closing the gap.
4. Develop guidelines for implementing a pavement management system with the intention of ultimately integrating it into an asset management plan.

### **Final Product:**

The research will result in the development of a guidelines document recommending how to develop and/or synergize pavement management system performance measures to strategic initiatives. Additional products of this research will include definitions that will improve the consistency in the use of relevant terms, a synthesis of current pavement performance measures, and recommendations for using performance measures effectively.

## III. RESEARCH OBJECTIVE

Under this study, states with successful asset management systems and their impact on pavement management will be documented, investigation of the connection 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. Innovative performance measures should be considered during this research. For instance, the use of nontraditional measures, such as the change in economic value over time, may be explored. Guidelines should also be developed for identifying effective performance measures for evaluating pavement preservation treatments in a pavement management system. Examples in which pavement management information has been used successfully for goal setting will be provided.

#### **IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD**

**Estimated Budget:** \$250,000

**Estimated Project Duration:** 12 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Pavement Management Data Mining: Improving Current Uses and Leveraging New Applications of Pavement Management Data*

## II. RESEARCH PROBLEM STATEMENT

There is an untapped potential to make greater use of pavement management data to better address current agency needs and to provide insight into new areas (e.g., asset value, new design methods, improved construction practices, corridor studies, forensic investigation, and impacts of weight limits on performance). However, for these types of analyses to take place, it is important that data from related data sources are better leveraged.

**Tasks:** The research will include the following tasks:

1. Survey practitioners for types of pavement management data they collect.
2. Identify new areas where pavement management data can be utilized (e.g., asset value, new design methods, forensic investigation, and improved construction practices).
3. Develop case studies that illustrate the uses of pavement management data for the areas identified under task 2.
4. Develop guidelines (including case studies identified in task 3) on how to use pavement management data for addressing the areas identified in task 2.

### **Final Product:**

The final product of the research is guidelines for using pavement management data to address the needs of other departments within an agency.

## III. RESEARCH OBJECTIVE

There are two specific objectives for the research. First, the research will identify what pavement management data is collected. The second objective is to define how to leverage such data for use in other departments within an agency.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$350,000

**Estimated Project Duration:** 24 months



# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Load Limit Impacts on Pavement Performance*

## II. RESEARCH PROBLEM STATEMENT

State legislatures are regularly faced with requests for load limit exemptions for a portion of the road system and often grant these requests without understanding the impacts to the road system. Nationally, there is pressure to raise the current 80,000 pound load limit on interstate highways to 97,000 pounds. In addition, agencies are faced with requests for permission to carry oversized loads or to levy fines to drivers of overweight vehicles. However, the impact of these heavy loads on performance measures, such as future pavement conditions, maintenance costs, and remaining service life, is not well understood and may be difficult for agency personnel to readily quantify.

Traditional methods of predicting pavement performance for pavement management purposes have utilized historical pavement condition data. A statistical analysis using regression is typically performed on pavement condition data to estimate changes in pavement condition with time. The historical data are assumed to be reliable predictors of future performance. However, if increased load limits are allowed on existing pavements, it is reasonable to expect that existing pavements will deteriorate at an accelerated rate since they were not designed to accommodate these weights. Future maintenance and rehabilitation costs may also increase to reflect the increased deterioration. Further, increased pavement thicknesses may be required for agencies designing new pavements or for rehabilitating existing pavements to accommodate the new load limits.

**Tasks:** The research will include the following tasks:

1. Identify one or more performance metrics that can be used to quantify the impact of increased loads (e.g., pavement condition, remaining service life, and increased maintenance costs).
2. Develop a methodology that illustrates the use of existing pavement management data to quantify the impact of changes in load limits on each of the selected performance metrics. Existing tools should be utilized as much as possible in developing the methodology.
3. Conduct trial applications of the methodology using data provided by SHAs.
4. Verify the methodology using data from an agency that recently increased load limits and has data that could be used to document impacts. Verification should include historical data from an agency where load limits have been increased at least 5 years prior to the start of the study. Comparisons should be made between the predicted impacts and the actual impacts as measured through pavement management or other methods.
5. Develop guidelines (including case studies) on using pavement management data for quantifying the impact of load limit increases, on how SHAs can incorporate developed procedures into the pavement management process, and how to verify/calibrate developed models to local conditions.

**Final Product:**

The research will result in the development of a methodology for evaluating the impact of load limit changes and guidelines on use of the methodology.

**III. RESEARCH OBJECTIVE**

There are three specific objectives for the research. First, the research will identify performance measures that can be used to quantify the impacts to the agency of increased vehicle loading. The second objective is the development of a methodology that can be applied using existing data to quantify the impacts associated with heavy vehicles loads. The final research objective is the development of guidelines that transportation agencies can use to implement the methodology.

**IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD**

**Estimated Budget:** \$500,000

**Estimated Project Duration:** 36 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Developing and Supporting a Pavement Management Business Plan*

## II. RESEARCH PROBLEM STATEMENT

Pavement management has been around for decades, but in some ways the integration of pavement management into the core business function of many agencies is very immature. Pigeonholing pavement management as the collection and reporting of pavement condition is too narrow, and the assumption that pavement management is a panacea of everything related to pavements is doomed to fail as too broad. Defining the focus for pavement management and defining and developing necessary skills should be documented in the form of a pavement management business plan. Although the purpose is to show the strong ties needed between pavement management and agency business plans, the focus should include a broad array of functions ranging from simplistic to very complex and anticipate use by established practitioners, pavement management newcomers, and agency executives.

