Improving Michigan's Transportation System through Research

Prepared by the Michigan Transportation Research Board for Michigan's Transportation Agencies

This publication contains:

- Outcomes of the first and second meetings of the Michigan Transportation Research Board (MTRB).
- Recommendations on how to improve results from transportation research in Michigan.
- Recommended priorities for research by Michigan transportation agencies and research institutions.

Edited by: Ronald S. Harichandran
Chairperson, Michigan Transportation Research Board

June 2008

Table of Contents

Executive Summary

In early 2003, a planning team was established by MDOT Director Gloria Jeff to help organize the first Michigan Transportation Summit. The planning team met from June to November 2003 to develop each of nine issues: asset management, communication, commerce and trade, coordination, funding, land use, mobility options, research and evaluation, and safety. The first Michigan Transportation Summit was held in Lansing in December 2003, and brought together over 500 people from Michigan, Canada and neighboring states. The purpose of the summit was to identify key issues that needed to be addressed in order to create a vision of Michigan's transportation system that will support Michigan as a magnet for jobs, growth, people and economic activity.

An outcome of the summit was the creation of the Research and Evaluation Action Team (REAT), which started its work in early 2004 by establishing an operating charter and identifying its stakeholders. The following four action items emerged from the summit for implementation by REAT:

1. Build partnerships between industry, governmental agencies, universities, and the private sector to identify mutual interests, needs, and to leverage resources.
2. Develop a process to implement research findings.
3. Evaluate the balance between the allocation of funds to planning vs. research.
4. Support and expand the LTAP program to assist in technology transfers across political levels and support the local effort through incentives to use the resulting technology.

REAT met approximately once a month from January 2004 to January 2005 to discuss, obtain broad-based input from stakeholders and other summit action teams, and create the Michigan Transportation Research Board (MTRB). Supported by MDOT's leadership, MTRB was to consist of all transportation professionals in state and serve as an advisory body to Michigan's transportation agencies. MTRB's aim was to assist in the identification and prioritization of research needs, interact with organizations that conduct and support research, champion the value of research in improving Michigan's transportation system, and support all efforts to improve the quality and effectiveness of transportation services in Michigan through research. Stakeholder categories for MTRB were identified as research sponsors, scientific and technical experts, users, and affected parties. A listing of the groups and organizations under each category are attached to the charter (see Appendix B).

The inaugural meeting of the MTRB was held on June 8, 2005 and a consensus was established to develop a structured process to stimulate research that addresses problems facing transportation providers and users in Michigan. Subsequently eleven committees, three focused on research processes and eight focused on technical issues, were established. The committees worked over the subsequent one-and-a-half years to develop ideas and issues to be included in this report.

This report includes recommendations for transportation agencies in Michigan as they plan to improve Michigan's transportation system over the next decade. Recognizing that the Michigan Department of Transportation (MDOT) allocates the largest share of funds for transportation-related research, some of the recommendations address MDOT-related issues. However,

many of the recommendations pertain to a broad array of transportation-related agencies in the state.

The structure of this report is as follows: (1) background of the MTRB (Sections 1.1 to 1.3); (2) recommendations on research management, implementation and funding (Sections 2.1 to 2.3); (3) overarching research themes in each technical area and titles of recommended problem statements that should be pursued over the next decade (Sections 2.4 to 2.11); and (4) appendices that include the MTRB charter (Appendix B), the charter for the Transportation Research Institute of Michigan (Appendix C), and detailed descriptions of each technical problem statement (Appendices H to M).

The MTRB strongly encourages transportation agencies in Michigan to review the recommendations contained in this report, implement the recommendations related to research management, implementation and funding, look for alignment between proposed research problem statements and their missions, and facilitate the solicitation of proposals and the funding of research problem statements appropriate to their missions. The collective action of Michigan's transportation agencies is necessary to address Michigan's transportation problems through applied research.

Acknowledgements

Numerous individuals contributed their time and effort to provide input and prepare this report. Appreciation is extended to all those who participated in the eleven committees of the Michigan Transportation Research Board (MTRB) and to the MTRB Executive Committee. Special appreciation is extended to the following committee chairs and co-chairs for leading the committees: Neeraj Buch, John Daly, François Dion, Aarne Frobom, Paul Hamilton, Ronald Harichandran, Starr Kohn, Sudhakar Kulkarni, Rick Lyles, Jerry Rowe, Pietro Semifero, Philip Tartalone, Sherif El-Tawil, Roger Till.

The Michigan Department of Transportation (MDOT) facilitated many of the MTRB meetings. Special appreciation is extended to Rick Hammond from MDOT who provided space at the MDOT Aeronautics Building for numerous meetings. The support and encouragement from MDOT senior management for forming the MTRB is appreciated.

URS Corporation in Farmington Hills donated the time of Candice Andre who provided administrative assistance since the inception of MTRB. Her effort is gratefully acknowledged.

1. Introduction

This report was compiled by the concerted effort of numerous individuals. The Michigan Transportation Research Board (MTRB) is composed of transportation professionals in Michigan who believe that research plays an important role in developing and enhancing the transportation system in the state. MTRB is led by an Executive Committee (EC). Subsequent to the inaugural meeting of the MTRB held on June 8, 2005, eleven committees were established. Three of these focused on research processes and eight focused on technical issues. Each committee was led by a chair, and some also had a co-chair. The members of the EC and of each committee are listed in Appendix A. Each committee developed ideas and issues to be included in this report, and the chairs compiled these into committee reports and submitted them to the EC. The EC edited the committee reports for consistency and style and compiled them into this final report.

This report includes recommendations for transportation agencies in Michigan as they plan to improve Michigan's transportation system over the next decade. Recognizing that the Michigan Department of Transportation (MDOT) allocates the largest share of funds for transportation-related research, some of the recommendations address MDOT-related issues. However, many of the recommendations pertain to a broad array of transportation-related agencies in the state.

The structure of this report is as follows: (1) background of the MTRB (Sections 1.1 to 1.3); (2) recommendations on research management, implementation and funding (Sections 2.1 to 2.3); (3) overarching research themes in each technical area and titles of recommended problem statements that should be pursued over the next decade (Sections 2.4 to 2.11); and (4) appendices that include the MTRB charter (Appendix B), the charter for the Transportation Research Institute of Michigan (Appendix C), and detailed descriptions of each technical problem statement (Appendices H to M).

