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 predication, 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 mentoring 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