The term “pavement management” means very different things to different people. Pavement management practitioners can use their systems for the traditional pavement condition data collection and reporting, generation of rehab/maintenance plans, support of design, materials, and construction activities, and support of research, among others. However, having all of these tasks greatly broadens the demands on pavement management systems and the practitioners. These demands also greatly broaden the skills needed in pavement management work groups to include communications, statistics, economics, electronics, computer science, physics, etc. The potential for a more unified pavement management community with targeted goals and business integration strategies should mature the field.

**Tasks:** The research will include the following tasks:

1. Define core business functions of pavement management.
2. Conduct a survey of SHAs to identify the status of pavement management systems in accordance with the core business functions.
3. Determine barriers that are preventing the success and develop plans to help address incorporation of the core business functions. This task could include training, institutional issues, staffing, appropriate data, competing requirements, and technology needs.
4. Determine what tangential areas are best for expansion and what practitioners need to accomplish incorporation of the core business functions.
5. Develop appropriate training, implementation strategies, marketing plan, etc. to promote and facilitate coordination between agency vision, mission, and pavement management.

### **Final Product:**

Training, implementation strategies, marketing plan, etc. to promote and facilitate coordination between agency vision and mission and pavement management.

### **III. RESEARCH OBJECTIVE**

The research should provide means to create practitioners with the skills to more fully understand pavements and associated technologies and skills to communicate that knowledge for business and marketing decisions. Presumably, in an altruistic sense, this research will result in better decisions by the agencies that can be strongly supported by pavement management and practitioners and ultimately by the users of transportation.

### **IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD**

**Estimated Budget:** \$350,000

**Estimated Project Duration:** 24 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Use of Pavement Management Information for National Reporting*

## II. RESEARCH PROBLEM STATEMENT

In many states, Highway Performance Monitoring System (HPMS) data and pavement management data are collected by separate divisions or reported by someone not involved in the data collection process. In some cases, the HPMS data are “passed off” without regard for the accuracy of reporting the information. As a result, there can be issues with data quality between what is collected by pavement management and what is reported to FHWA through the HPMS process. Additionally, there is an inefficient use of resources if similar data are being collected by two different groups within the same agency. There is also generally less buy-in or credibility in the HPMS data than in the pavement management data. Furthermore, HPMS data does not always represent data that drives an agency’s project and treatment selection processes.

**Tasks:** The research will include the following tasks:

1. Identify example SHAs who could supply both HPMS and pavement management system data.
2. Compare and identify data inconsistencies or quality issues that would keep an agency’s pavement management data from meeting HPMS requirements.
3. Develop guidelines for standardizing data elements to meet both pavement management and HPMS needs.

### **Final Product:**

The final product of the research is development of guidelines for a standardized method of reporting this information.

## III. RESEARCH OBJECTIVE

There are two specific objectives for the research. First, the research will identify common inconsistencies between pavement management and HPMS data needs. The second objective is to develop guidelines for standardizing data collection and reporting to satisfy both requirements.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$100,000

**Estimated Project Duration:** 12 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Using Pavement Management Data to Support Design Activities*

## II. RESEARCH PROBLEM STATEMENT

Historically, pavement management activities have been implemented to support activities associated with the planning and programming of rehabilitation projects and preservation treatments. However, information from pavement management could be used to better support design functions if data integration and data quality issues are addressed. In this regard, additional tools are needed to use pavement management data to support the prediction of pavement performance (including the structural aspect) as are guidelines for using this information to locally calibrate performance prediction models using measured data. In addition, with the upcoming release of AASHTO DARWin-ME, more and more states will be looking toward their pavement management data to aid in the calibration process. The communication between the pavement design and pavement management staff will be critical to fully capture the benefits of mechanistic empirical based design and the predicted outcomes. A process to compare/check the predicted performance from mechanistic-empirical based design to the performance predicted from the pavement management system is needed.

**Tasks:** The research will include the following tasks:

1. Survey practitioners regarding how implementing AASHTO DARWin-ME has impacted, or compares to, their pavement management practices and/or recommendations, and how such impacts have been addressed.
2. Develop guidelines for determining the compatibility of prediction and recommendations from both the pavement management system and AASHTO DARWin-ME.
3. Develop software to reconcile and calibrate performance prediction models using pavement management and AASHTO DARWin-ME.

### **Final Product:**

The research will result in the development of guidelines for determining the compatibility of pavement performance prediction between a pavement management system and AASHTO DARWin-ME, as well as the development of software to reconcile and calibrate the performance prediction models within a pavement management system and AASHTO DARWin-ME.

## III. RESEARCH OBJECTIVE

There are two specific objectives for the research. First, the research will develop guidelines for determining the compatibility of pavement management and AASHTO DARWin-ME prediction and recommendations, and the second objective will develop guidelines and software tools for reconciling and calibrating pavement management systems and AASHTO DARWin-ME performance prediction models.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$350,000

**Estimated Project Duration:** 24 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*National Funding Allocations that Account for State Priorities*

## II. RESEARCH PROBLEM STATEMENT

Each state has its own way of prioritizing needs and allocating funding. As a result, there will be differences in the pavement performance measures that can be accomplished within each agency. However, there is a tendency toward national comparisons of pavement performance that do not account for these differences.