This report should be useful to transportation agencies in Michigan as they improve their research management, implementation and funding. Agencies should consider supporting research problem statements included in this report that align with their interests. Michigan's transportation agencies need to collectively address the state's transportation problems through applied research.

1.1 Genesis of the MTRB

In the summer of 2003, MDOT assembled a group of transportation professionals and stakeholders from industry, government, academia and user groups to start planning for a summit for the purpose of identifying key opportunities and potential action plans that impact, improve, and develop Michigan's transportation system. The summit would address jobs, economic growth, societal needs, and the quality of people's lives. The customers of this planning team's output were envisioned to include Michigan's citizens and potential citizens, the business community, the tourism industry, transportation industry professionals, the international community, the media, public safety/emergency response officials, and federal, state, and local governments. The initial vision of the Planning Team was to provide a mechanism to continue the development of the transportation system for Michigan's future by creating specific action steps and implementation strategies.

After developing an operating charter that set the stage for open communications, commitment to excellence with high ethical standards, and establishment of a desired structure of accountability, the Planning Team identified nine key issues, and organized meetings in the summer and fall months to explore, discuss and develop each of these issues in preparation for the summit. The following issues were considered:

- Asset management
- Communication, consciousness raising and public involvement
- Coordination, cooperation and connectivity
- Commerce and trade
- Funding
- Land use
- Mobility options
- Research and evaluation
- Safety

Experts were invited to speak on these topics. The comments and insights from these experts and from the planning team members attending the meetings were documented and made available to the public through the transportation summit Web site. The planning team also developed a list of issues, actions and goals associated with each topic for further development and refinement at the summit.

The first Michigan Transportation Summit was held in Lansing on December 3 and 4, 2003, bringing together over 500 people from Michigan, Canada and neighboring states to discuss the issues, goals and actions generated by the planning team and draft a collective vision for Michigan's transportation system. The vision statement that came out of this summit was as follows:

> *"Michigan will lead the 21st century transportation revolution as it led innovation in the 20th century. We will move people and goods with a safe, integrated, and efficient transportation system that embraces all modes, is equitably and adequately funded, and socially and environmentally responsible. Michigan's transportation community will work together to ensure that resources are in place to deliver the system."*

The summit included plenary speakers and breakout sessions. A significant outcome of the summit was to form action teams for each of the nine key issues, to address the issues and action plans that were further developed and prioritized at the breakout sessions. The action team to focus on research and evaluation was born from this effort.

The Research and Evaluation Action Team (REAT) started its work in early 2004 by establishing an operating charter and identifying its stakeholders. The following four action items emerged from the summit for implementation by REAT:

1. Build partnerships between industry, governmental agencies, universities, and the private sector to identify mutual interests, needs, and to leverage resources.
2. Develop a process to implement research findings.
3. Evaluate the balance between the allocation of funds to planning vs. research.
4. Support and expand the LTAP program to assist in technology transfers across political levels and support the local effort through incentives to use the resulting technology.

Through monthly team meetings, discussions, and solicitation of broad-based input from the stakeholders, as well as the other summit action teams through MDOT-coordinated meetings of the team moderators, REAT decided to create an entity named the Michigan Transportation Research Board (MTRB) to develop an integrated implementation plan addressing the above four action items. REAT drafted a charter for MTRB that articulated its mission, vision, goals, membership and executive committee structure, values, and operational procedures. MTRB was envisaged as a voluntary advisory body to Michigan's transportation agencies, with support from MDOT's leadership, that would: assist in the identification and prioritization of research needs; interact with organizations that conduct and support research; champion the value of research in improving Michigan's transportation system; and support all efforts to improve the quality and effectiveness of transportation services in Michigan through research. Four stakeholder categories were identified for MTRB, namely, research sponsors, scientific and technical experts, users, and affected parties. A listing of the groups and organizations under each category are attached to the charter (see Appendix B).

The MTRB concept and the draft charter were presented to Michigan's transportation community in the plenary session of the second transportation summit (Michigan Transportation Summit of 2004), which was held on December 15, 2004, to solicit further feedback from the participants. In the ensuing breakout sessions, additional efforts were undertaken to explore the linkages between the action plans on different key issues, and identify resource sharing opportunities with other action teams. Final revisions to the charter were made based on this feedback, and an MTRB Executive Committee (MTRBEC) was formed, composed of the representatives of the stakeholder groups. MTRB was officially established on March 1, 2005 by organizing a joint meeting of REAT and the MTRBEC. It was decided at this meeting to sunset REAT and transfer all of REAT's work products (to that date) to the MTRBEC. The MTRB Charter is presented in Appendix B.

1.2 Charge to the MTRB for 2005-06

An important function of the MTRB is to stimulate research that addresses problems facing transportation providers and users in Michigan. The MTRB committees were formed to play a key role in fulfilling this function. The inaugural MTRB meeting established a consensus on the need to develop a structured process to achieve this goal. The MTRB committees were charged by the MTRBEC to use the participant feedback from the inaugural MTRB meeting and to perform the tasks outlined below.

1.2.1 Process Committees

1. Make contacts and recruit more people to serve on committees.
2. Identify problems that exist within current research administration processes. These could include problem identification, prioritization, selection, allocation, management, implementation, dissemination, etc.
3. Suggest improvements to the current research administration processes.

1.2.2 Technical Committees

1. Make contacts and recruit more people to serve on the committees.

2. Identify major problems that need solutions within the focus area of each committee. These should be overarching problems that affect the performance or safety of the transportation system.
3. Develop a list of research problems that must be addressed to meet the overarching needs. These should be smaller problems that can be answered with one to three years of research. The format for problem statements should be as follows:
    a. Research problem title
    b. Research objectives and outcomes (including broader impacts)
    c. Practical importance (written for lay audience)
    d. Technical importance (written for technical audience)
    e. Required length for research project
    f. Impact of expected outcomes (short term, mid-term and long-term), urgency, and implementation timeline
    g. Prioritization: high, medium or low

Each committee should solicit its members for transportation research needs. Direct input from the committee members should be supplemented by formal requests to major transportation providers, users groups and other interested parties.