**Tasks:** The research will include the following tasks:

1. Survey SHAs regarding allocation of state funds toward highway transportation, conditions of their networks, and pavement management priorities.
2. Correlate SHA objectives and priorities to network condition and annual budget and expenditures.
3. Develop a methodology for determining a SHAs' success in terms of pavement condition relative to funding.

### **Final Product:**

The final product of the research is a formula or set of benchmark guidelines for comparing SHA pavement management practices relative to funding priorities.

## III. RESEARCH OBJECTIVE

There are two specific objectives for the research. First, the research will correlate SHA funding priorities with pavement management activities. The second objective is to formulate a sort of common denominator for all SHAs so as to appropriately compare relative success of pavement management practices.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$250,000

**Estimated Project Duration:** 12 months



# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Identify Data Needs to Support Other Processes*

## II. RESEARCH PROBLEM STATEMENT

As data collection has become more sophisticated, the demand on data contained within the pavement management system has increased. This increase has been noted by pavement performance data for use in calibration of the Mechanistic-Empirical Pavement Design Guide (MEPDG), the HPMS reassessment, warranties, public-private partnerships, and forensic studies, among others. An assessment of what and how pavement management data can be used to support these various applications is needed.

**Tasks:** The research will include the following tasks:

1. Identify applications that can benefit from the use of pavement management data.
2. For the identified applications, determine the type of data, the amount of data, and the level of detail needed to support the various applications.
3. Determine the cost/benefit of collecting and incorporating the data into the pavement management system if not already present.
4. Quantify the risk of managing known versus unknown problems.
5. Conduct case studies to demonstrate benefit of using pavement management data in other applications.
6. Develop guidelines that demonstrate how pavement management data can be used in other applications.

### **Final Product:**

Guidelines on what and how data contained within a pavement management system can be used to support other applications within a highway agency.

## III. RESEARCH OBJECTIVE

The objectives of this research include identifying applications that could benefit from pavement management data, identifying current data that can be used to improve/enhance these applications, identifying gaps in needed data, and providing guidelines on how to better utilize pavement management data in other applications.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$350,000

**Estimated Project Duration:** 24 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Methodologies to Reliably Support Innovative Contracting*

## II. RESEARCH PROBLEM STATEMENT

With increases in the use of warranty, concessionary, and public-private partnerships, as well as other innovative contracting processes, changes in the use of pavement management data can be expected. For instance, historical pavement performance data and forecasted conditions may be used to set acceptable condition levels and to determine whether contractual performance requirements have been satisfied. As a result, a higher level of reliability is required of the data than is needed for traditional processes, and so data collection processes may need to be modified.

**Tasks:** The research will include the following tasks:

1. Identify data needs for managing innovative contracting projects, such as critical data for measuring performance.
2. Determine the impacts innovative contracting has on pavement management practices, and develop recommendations for accommodating these impacts (i.e., selecting applicable performance measures).
3. Identify means for collecting data to support performance measures.
4. Develop guidelines for ensuring pavement management needs are satisfied by innovative contracted projects.

### **Final Product:**

The final product of the research is a set of guidelines for ensuring pavement management needs are satisfied by innovative contracting practices.

## III. RESEARCH OBJECTIVE

There are three specific objectives for the research. First, the research will identify the various impacts innovative contracting has on pavement management systems. The second objective is to determine how to account for the impacts innovative contracting has on pavement management systems; for example, developing performance metrics and applicable data to measure said impacts. The final research objective is to develop guidelines for ensuring pavement management needs are satisfied by innovative contracting practices.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$250,000

**Estimated Project Duration:** 12 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Impact of Earmarks on Pavement Performance*

## II. RESEARCH PROBLEM STATEMENT

Earmarks can consume considerable SHA funding, leaving less funds to address the needs of the entire highway system. Some earmarks require bond indebtedness that has a long lasting obligation to the SHA. When earmarks are large in dollars or numbers, they significantly alter the ability of the SHA to address pressing needs such as pavement preservation.

**Tasks:** The research will include the following tasks:

1. Survey practitioners and prepare a synthesis regarding the impact earmarks have on long range programming and planning.
2. Reconcile SHA network needs with earmarks relative to funds allocated.
3. Identify any trends between the status of network condition in the wake of large expenditures for earmarked projects.
4. Prepare a report that summarizes findings.

### **Final Product:**

The final product of the research is a report analyzing the impacts earmarks have on a pavement management program and agency priorities and goals in terms of services provided by such earmarks, as well as any reduction in services provided according to the recommendations based on pavement management information.

## III. RESEARCH OBJECTIVE

The primary objective for the research is to determine the impact earmarks have on an SHA achieving its network condition goals and/or addressing recommendations provided by its pavement management system.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$100,000

**Estimated Project Duration:** 12 months

**THEME 4**  
**PROBLEM STATEMENTS**

**Theme 4 – New Tools, Methodologies, and Technology**

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, problem 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.

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Development of Automated Condition Data Processing Tools*

## II. RESEARCH PROBLEM STATEMENT

Improvements to current tools for automating the processing of some measures of pavement evaluation are needed to accelerate the rate at which survey results become available and to improve the consistency and reliability of the information. In particular, improvements are needed to the processing of surface distress data, GPR, and rutting. For cracking, algorithms are needed for 1-mm 3-D data systems; for rutting, a methodology is needed to interpret thousands of points of transverse profile; and for GPR, algorithms are needed for improved thickness detection.