1.3 Definition of Research

The Merriam-Webster dictionary defines research as:

> *Studious inquiry or examination; especially investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws.*

Some of the research problem statements developed by technical committees and presented in this report are ongoing program management activities and not true research efforts. The MTRB Executive Committee recommends that research funds allocated by transportation agencies be consistent with the definition of research provided above, and generally not be used to conduct standard administrative tasks. However, the limited use of research funds to:

- support administrative structures in support of research; and
- implement in Michigan products and practices already developed and tested elsewhere

is acceptable when such activities will catalyze solutions to Michigan's transportation problems.

1.4 Next Steps

This MTRB report entitled "Improving Michigan's Transportation System through Research" is being submitted to transportation agencies in Michigan and at the federal level. Research sponsors should use this report to identify projects for funding. Research problem statements developed by the MTRB also may find their way into national research efforts through NCHRP, AASHTO, and TRB.

Research sponsors will be responsible for the solicitation of detailed proposals for research problems selected for funding. The MTRB is willing to coordinate detailed research proposals as needed.

The involvement of private agencies needs to be further cultivated. Efforts should be made to engage the automobile manufacturers, tire manufacturers, and others whose products and services interface closely with the road network.

2. MTRB Committee Reports

Sections 2.1 to 2.3 below provide recommendations from the three committees that focused on issues related to the research process. The remaining sections provide recommendations made by technical committees.

2.1 Research Process Management and Prioritization

2.1.1 Current Shortcomings

The Research Process Management and Prioritization Committee identified the following difficulties that exist at present:

- There is a lack of uniformity in the process by which research problems are solicited, prioritized and allocated within the various research groups at MDOT.
- The research projects managed by different groups can significantly decline as key personnel retire from or leave MDOT. This disrupts the flow of research funds to university faculty with expertise in the unsupported areas. If there are untenured faculty in these areas, then universities may be forced to cut positions in unsupported areas and may not be able to recover these later when MDOT decides to reactivate unsupported areas.
- Active promotion of research is lacking within transportation agencies in Michigan—there are no champions.
- The involvement of Michigan researchers within the NCHRP research process is weak.
- Engineers in the MDOT regional offices do not participate enough in the identification, prioritization, or execution of research problems.
- TRB dues of approximately $1.0 million per year are paid from Strategic Planning and Research (SPR) funds allocated to research, although both the research and planning divisions participate and benefit from TRB.
- MDOT currently funds only the federally mandated minimum of 25% of SPR funds on research and allocates the remaining 75% to internal planning operations. Some states that actively promote research allocate more funds to research.

2.1.2 Recommendations for Improvement

In order to improve transportation-related research in Michigan the Research Process Management and Prioritization Committee recommends the following:

- Establish a centralized transportation research institute in the state as a non-profit organization to address several of the shortcomings listed in Section 2.1.1. The committee suggests that the institute be called the Transportation Research Institute of Michigan (TRIM). TRIM will serve as the champion for transportation-related research in the state in coordination with MDOT and other Michigan transportation agencies. TRIM's mission will be to facilitate research that is effective in addressing Michigan's present and future transportation needs; to promote transportation excellence through objective research; to provide the foundation for long-term visionary transportation research in Michigan; to

broaden the participation of state, federal, and private research sponsoring agencies; and to promote implementation and dissemination of research.

- MDOT should pay dues to TRB from funds allocated to research and planning in direct proportion to the percent allocation. Based on the current allocation, MDOT should pay 25% of the TRB dues from SPR funds allocated for research, and 75% of the TRB dues from SPR funds allocated for planning.
- Use a uniform process across all research areas of interest for soliciting, prioritizing and selecting research projects for funding. MTRB recommends the process used by the Bridges and Structures group at MDOT as a model. Appendix D outlines the recommended process.

2.2 Implementation

The objective of the Research Implementation Committee (RIC) was to identify impediments/obstacles of research implementation into practice and to propose potential/possible solutions. Appendix E provides the findings of the RIC based on its review of current practices in research implementation. The committee recommends that:

- A recognition system, such as state innovation awards, be set up to counterbalance issues concerned with research implementation inertia, risk and cost issues. The recognition system should target technology championship, research innovations, and pioneering design and implementations.
- MDOT implements LCA to a larger extent than currently employed to account for life cycle economic and environmental cost in adopting research findings that may have higher initial cost.
- Bench-marking be established in research implementation at MDOT vs other state DOTs.
- MDOT establishes a systematic means to select research projects annually for national exposure via the Technology Implementation Group at AASHTO.
- Universities and MDOT develop an approach that recognizes the wish of universities to patent intellectual properties and the needs of MDOT to handle Fed Title 23.
- Stronger communication platform be established between all stake-holders making use of traditional and Web-based approaches, perhaps through extension of LTAP activities. An on-line searchable database of research needs and research projects and findings targeted at research providers and users should be established. Old internal research reports from MDOT and other agencies should be digitized and made available to the research community.
- Annual conferences be established that highlight implementation of research findings.
- Funding mechanisms be established for research finding implementation, including use of leveraging funding (e.g. pool-funding among states).
- Researchers and transportation agencies alike make efforts to educate the general public and political leaders (whose support is needed to fund research) about research needs and successes. The impact of research projects on the driving public or system user should be well articulated in both problem statements and final research reports.

2.3 Research Funding and Legislation

The research funding and legislation committee recommends the following action items.

- TRIM (if established) should identify request for proposals from NCHRP and FHWA that align with MTRB's focus areas and bring these to the attention of individual research providers.
- Currently MDOT allocates SPR Part II funds to research along with the mandatory 20% match from state funds. MDOT's allocation is limited to $7 million by state legislation even though $9.4 million is available. The remaining $2.4 million remains unallocated and builds up. MDOT only saves the 20% match on this unused portion. It is not clear why the state imposes a cap on the allocated funds. An effort should be made to change the state legislation so that all the available federal research funds are allocated by MDOT.
- MTRB should provide an annual report to Michigan's Transportation Commission.
- TRIM (if established) or MTRB should establish strong partnerships with industry to develop private funding and mechanisms through which industry can get their research needs met. TRIM/MTRB could serve as the clearinghouse through which industry research projects are let.