**Tasks:** The research will include the following tasks:

1. Identify problems and performance needs (including acceptable levels of precision and bias) for data processing of automated pavement crack detection, transverse profile, and GPR.
2. Develop new algorithms to fully automate crack and rut detection based on 1-mm 3-D data systems.
3. Improve thickness detection algorithms for GPR devices.

### **Final Product:**

The final product of the research is a modular software package incorporating new or improved algorithms for cracking and rutting detection and thickness determination using GPR.

## III. RESEARCH OBJECTIVE

There are two specific objectives for the research. First, the research will develop fully automated crack and rut detection algorithms, and the second objective is to develop improved thickness detection algorithms for GPR devices.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$800,000

**Estimated Project Duration:** 48 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Methods to Quantify the Benefits of Pavement Management*

## II. RESEARCH PROBLEM STATEMENT

Pavement management practitioners can usually describe the benefits associated with pavement management, particularly in terms of effective use of agency funding and improvements in pavement condition. However, the potential cost saving to the agency associated with the use of pavement management information by other stakeholders (such as design) is often nebulous and esoteric. In addition, social benefits (e.g., user costs, sustainability, livability, and environmental) are typically ignored when considering benefits associated with pavement management. Thus, the direct and indirect benefits of pavement management must be quantified so that cost savings can be used as justification for future investment in pavement management and data collection activities. Benefits that might be incorporated into this study may include better data access, improved decision making, user cost savings (e.g., vehicle operating costs), improved design features, and reduction in maintenance costs.

**Tasks:** The research will include the following tasks:

1. Identify links and prioritize the relative significance of these inter-relationships between pavement management and areas (e.g., economic development, safety, and environment) other than facilities' condition.
2. Conduct a survey of practitioners (both public and private) to determine how these links are quantified (e.g., user costs) and accounted for in decision making and presented in reports.
3. Prepare a synthesis of findings, including case studies.

### **Final Product:**

The research will result in a synthesis of the state of the practice to account for social, economic, and environmental impacts as determined using pavement management data.

## III. RESEARCH OBJECTIVE

The research will provide the means to quantify and account for benefits and consequences determined by pavement management systems in terms of various other areas, such as social, economic, and environmental impacts.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$30,000

**Estimated Project Duration:** 9 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Improving Factors Considered in Project and Treatment Selection Decisions*

## II. RESEARCH PROBLEM STATEMENT

Ideally, the recommendations for project and treatment selection closely match the activities that are funded for construction. However, this has not always been the case. One of the factors that have impacted the degree to which pavement management recommendations are followed is the correlation between treatment selection factors considered by the pavement management system and those considered by personnel in the field. To better improve this match, it is important that the pavement management analysis begin to consider factors that have not been taken into account in the past, including safety, congestion, sustainability (environment), life-cycle costs including user costs, and other emerging issues.

**Tasks:** The research will include the following tasks:

1. Develop a survey for practitioners to determine what factors are used by field personnel in deciding which pavement preservation treatment regimen to administer.
2. Reconcile field factors with those considered by the agency's pavement management system.
3. Develop a methodology for considering factors that have not been taken into account in the past (e.g., safety, congestion, environment, and other emerging issues).
4. Develop best practices for coordinating treatment selection and application timing between those recommended by the pavement management system and those determined by field personnel.

### **Final Product:**

The research will result in the development of 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.

## III. RESEARCH OBJECTIVE

There are three specific objectives for the research. First, the research will provide means for SHAs to reconcile factors considered by their field personnel with respect to pavement management system recommendations. The second objective is to develop a methodology that considers factors that have not been taken into account in the past. The final research objective is to develop guidelines that assist in resolving potential recommendation differences between pavement management system and field personnel.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$250,000

**Estimated Project Duration:** 24 months



# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Analysis of trade-offs associated with alternate methods of data collection*

## II. RESEARCH PROBLEM STATEMENT

As new technology comes along to aid in the pavement management efforts, many agencies will be contemplating whether they should switch from their current practices and adopt new ones. These may include new data collection equipment, analysis procedures, software, etc. Due in part to limited budgets, but also as a practical matter, agencies will need to determine which of their current activities can be modified or even eliminated as a result of this new technology. Procedures that allow an agency to calculate the pros and cons of switching technologies would be very beneficial. This tool would allow them, for example, to make a case for purchasing new data collection equipment, if they can show that other, manual procedures can be eliminated. One example might be the impact of switching from a semi-automated distress analysis procedure to a fully automated procedure. Potential questions that could be addressed include: What equipment would be needed? What costs would be incurred? Could current staff be reduced? Could the data be turned around more quickly? Would the results be more accurate? Could a larger sample of the network be done? Would it be worth the added cost, time, and effort?

**Tasks:** The research will include the following tasks:

1. Determine the (ideal) core functions of pavement management. This task may include identifying what data is currently being collected, what equipment and analysis procedures are being used, and what little used new technology might be available for a state agency to consider.
2. Determine if those core functions are broadly being met.
3. If the core functions are not being met, then determine what barriers are preventing the success and develop plans to help address those. This plan may include training, addressing institutional issues, determining needed staffing levels, identify appropriate data to be collected, identify competing requirements, and determining technology needs.
4. Determine what tangential areas are best for expansion of the core functions and what practitioners need to do to accomplish expansion of the core functions.
5. Conduct case studies with specific agencies looking to upgrade equipment or change pavement management activities, and develop an analysis tool to illustrate such outcomes as trade-offs, pros/cons, and added costs or savings. The developed analysis tools would assist in providing the impact proposed changes would have on the agency's budget, labor force, analysis schedule, etc.
6. Develop appropriate training, implementation strategies, marketing plan, etc. to promote and facilitate coordination between agency vision, mission, and pavement management.