2.4 Bridges and Structures

Appendix H outlines the process followed by the Bridge Committee. The committee arrived at the following overarching themes.

- **Preservation** — Includes: materials; durability; economics; speed of application; safety and security; asset management; repair/rehabilitation/renewal/preservation technology; monitoring and assessment; high risk emerging technology with high payoff; ideas concept; design methods
- **New Materials and Systems —** Includes: materials; information technology; long lasting, cheap, fast; bridge systems; bridge performance; environmentally friendly materials and construction methods; high risk emerging technology with high payoff; design methods
- **Performance and Reliability —** Includes: information technology; safety and security; reliability; asset management; bridge loading; load models; bridge performance; monitoring and assessment; high risk emerging technology with high payoff
- **Rapid Construction —** Includes: materials; information technology; long lasting, cheap, fast; bridge systems; repair, rehabilitation, renewal and preservation technology; high risk emerging technology with high payoff
- **Information Technology —** Includes: cyber and information technology; reliability; bridge systems; asset management; monitoring and assessment; high risk emerging technology with high payoff; design methods

Research problem statements (RPSs) were grouped according to themes as shown below.

2.4.1 Theme: Preservation

Research Problem Statement Title	Duration (years)	Priority (H,M,L)
Effectiveness of Bridge Preventive Maintenance Activities	2	High
Minimizing the Life-Cycle Cost of Bridge Structures with Corrosion-Susceptible Steel Components	8	High
Develop and Validate Deterioration Models for Bridge Deck Elements.	1.5	High
*Crack resistant concrete for bridge decks and pavements	9	High
Advanced Technologies for Improved Planning and Execution of Bridge Inspections	3	High
Scour Countermeasures	Long Term	High

*Developed in cooperation with the pavement committee and is rated as high priority by both committees.

2.4.2 Theme: New Materials and Systems

Research Problem Statement Title	Duration (years)	Priority (H,M,L)
*Crack resistant concrete for bridge decks and pavements	9	High
Precast Elements and Systems for Rapid Construction	8	High
Design and Performance of Jointless Bridges	6	High
Development of Self-Consolidating Concrete Mixes and Design Guidelines	3	High

*Developed in cooperation with the pavement committee and is rated as high priority by both committees.

2.4.3 Theme: Performance and Reliability

Research Problem Statement Title	Duration (years)	Priority (H,M,L)
Effectiveness of Bridge Preventive Maintenance Activities	2	High
Minimizing the Life-Cycle Cost of Bridge Structures with Corrosion-Susceptible Steel Components	8	High
Develop and Validate Deterioration Models for Bridge Deck Elements.	1.5	High
*Crack resistant concrete for bridge decks and pavements	9	High
Advanced Technologies for Improved Planning and Execution of Bridge Inspections	3	High
Design and Performance of Jointless Bridges	6	High
Scour Countermeasures	Long Term	High

*Developed in cooperation with the pavement committee and is rated as high priority by both committees.

2.4.4 Theme: Rapid Construction

Research Problem Statement Title	Duration (years)	Priority (H,M,L)
Effectiveness of Bridge Preventive Maintenance Activities	2	High
Precast Elements and Systems for Rapid Construction	8	High
Development of Self-Consolidating Concrete Mixes and Design Guidelines	3	High
Advanced Technologies for Improved Planning and Execution of Bridge Inspections	3	High

2.4.5 Theme: Information Technology

Research Problem Statement Title	Duration (years)	Priority (H,M,L)
Advanced Technologies for Improved Planning and Execution of Bridge Inspections	3	High

2.5 Pavements and Roadways

The Pavement and Roadways Committee identified the following overarching themes:

- **Pavement Preservation—**Includes asset management, development of forensic tools to detect surface and sub-surface distresses, life cycle cost analysis for various pavement preservation strategies and integration of pavement preservation and safety.
- **Techniques and Processes for Improving Quality and Performance of Pavements—** Includes the development of tools to monitor construction quality in "real" time and "as built" ride quality.
- **Pavement Design and Performance—**Includes: the evaluation of the new pavement design guide for flexible and rigid pavements, investigation of early age behavior of concrete pavements and its impact on long term performance, and application of SUPERPAV to local roads.
- **Vehicle Pavement Interaction—**Includes the investigation of the impact of axle loads on pavement performance during spring-thaw seasons and the investigation of the interaction between vehicle dynamics and pavement performance.

2.5.1 Theme: Pavement Preservation

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Development of Remaining Service Life for Pavement Smoothness and Ride Quality[+]	24	High
Development of Field Investigative Tools to Detect Asphalt Hardening in HMA Surfaces	36	Medium
Safety Integration with State Pavement Preservation Practices	36	Medium
Low Volume Road Rehabilitation Methods	24	Medium
Impact of Contract Warranty on Life Cycle Cost (LCC) and Road Performance	24	Medium
Use of In-situ Field Test Data to Validate the New Dynamic Load Roughness Index[*]	24	Low

2.5.2 Theme: Techniques and Processes for Improving Quality and Performance of Pavements

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Real Time Smoothness Field Trials	12	High
Effectiveness of Pavement Drainage Systems[+]	24	High
Real Time Quality Control	24	High
Warm Mix	24	Medium
Development of Field Investigative Tools to Detect Asphalt Flushing in HMA Surface Treatments	36	Medium
Non-Density Methods for Embankment Acceptance	36	Medium
Local Agency Specification Interpretation	18	Low

[+] Ranked as high priority in multiple themes
[*] Ranked as low priority in multiple themes

2.5.3 Theme: Pavement Design and Performance

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Crack resistant concrete for bridge decks and pavements+	Multi-phase	High
Development of Remaining Service Life for Pavement Smoothness and Ride Quality+	24	High
Effectiveness of Pavement Drainage Systems+	24	High
Spring Weight Restrictions+	Unknown	High
Evaluating the readiness of MDOT Pavement Management Data for the New Pavement Design Guide-Rigid Pavements	24	High
Evaluating the readiness of MDOT Pavement Management Data for the New Pavement Design Guide-Flexible Pavements	24	High
Optimization of Mechanical Load Transfer Devices for Transverse Joint in Jointed Plain Concrete Pavements	36	Medium
SUPERPAVE for Local Roads.	24	Medium
Early Age Behavior of Jointed Concrete Pavements	12	Medium
Micro Piles or other Deep Foundations for Roadway Embankments	18	Low