**Final Product:**

The final product would include an analysis tool for evaluating alternative methods/equipment for collecting pavement condition data, training on use of the developed tool, strategies for implementing equipment/method modifications, and guidelines for how to market, promote and facilitate proposed modifications.

### **III. RESEARCH OBJECTIVE**

Advance the tools, methodologies, and practices of state highway agencies to incorporate equipment and analysis advancements that provide improved, cost-effective data collection procedures and techniques.

### **IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD**

**Estimated Budget:** \$350,000

**Estimated Project Duration:** 24 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Pavement Management in a Changing World*

## II. RESEARCH PROBLEM STATEMENT

Pavement management must operate in an environment that is constantly changing. For instance, there are continual changes in leadership, and each change typically brings new agendas. There are also unfunded mandates, changes in freight weights and movements, increased data requirements, scope creep, and changes in regulations that must be addressed. Transportation agencies have limited experience quantifying and communicating the impact of these changes on the highway network.

**Tasks:** The research will include the following tasks:

1. Identify potential external impacts that impact the pavement management process (e.g., funding, pavement condition, data collection, and state and federal regulations).
2. Survey SHAs to determine trends and potential impact on pavements (i.e. increased damage and changes in decision).
3. Quantify the benefits of different funding scenarios.
4. Show impact on network strategies.
5. Create metrics to allow flexibility to deal with changing priorities.
6. Develop guidelines (including an analysis tool) that can be used to quantify changes and demonstrate impact on pavement performance.

### **Final Product:**

The final product of this research will be guidelines and an analysis tool for quantifying and communicating the impact of external changes on pavement management systems.

## III. RESEARCH OBJECTIVE

A number of external impacts can affect the pavement management process (e.g., pavement condition, funding levels, and agency preservation/rehabilitation priorities). The objective of this study is to provide highway agencies the ability to access and communicate these impacts to stakeholders.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$500,000

**Estimated Project Duration:** 36 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Performance Models that Consider Series of Treatments*

## II. RESEARCH PROBLEM STATEMENT

Projecting the performance of a roadway has historically been conducted treatment by treatment, by considering the “bump” in condition from a treatment and the expected life of the treatment. When the next treatment was applied, it was considered as independent of all the preceding treatments. Time has shown us that this independence is not necessarily true; long-term performance is the net effect of all the treatments and their timing. Considering a series of treatments enables an agency to think and act programmatically and develop “cradle to grave” economic analysis. It could also assist agencies in considering in situ situations where one or more treatments impacts lower pavement layers (for example, a series of surface seals resulting in stripping of lower hot-mix asphalt [HMA] layers).

**Tasks:** The research will include the following tasks:

1. Literature search on impact of series of treatments on performance of pavements. Perhaps a survey of agencies on common series and timing for various roadway categories.
2. Develop a strategy for evaluating treatments in series. Part of this strategy is to identify the types and amounts of data required to develop performance curves.
3. Collect sufficient data from state agencies to allow development of sample curves and validation of process.
4. Analyze data to develop example curves. Demonstrate the impact of the series versus one action at a time analysis.
5. Develop guidelines that allow an agency to develop performance curves for series of treatments if this analysis is demonstrated to be valuable.

### **Final Product:**

This research will produce guidelines on how performance curves can be developed that incorporate a series of treatments. In addition, a final report will be developed that documents the approach, analysis, and findings of the research project.

## III. RESEARCH OBJECTIVE

The objective of this research is to improve pavement performance modeling by considering the impact of the timing and treatments as a series rather than as independent activities.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$500,000

**Estimated Project Duration:** 36 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Method for Effectively Modeling Structural Condition*

## II. RESEARCH PROBLEM STATEMENT

Pavement performance models, to some extent, use only inputs from IRI and surface distress to predict future performance; however, it may be difficult to determine if surface distress identified through visual surveys is limited to the roadway surface (e.g., rutting or top-down cracking) or if it extends full-depth (e.g., bottom-up fatigue cracking). IRI and surface distress may not directly relate to measures of mechanistic features and therefore may not predict the present or future structural capacity. In addition, network-level (high-speed) structural condition data is limited in its availability and is a time consuming process. The availability of structural condition data on a network level would facilitate the development of improved performance models, which could be utilized in pavement preservation and treatment selection techniques. However, the actual benefits of collecting network-level structural condition data have not been fully quantified.

**Tasks:** The research will include the following tasks:

### Phase I

1. Survey practitioners regarding network-level structural deflection testing.
2. Quantify cost/benefit ratio of network-level structural deflection testing.
3. Develop performance models, determine the applicability of use, and calibrate/validate to field conditions for the use of structural testing data.

### Phase II

1. Validate/correlate high-speed deflection testing with traditional deflection testing devices.
2. Determine precision and bias statements for high-speed deflection testing.
3. Conduct pilot studies where high-speed deflection testing is used for quantifying pavement condition and estimating structural capacity needs.
4. Develop specifications and guidelines for use of high-speed deflection testing at the network-level.

### **Final Product:**

The final product of the research is a set of guidelines for incorporating network-level structural testing into pavement management systems.

## III. RESEARCH OBJECTIVE

There are three specific objectives for the research. First, the research will determine the cost/benefit ratio for network-wide structural testing to be incorporated into pavement management systems. The second research objective is to develop guidelines and performance models for incorporating structural testing into pavement management systems. The final

objective is to validate high-speed structural testing equipment to accomplish network-level testing.

#### **IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD**

**Estimated Budget:** \$350,000

**Estimated Project Duration:** 24 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Automation of Surface Texture Characteristics*

## II. RESEARCH PROBLEM STATEMENT

The use of automated (and semi-automated) pavement condition surveys have identified gaps in identifying and quantifying surface related characteristics such as bleeding, raveling, oxidation, splash/spray, friction, and noise. The need for identifying and quantifying these surface conditions for pavement preservation and pavement rehabilitation treatments/applications is vital. This study will identify surface characteristics that can be identified and quantified using existing high-speed data collection equipment, identify potential methodologies for quantifying distress, identify equipment and analysis gaps, develop specifications, and software and equipment modifications as necessary.

**Tasks:** The research will include the following tasks:

1. Survey manufacturers regarding data collection equipment's capabilities to measure and/or identify surface characteristics at traffic speeds. In addition, survey state highway agencies to determine data collection needs in relation to surface characteristics.
2. Identify analysis gaps and provide potential methodologies suited to identify/measure missing data sets.
3. Develop specifications, analysis procedures, software elements, and equipment modifications, as necessary, to address missing data sets.

### **Final Product:**

The final product of the research is a set of guidelines, specifications and procedures for modify or implementing new pavement surface characteristics measuring capabilities at traffic speeds.

## III. RESEARCH OBJECTIVE

There are two specific objectives for the research. First, the research will identify areas of improvement in enhancing or expanding automated pavement condition data collection capabilities. The second objective is developing specifications, guidelines, and methodologies for aiding the implementing of new data collection methods and analysis procedures.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$500,000

**Estimated Project Duration:** 36 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Identifying Strategies for Incorporating Emerging Technologies into Pavement Management Systems*

## II. RESEARCH PROBLEM STATEMENT

There are many changes that are impacting the use of pavement management in transportation agencies. For example, there is increased concern about the economic, environmental, and social impacts of pavement management decisions. For instance, pavement surface characteristics have become increasingly important to address user concerns regarding wet weather crashes, noise, and splash/spray. Similarly, methodologies are needed for incorporating sustainability factors into the project and treatment decision process. Finally, a methodology is desired for evaluating when new data collection technology should be incorporated into the pavement management process to further support agency decisions.

**Tasks:** The research will include the following tasks:

1. Identify the current state of the practice for incorporating emerging issues (e.g., sustainability) and technologies (e.g., new pavement friction testing equipment and data) into pavement management, including identification of critical performance criteria.
2. Develop best practices guidelines for modifying pavement management systems to incorporate emerging issues and/or technologies, including selecting applicable performance measures.
3. Develop tools (e.g., software) to support implementation of the developed guidelines.

### **Final Product:**

The final products of the research are guidelines and software (or other support tools) to identify and evaluate the benefits of incorporating emerging technologies into a pavement management system.

## III. RESEARCH OBJECTIVE

The objectives of this research include the development of guidelines for assisting pavement managers with incorporating emerging issues and related technologies into the pavement management systems, and the development of software or other decision-support tools that will help determine how new technologies can be most beneficially incorporated into pavement management.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$350,000

**Estimated Project Duration:** 24 months



# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Quantifying the Cost of Pavement Use*

## II. RESEARCH PROBLEM STATEMENT

It is likely that “pay per use” strategies for funding transportation projects will have higher potential for use in the near future; however, this requires that agencies have the ability to quantify the cost of providing a sound, safe pavement for customer use so that rational pricing schemes can be developed.

**Tasks:** The research will include the following tasks:

1. Determine inputs needed to ascertain cost per use.
2. Develop an economic framework to derive the cost per use.
3. Develop guidelines for determining the cost per use.
4. Develop software based on process outlined in guidelines developed during task 3.

### **Final Product:**

The research will result in guidelines and software for determining cost per use for funding transportation projects.

## III. RESEARCH OBJECTIVE

There are three specific objectives for the research. First, the research will determine means to quantify the cost of providing pavement structures to the traveling public. The second objective is to develop written guidelines for using the means to quantify the cost per use of public transportation facilities. The final research objective is to develop a software program or package based on these guidelines.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$350,000

**Estimated Project Duration:** 24 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Develop Nondestructive Testing for Measurement of In-Place Material Properties*

## II. RESEARCH PROBLEM STATEMENT

Areas of low density in HMA pavements are susceptible to early failure due to stripping, cracking, and potholes. Low strength in portland cement concrete (PCC) pavements can result in fatigue cracking, poor load transfer, and spalling. The ability to quantify full lane width material properties, such as HMA density and PCC strength, would be beneficial for determining contractor pay incentives, quality assurance, and performance prediction models. Research using GPR to determine HMA density has been conducted; however, this process has not received wide-spread use in the United States. Similarly for PCC, the use of impact echo and spectral analysis of surface waves has been evaluated and utilized but has not received wide-spread use.