*****Problem statement co-sponsored by the pavement and bridge committee.

2.5.4 Theme: Vehicle Pavement Interaction

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Spring Weight Restrictions+	Unknown	High
Pavement Distress as a Result of Lift Axle Usage	Unknown	Medium
How Quite is Quiet Enough	18	Medium
How Smooth is Smooth Enough	24	Medium
Use of In-situ Field Test Data to Validate the New Dynamic Load Roughness Index*	24	Low

2.6 Traffic Operations and Safety

While the committee started with some basic themes (traffic operations, safety, ITS), as the RPS categories were better defined and the RPSs themselves were drafted, the overarching themes evolved to the following:

- **Intelligent Transportation Systems** — The use and integration of new and conventional technologies and methods will enhance our understanding of the root causes of accidents/incidents and congestion and to devise solutions/measures that will lessen their negative impacts. The research proposed in this area will enable a more proactive approach to combating safety and traffic operational problems thus enabling more effective and timely solutions. The research proposed in this area will achieve that by exploiting newly available and more accurate data/information along with advances in computation and communication technologies. The research outcome in this area will enable responsible agencies to target more cost-effective measures and technologies, implement more consistent and supportive policies, and be more responsive to system users. Implementation of the research outcomes will take different forms including immediate adoption of measures and policies that appear to be effective, start acquiring hardware that is more reliable, and adopt policies and practices that will support physical and operational improvements. System users including travelers and freight movers will have a safer and more reliable system.

- **Driver Behavior and Safety** — The problems addressed in this research topic focus on older drivers, young novice drivers and driver distraction. The research themes in the three areas address the questions of understanding and quantifying the effect of the particular behaviors on traffic safety, and on developing and evaluating countermeasures to reduce the crash risk associated with the behaviors. The issues with respect to older drivers are centered on understanding how older drivers self-regulate their driving to reduce exposure to high-risk situations; to examine the cost/benefits of modifications in geometry of roadways, signage, and traffic engineering recommended by the FHWA to help older drivers; to examine the licensing and assessment of older drivers; a to develop a process of removing unsafe drivers from the ranks of licensed drivers; and to develop ways of providing mobility to those who can no longer drive safely. The issues with respect to young novice drivers are concerned with quantifying the effects of the various components of graduated licensing programs; on developing a model driver education program; and on evaluating the effects of countermeasures to risky young driver behavior. The third topic area, driver distraction, is relevant across all ages of drivers. The research proposed addresses the question of measuring the extent to which driver distraction is a cause of crashes; measuring the amount of driver distraction; rank ordering the various distracting behavior; and developing countermeasures to address the worst distractions with respect to crash causation. The Secretary of State, Office of Highway Safety Planning, and the Michigan State Police play important roles related to this research topic and research efforts should be coordinated with these constituents.
- **Work Zone Safety** — Every Michigan driver will go through a work zone at some point, and every worker in those zones will see at least one of those drivers crash in their workplace. There are a significant number of work zone crashes and traffic fatalities each year, affecting both drivers and workers. The work zone safety research problem statements seek ways to use work zone speed limits and traffic controls to reduce the number and severity of crashes. Successful research outcomes will reduce crashes, deaths, and injuries in work zones.
- **Data Collection, Retrieval and Management** — Data are at the core of almost any activity concerned with the planning, design, operation, or evaluation of the transportation system. Currently, there is little coordination among the producers and users of data in Michigan, and the data that are collected are not well integrated or necessarily widely available. Indeed, in many instances valuable data are collected for specific projects or activities and then discarded. This set of projects is addressed to taking steps to begin to remedy this situation. While the projects are Michigan-based (and hence MDOT and other state agencies are the suggested funding agency), they are of sufficient interest that they could be funded by multi-state consortiums or the NCHRP. Benefits accrue to all of those who use traffic/transportation-related data in Michigan and through better research based on better data.
- **Operations and Safety Issues** — The U.S. Department of Transportation and the Michigan Department of Transportation have both set goals for reducing traffic crash fatalities. It is clear that these goals can only be met if the transportation community addressed these elements of the transportation system that contribute to the overall fatality rate on our highways. Commercial vehicles, motorcycles and pedestrians each make a significant contribution to the number of crash fatalities. However, it is difficult to develop successful countermeasures to these crashes without adequate research on what makes a specific

location, or a particular user, to be over represented in serious traffic crashes. The projects included in this research plan will, if completed, contribute to our understanding of the factors contributing to these crashes, and thus allow effective safety programs to be developed and implemented.

The RPS titles are listed below. The priority was determined by a vote of the committee and was based on a consideration of all RPSs that were developed by the committee.

2.6.1 Theme: Intelligent Transportation Systems

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Determination of Interdisciplinary Ways to Reduce Congestion and Increase Transportation System Capacity—Phase I	18	High
Evaluation of New Concepts and Technologies in Traffic Signal Control	12	High
Development of an ITS Management Plan for the Michigan Department of Transportation	108	Medium
Prediction and Characterization of Freeway Congestion	12	Medium
Using Dedicated Short-Range Communications Technology for Incident Detection on Rural Interstates	18	Medium
Optimizing Investments in Rural ITS Applications in Michigan	9	Medium
Virtual Testbed for Vehicle Infrastructure Integration (VII)	24	Low
Development of an Intelligent Transportation System Maintenance Plan for Michigan	12	Low
Exploration of Potential for Electronic Identification of Hazardous Material Vehicles	9	Low
In-Vehicle Technology and Cognitive Loads		Low

2.6.2 Theme: Driver Behavior and Safety

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Older Drivers: Impacts on Traffic Safety and Operations	18	High
Older Driver Behavior	72	Medium
Role of Driver Distraction in Vehicle Crashes in Michigan	18	Medium
Safety Improvements for Older Drivers	36	Medium
Effective Components of Graduated Driver Licensing	24	Low
Beyond Skills: Driver Education for Safety	24	Low
Safety Improvements for Younger Drivers	36	Low