**Tasks:** The research will include the following tasks:

### Phase I

1. Conduct a literature search of recent research related to the full lane width and high speed assessment of in situ material properties, specifically related to the upper wearing surface (e.g., HMA or PCC layer).
2. Identify limitations/benefits of developed testing equipment and procedures.
3. Determine the most effective and accurate methodology that can operate at highway speeds for determining the in situ material properties of a full lane width.

### Phase II

1. Based on the findings of phase I, recommend methodologies for addressing equipment and/or analysis limitations.
2. Refine equipment and/or analysis techniques as needed.
3. Conduct case studies that demonstrate the ability (e.g., accuracy and repeatability) of equipment and/or analysis techniques modified in task 2.

### **Final Product:**

Data collection equipment (operating at highway speeds) and analysis procedures/software for assessing the in situ material properties (full lane width) will result from this research.

## III. RESEARCH OBJECTIVE

The objective for this research is to develop testing equipment and analysis procedures for measuring in situ material properties at highway speeds.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$800,000

**Estimated Project Duration:** 48 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Quantifying the Benefits of Pavement Research*

## II. RESEARCH PROBLEM STATEMENT

Several industries, such as the pharmaceutical industry, regularly invest a percentage of their sales in research and development activities. This practice is not widely practiced among transportation agencies; therefore, the consequences associated with the lack of funded research are not well understood.

**Tasks:** The research will include the following tasks:

1. Conduct a survey of SHAs in relation to pavement-related research conducted and implemented over the last 10 years, determine the investment costs for conducting the research (including implementation and training costs), and report benefits (e.g., extending pavement life or lowering life-cycle costs) due to the pavement research results.
2. Develop methodologies by which states can demonstrate the benefits of supporting higher investments for pavement research.
3. Prepare a report of findings and develop marketing tools that clearly illustrate the study findings.

### **Final Product:**

The research will result in a methodology allowing a transportation agency to evaluate its research investments.

## III. RESEARCH OBJECTIVE

The research will estimate the potential payoff afforded a transportation agency according to the level of research investment in pavement management.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$250,000

**Estimated Project Duration:** 12 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Develop Default Models for Low-Volume Roads*

## II. RESEARCH PROBLEM STATEMENT

Many pavement management systems were not developed using data from low-volume roadways. Dependent on the demographics of an individual state, lack of data for low-volume roads may be related to challenges due to collecting data in remote areas, minimal traffic loadings that would typically require standard preservation/rehabilitation treatments (e.g., chip sealed roadway that will only receive future chip seals), or possibly the lack of needed data (e.g., construction history) due to roadway transfer from local agencies. In addition, the Mechanistic-Empirical Pavement Design Guide (MEPDG), due to lack of reliable data concerning low-volume pavement design and performance, specifically excluded the design of low-volume roadways. However, pavement performance and treatment selection on low-volume roadways can be significantly different than that of higher volume roadways.

**Tasks:** The research will include the following tasks:

1. Survey local and state highway agencies regarding data for low-volume roads, specifically related for use in pavement design, performance prediction, and selection of appropriate preservation and rehabilitation treatments.
2. Identify available models for predicting pavement performance on low-volume roads. If necessary, provide recommendations to modify, or if unavailable, develop pavement performance prediction models for low-volume roadways.
3. Identify available pavement design procedures for low-volume roadways (including those developed abroad). If necessary, provide recommendations to modify, or if unavailable, develop pavement design procedures/practices (for consideration in DARWin-ME) for low-volume roadways.
4. Develop guidelines for including performance prediction models and pavement design practices into pavement management and pavement design practices and procedures.

### **Final Product:**

The final product of the research is pavement performance models and design procedures for low-volume roadways.

## III. RESEARCH OBJECTIVE

There are three specific objectives for the research. First, the research will determine the availability of pavement management data in relation to low-volume roadways. The second objective is to identify, modify or develop practices, procedures, and performance prediction models into pavement management systems. The final objective is to identify, modify, or develop pavement design procedures for low-volume roadways.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$350,000

**Estimated Project Duration:** 24 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Impact of Climate Change on Performance Prediction*

## II. RESEARCH PROBLEM STATEMENT

Little is known about the impact of climate change (e.g., rising temperatures and sea levels, increased storm frequency) on the future performance of highway pavements. In recent years, pavement related impacts of climate changes, such as Hurricane Katrina, flooding of the Red River, and the rising temperatures found in many regions of the United States and abroad, are needed. Specifically, information is needed on how climate change may affect the ability to predict pavement performance.

**Tasks:** The research will include the following tasks:

1. Conduct a literature search and review investigating links between pavement performance and climate change impacts.
2. Identify potential performance models taking into account climate change.
3. Evaluate and revise existing models and develop new models addressing needs identified in the literature as not being presently accounted for.
4. Develop guidelines for incorporating the models vetted in task 3 into pavement management.

### **Final Product:**

The final product of the research is a set of guidelines for incorporating models linking pavement performance and climate change impacts.