2.6.3 Theme: Work Zone Safety

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Development of Work Zone Speed Limit Methodology	12	High
Countermeasure Development for Work Zone Speed Control	12	High
The Impacts of Vehicular Speed on Safety and Traffic Crashes in Highway Work Zones	12	High
What Specific Traffic Control Devices should be Required for Short Duration Work Zones?	12	Low

2.6.4 Theme: Data Collection, Retrieval and Management

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Development of Statewide Traffic Data Management System (two phases)	48	High
Investigation and Assessment of New Technologies for Data Collection for Asset Management Activities	12	High
Mining the Michigan Traffic Crash Database to Extract and Discover New Useful Correlations	18	High
Improving Reliability of Transportation Systems—the Case of Travel Time Predictions and System Condition Assessment	18	Medium

2.6.5 Theme: Operations and Safety Issues

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Determine Criteria for Implementing Protected-Only-Left-Turn Phasing instead of Permitted/Protected Left-Turn Phasing	12	High
Statewide Commercial Vehicle Crash Analysis and Development of Safety Measures	24	High
Pedestrian Crash Location Identification	12	Medium
Resource Allocation to Optimize Safety Improvements	18	Medium
Impacts of Alternative Designs on Transportation Safety and Operations and Non-Motorized Users	60	Medium
Determining Relative Safety of Box Span Design and Diagonal Span Design for Traffic Signals	24	Medium
Motorcycle Exposure Study	12	Low
Share the Road Campaign	12	Low

2.7 Public Transportation

The committee identified potential public transportation research topics in the areas of planning, operations, equipment, implementation, and others. Several of the topics related to the development of handbook type materials for managing and operating transit systems. These handbooks or synthesis of practice were seen to be particularly valuable for smaller operators or communities. After potential topics were identified, the committee developed research statements and tried to determine levels of need or priorities. The committee found it difficult to reach consensus on specific priorities but did identify a high, medium, low, or not rated assessment for each topic.

2.7.1 Theme: Planning

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Handbook - Introduction to public transit for elected officials	12	High
Tools to assess transportation mobility options	12	High
Who uses public transit in Michigan	12	High
Impact of our aging population on future transit in Michigan		
Applications of GIS/GPS for Michigan transit		
Improving transit for users and non-users with disabilities		

2.7.2 Theme: Operations

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Best practices for signal prioritization for transit vehicles	12	Medium
Best practices for bus stop and shelter locations	12	Medium
Best practices for fare collection	12	
Best practices for intersection design for transit vehicles	12	

2.7.3 Theme: Equipment

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Guidance for equipment selection and purchase	12	Low
Bicycle racks on transit vehicles in Michigan		
Lifts for loading/unloading of passengers with disabilities		

2.7.4 Theme: Implementation

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Transit Funding sources	12	Medium
Alternative funding and financing techniques	12	Low
Information exchange between operators and customers		
Information exchange between operators and government agencies		

2.7.5 Theme: Other

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Voucher systems		
Guidelines for rail transit in Michigan		
Rail access to Michigan airports		
Society cost of transit and automobile facilities in Michigan		

2.8 Planning, Land Use and Environmental Impacts

The focus of overarching themes identified by the Planning, Land Use and Environmental Impacts Committee can be characterized as research which:

- Focuses on practical applications;
- Improves decision making and processes;
- Provides better data for decision makers;
- Improves traffic models and application;
- Offers new approaches which enhance partnerships;
- Provides new tools and best practices;
- Enhances inter-connections and partnerships across disciplines and modes;
- Addresses matters of local, regional and state global economic competitiveness; and
- Supports efforts to vigorously pursue a research agenda through state and national institutions, association and agencies.

In general, the committee's priorities focused on the following overarching needs:

- **Improving Environmental Mitigation —** Polluted urban runoff; roadside lead and salts; streamlined analysis of contaminated sites; wetland mitigation and banking; erosion control; wildlife preservation; impacts of roadways on cardiovascular disease; archeological sites; integrating environmental mitigation with the planning process; or impacts of scour.
- **Improving Current Travel Models and Appropriate Applications for Simulation Models —** Appropriate uses of simulation models; applying micro simulation models to work zones; collecting and synthesis of speed studies to improve travel models; backcasting/benchmarking or sensitivity testing of travel models to identify needed improvements and testing impacts of EPA's new MOVES model.
- **Evaluating and Documenting Impacts of New Design Standards —** Evaluating Michigan experience with effects of alternate street designs on traffic operations and safety, including impacts on non-motorized users, such as: roundabouts; traffic calming devices; alternative lane widths; lane reductions from 4 to 3 and other design innovations.
- **Enhancing Scenario Planning through Best Practices —** Identifying recommended best practices, tools and methods for scenario planning or alternatives analysis for various types and sizes of Michigan communities.
- **Improving Development Impact Reviews —** Standardized development impact review procedures for Michigan; evaluating impacts of alternative transportation investments on sprawl; development of a Michigan trip generation manual; legal analysis and takings; integrating context sensitive solutions in planning; and assessing and streamlining project selection criteria.

2.8.1 Theme: Improving Environmental Mitigation

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Treatment of polluted urban runoff *	36	High
Roadside lead and salts*	36	High
Streamlined analysis of contaminated sites*	36	High
Wetland mitigation areas/banking	36	High
Effect of roadways on occurrence of cardiovascular disease	36	
Erosion control	36	
Wildlife preservation	36	

2.8.2 Theme: Improving Current Travel Models and Appropriate Applications for Simulation Models

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Right model with right data for right studies*	24	High
Application of travel demand models to work zone coordination*	18	High
Synthesis and collection of speed studies	18	High
Benchmarking, sensitivity testing, backcasting to improve Michigan's travel demand models	36	

* The subcommittee agreed these high priority Research Problem Statements within this particular category of issues should be grouped together and considered as linked efforts.