## III. RESEARCH OBJECTIVE

There are three specific objectives for the research. First, the research will determine the current state of the practice regarding pavement performance relative to climate change. The second objective is to develop performance models to address climate change impacts on pavement performance. The final research objective is to develop guidelines that transportation agencies can use to implement pavement performance models based on climate change impacts.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$350,000

**Estimated Project Duration:** 24 months

# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Development and Integration of Wireless Sensors with PMS*

## II. RESEARCH PROBLEM STATEMENT

Technology for the monitoring of pavement condition does not appear to have kept pace with other technological improvements over the past several years. Research and development are underway to advance the monitoring of pavement condition to provide better relationships among distresses, performance, traffic, maintenance, and other significant variables. Presently, two approaches are typically taken to monitor the condition of pavements: manual distress surveys and automated condition surveys using specially equipped vehicles (e.g., imaging technology for distress survey and transverse profiling for the wheel path rutting). However, these monitoring approaches remain rather more reactive than proactive in terms of detecting damage, since they merely record the distress that has already appeared. Other testing approaches are also used (e.g. deflection testing); however, most of these methods either require significant personnel time or the use of costly equipment. Thus, they can only be used cost effectively on a periodic and/or localized basis. Currently, pavement instrumentation for condition monitoring is done on a localized and short-term basis. The current technology does not allow for continuous long-term monitoring, and the deployment of existing systems on a network level remains unfeasible due to cost, unease of installation, and data collection techniques. Long-term monitoring of mechanical loading for pavement structures could reduce maintenance cost, improve longevity, enhance safety, and advance research in pavement design and construction operation.

There is ongoing research to develop a self-contained smart pavement monitoring system consisting of wireless integrated circuit sensor that consumes less than one microwatt of power and interfaces directly with and draws its operational power from a piezoelectric transducer. By combining floating-gate transistors with piezoelectric transducer, the sensor is able to achieve operational limits wirelessly. The miniaturized sensor will enable continuous battery-less monitoring of integrity of pavement structures over long periods (i.e., detect damage, monitor loading history, and predict fatigue life of the monitoring pavement). The envisioned system would consist of a network of low cost sensors distributed along the pavement during new construction, reconstruction, or resurfacing of both asphalt and concrete pavements. Each sensor node would be self-powered and capable of continuously monitoring and storing the dynamic strain levels in host pavement structure. The data from all the sensors would be periodically uploaded wirelessly to a central database, either through radio-frequency transmission using a radio-frequency reader either manually operated or mounted on a moving vehicle. It is possible that this update can be accomplished during the pavement management condition surveys by adding receivers to the same automated data collection vehicle enabling the collection and population of the sensor data to the pavement management system in a timely and consistent manner. The data will help facilitate a more effective pavement maintenance and rehabilitation/preservation schedule.

Additional research is needed to optimize data collection and storage with these types of sensors. Efforts are needed to integrate this sort of data within existing agency databases in order to make optimal use of the data available.

**Tasks:** The research will include the following tasks:

1. Determine hardware and software needs for the pavement network system data collection, storage and retrieval, etc.
2. Evaluate data collection alternatives (i.e., the storage node placement for data collection and retrieval, reader driving over pavement, etc.).
3. Evaluate data retrieval alternatives and method of transmitting data to a central place for archiving and analysis.
4. Utilize wireless sensor system in the field and evaluate pavement network system data collection, storage, retrieval, and transferring processing operation.

**Final Product:**

The research products will be reports that document the test results, guidelines for usage and integration of the sensors, and prototype sensors with information to make them commercially available.

**III. RESEARCH OBJECTIVE**

The overall objective of the study is to utilize a wireless, self-powered, and low-cost integrated network sensor system for long-term monitoring pavement condition. The system enables continuous monitoring and stores the dynamic strain levels in host pavement structure. The data from the sensors would be periodically uploaded, using a radio-frequency reader either manually operated or mounted on a moving vehicle, wirelessly to a central database to help facilitate a more effective pavement maintenance and rehabilitation/preservation schedule.

**IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD**

**Estimated Budget:** \$500,000

**Estimated Project Duration:** 36 months



# RESEARCH PROBLEM STATEMENT

## I. PROBLEM TITLE

*Use of Aerial Images for Distress Analysis*

## II. RESEARCH PROBLEM STATEMENT

Nationwide, the current method of collecting pavement distress involves either driving or walking an extensive pavement network. Data collection and analysis can range from manual, semi-automated to fully automated procedures. For a SHA using semi-automated or automated data collection equipment, the distance traveled during data collection can easily be double or triple the number of miles of data collection (due to dead heading and mobilization of equipment and staff). In addition, depending on weather and traffic conditions, the time to collect pavement condition data can be restricted such that it becomes challenging to collect data in a reasonable period of time. The use of satellite images for quantifying pavement distress may provide another source of data collection that can be quickly collected, drastically minimize or element the need to drive to the testing locations, and minimize safety issues by removing staff from the data collection process.

**Tasks:** The research will include the following tasks:

### Phase I

1. Determine the adequacy of current technology in use of aerial images for pavement condition surveys.
2. Identify gaps in data collection and analysis, determine what needs to be developed to further the application of this technology, and determine if declassification of images is needed in order for this process to become a reality.

### Phase II

1. Determine which technologies have possibilities for use in the pavement condition survey.
2. Develop, as needed, technologies and necessary software for using aerial images for data collection and analysis.
3. Develop guidelines on use of aerial images for pavement condition surveys.

### **Final Product:**

The product of this research will be software and guidelines for using aerial images for pavement condition assessment.

## III. RESEARCH OBJECTIVE

Identify what improvements could be made to existing imagery or would need to be developed to make the use of aerial images for pavement condition assessment possibility. In addition, determine if satellite imagery can provide data that is cost effective and of sufficient quality to meet the needs of (or contribute to) a pavement management system.

## IV. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

**Estimated Budget:** \$800,000

**Estimated Project Duration:** 48 months