2.8.3 Theme: Evaluating and Documenting Impacts of New Design Standards

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Impact of alternative street designs and standards (on non-motorized)**	12	High

2.8.4 Theme: Enhancing Scenario Planning through Best Practices

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Evaluating transportation scenario analysis tools for use in various geographic settings	6	High

2.8.5 Theme: General Land Use/Development

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Development impact review process and procedures	24	High
Transportation investment and sprawl in Michigan	24 (Phase 1) 12 (Phase 2)	
Development of a Michigan trip generation manual	12-18 (Phase 1) 18-24 (Phase 2)	

2.8.6 Others

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Integrating environmental mitigation in the planning process	36	High
Role and integration of context sensitive solutions in planning		
Scour		
Beta Testing and impacts of the MOVES model		
Legal analysis/taking		
Archeological sites		
Assess project selection criteria, streamlining of project selection; standardizing training		

2.9 Border Issues and Homeland Security

Contributions from individual committee members varied, with some persons contributing significantly more than others. However, everyone on the committee membership roster contributed at some point or another. All committee members were kept up to date on the committee's activities and frequently invited to participate.

The committee's main focus can be divided into four different, but complementary, areas:

- Efficient operations of border crossings
- Homeland security requirement for border crossings
- Protection of transportation infrastructure
- Emergency preparedness

Issues related to the efficient operations of international border crossings primarily deal with the need to minimize delays incurred by truck operators and travelers at border crossings.

** Note: Similar problem statements and needs are also in reports from both the Non-Motorized and Traffic Safety and Operations Committees.

This need arises from the economic importance of trade activities between the United States and Canada. Since Michigan acts as a key entry/exit point for merchandises and persons coming from and going to Canada, it is important to maintain efficiency in flows crossing the US-Canada border and keep delays at a minimum. This is particularly emphasized by the fact that the Great Lakes significantly restrict the number of regional crossings. In Michigan, only three fixed border crossings currently exist in the southern portion of the state for automobiles and trucks, where most of the border crossing traffic occurs, with a single additional one in the Upper Peninsula at Sault St. Marie. There are two rail tunnels that carry a substantial amount of freight, a rail bridge at Sault St. Marie, and two water ferry operations in Detroit and Marine City that also are important.

Issues related to homeland security primary deal with the need to prevent terrorist activities within the nation. A strong link is first established here with border operations, as verification of the identity of travelers and the nature of cargo shipments coming across the border constitutes one of the first lines of actions to prevent terrorist activities. However, while homeland security requirements typically call for increased scrutiny, these activities have the potential to negatively impact border operations by creating delays and barriers to trade. They must therefore be carefully balanced.

Another element addressed by homeland security is the need to prevent attacks on the transportation system itself. Transportation systems, whether inclusive of roadways, railways, public transit systems, or waterways, play a vital role in creating and sustaining economic activities. Any disruptions to system operations can thus lead to significant impacts on economic activities. Within this context, it becomes important to identify areas of vulnerability to attacks. Examples of elements to consider are the needs to prevent physical attacks on bridges or hacking attacks on data storage and computerized systems.

The final area deals with how to best use the transportation system in situations of emergency. This includes elements such as plans for population evacuation and how to maintain operability of a transportation system that may be subject to significant stresses.

2.9.1 Research Themes

Most of the committee discussions centered on the efficiency of operations of border crossings. Very little attention has been put on issues related to homeland security that did not impact border crossing operations. This is not surprising given the committee membership, which, aside from academics, is primarily constituted of individual involved or having interest in the day-to-day operations of border crossings. It was also noted that while homeland security issues are important at a national level, the complexity of these issues does not easily lead to practical problems that be addressed by transportation agencies acting alone or on relatively small budgets. Many of the problems currently associated with homeland security that were discussed were for instance seen as being very dependent on the development of new technologies, and henceforth, very risky in nature. Many issues were also deemed to be currently too dependent on political mood and will to be considered. The current sponsoring of research activities by the Department of Homeland Security and other federal agencies, as well as current skepticism towards the ability to truly impact transportation security, further lead to arguments towards adopting a wait-and-see approach in matters regarding homeland security issues.

In the area of border operations, a number of draft problem statements were submitted and discussed. However, discussions on many potentially interesting statements were preempted by

a request from representatives of transportation agencies to wait for the publication of a report to be produced by the Transportation Border Working Group. This group includes, among others, officials from U.S. Customs, U.C. Citizenship and Immigration Services, the Department of Foreign Affairs and International Trade of Canada, Canada Customs and Revenue Agency, the Canadian Food Inspection Agency, the U.S. Border Station Partnership Council. The Michigan DOT is also a member of this group. The report was to address issues regarding border operations, particularly operations metrics with respect to a goal to reduce border crossing times by as much as 25%. The basis of the request to delay discussions on these topics was that it would not be to the advantage of the Michigan Transportation Research Board, particularly in terms of its credibility, to propose research statements that would duplicate work that has already been accomplished by the Transportation Border Working Group.

Finally, some potential problem statements were struck down due to the particularity of Michigan border crossings, which include both public and private crossings. Problem statements leading to the evaluation of whether new public crossings should be considered were for instance not received favorably by the private operators as the addition of such crossings could impact their operation.

After much discussion, only two problem statements were produced in this round for inclusion in the report, as indicated in the table below.

Research Problem Statement Title	Research Theme				Duration (Months)	Priority
	Crossing Efficiency	Homeland Security	Protection of Infrastructure	Emergency Preparedness		
Potential impacts of the western hemisphere travel initiative on border/traffic management at Canada/U.S. land crossings	√	√			12	High
Ownership, tenure and governance of the proposed detroit-windsor river crossing	√				24	Medium

2.10 Aviation, Maritime, Rail and Freight

The Aviation, Maritime, Rail and Freight Committee proposed two problem statements, one in each of two overarching themes. The overarching themes were:

- Aviation Safety and Aircraft Surveillance
- Aviation Education/Maintenance Engineering

2.10.1 Theme: Aviation Safety and Aircraft Surveillance

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Establishing Automatic Dependent Surveillance-Broadcast (ADS-B) in Michigan		High

2.10.2 Theme: Aviation Education/Maintenance Engineering

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
The gap between technology and technology education		High

2.11 Non-Motorized Transportation

The Non-Motorized Transportation Committee developed the following overarching themes.

- **Facilities Design –** The highest research priorities seemed to involve design guidance for agencies working with non-motorized facilities: pedestrian pathways, sidewalks, bike paths, trails, and most especially facilities that mix these uses or are joint with other networks. The relevance of AASHTO and other nationwide standards and practices to Michigan is debatable. It was evident that much work is under way, but some basic questions remain. Most significant was the integration of non-motorized provisions with newly-developed road designs.
- **Usage and Demand Data; Market Research** – Practitioners do not know as much as they would like about the demographics and rates of use of non-motorized transportation. Pedestrians and cyclists are not counted as easily as vehicles, and this makes it difficult to design facilities and explain the economic returns from investments.
- **Institutional Issues** – At least some research is needed into how to improve the legal and organizational environment that non-motorized transportation operates in. Changes to the Michigan Vehicle Code may be needed, or to law governing local governments' liability for pedestrian ways, but should not be made blindly.
- **Safety** – The representation of pedestrians and bicyclists in crash statistics suggests that these road users may deserve special attention in the design of safety research or crash countermeasures.

Many of the problems in non-motorized transportation stem from the ways non-motorized traffic interacts with automotive traffic. Research topics in non-motorized facilities design, legal issues, and safety can't be addressed separately from the same issues in the road system at large, so it's expected that coordination of these topics with the Committees on Pavements and Roadways and Traffic Safety and Operations will lead to more productive research designs.

2.11.1 Theme: Facilities Design

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Michigan design guide for non-motorized facilities	24	High
Impacts in Michigan of alternative road designs on pedestrian and cyclist safety	24	High
Potential in Michigan for trails next to operating short-line railroads	12	Low
How to improve pedestrian interfaces with transit	18	Low
Improving pedestrian circulation at high-activity locations	18	Low

2.11.2 Theme: Usage and Demand Data

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Who uses sidewalks, trails, and other non-motorized facilities in Michigan?	30	High
Prioritization of non-motorized projects for Michigan road agencies	12	Low
Solutions to Michigan weather for non-motorized travel	12	Low

2.11.3 Theme: Non-motorized Institutional Issues

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Community manual for non-motorized transportation programs	18	Medium
Modernizing the Michigan vehicle code with respect for non-motorized transportation	24	Medium
Coordination of non-motorized trail and transportation programs statewide	24	Low

2.11.4 Theme: Safety

Research Problem Statement Title	Duration (Months)	Priority (H,M,L)
Improve non-motorized crash data in Michigan	24	Medium
Contribution of enforcement to non-motorized transportation safety in Michigan	18	Low

Appendix A
Members of the MTRB Committees

A.1 Executive Committee

Name	Organization
Ronald Harichandran (Chairpeson)	Michigan State University
Gary Taylor (Vice-Chairperson)	ACEC
Gerald Rowe (Secretary/Treasurer)	MTPA
Tess Ahlborn	Michigan Technological University
David Bertram	MTA
Donald Cameron	FHWA
John Daly	CRAM
John Egelhaaf	MAR
Joe Fivas	MML
Aarne Frobom	MDOT
Rick Hammond	MDOT
Clark Harder	MPTA
Victor Li	University of Michigan
Charles Mills	MITA
Calvin Roberts	MDOT
Pietro Semifero	Office of Highway Safety Planning
Mumtaz Usmen	Wayne State University

A.2 Research Process Management and Prioritization

Name	Organization
Ronald Harichandran (Chair)	Michigan State University
Sudhakar Kulkarni (Co-chair)	MDOT
Gary Taylor (E.C. Rep.)	ACEC
Osama Abudayyeh	Western Michigan University
Don Cameron	FHWA
François Dion	Michigan State University
Tim Gordon	University of Michigan
Rick Lyles	Michigan State University
Larry Sutterer	Michigan Technological University
Sherif Yehia	Western Michigan University
Mumtaz Usmen	Wayne State University

A.3 Research Implementation Committee

Name	Organization
Victor Li (Chair/E.C. Rep.)	University of Michigan
Haluk Aktan (Co-chair)	Wayne State University (currently at Western Michigan University)
Osama Abudayyeh	Western Michigan University
Gilbert Baladi	Michigan State University
Tandy Bidinger	
Terry McNinch	Michigan Technological University
Maria Szerszen	University of Michigan
Roger Till	MDOT
Michael Lepech	University of Michigan

A.4 Research Funding and Legislation Committee

Name	Organization
John Daly (Chair/E.C. Rep.)	CRAM
Ronald Harichandran (Co-chair)	Michigan State University
Osama Abudayyeh	Western Michigan University
Don Cameron	FHWA
Sudhakar Kulkarni	MDOT
Roger Till	MDOT
Thomas VanDam	Michigan Technological University

A.5 Bridges and Structures Committee

Name	Organization
Roger Till (Chair)	MDOT
Sherif El-Tawil (Co-chair)	University of Michigan
Tess Ahlborn (E.C. Rep.)	Michigan Tech. Univ.
Osama Abudayyeh	Western Michigan Univ.
Charles Arnold	Consultant
Steve Beck	MDOT
Glenn Bukoski	MI-ITA
Rigoberto Burgueño	Michigan State Univ.
Craig Dashner	OHM Engineering
Gongkang Fu	Wayne State Univ.
Nabil Grace	Lawrence Tech. Univ.
David Juntunen	MDOT
Jerry Lynch	University of Michigan
John Nekritz	FHWA
Mukund Patel	URS Corporation
Maria Szerszen	University of Michigan
H.C. Wu	Wayne State Univ.
Sherif Yehia	Western Michigan Univ.

A.6 Pavements and Roadways Committee

Name	Organization
Neeraj Buch (Chair)	Michigan State University
Starr Kohn* (Co-chair)	Soils and Materials Engineers
Gary Taylor (E.C. Rep.)	ACEC
Charles Arnold	Consultant
Gilbert Baladi	Michigan State University
Michelle Barnes	University of Michigan Transportation Institute
Dave Calabrese	Federal Highway Administration
Karim Chatti*	Michigan State University
Michael Craine	
Mark Dionise*	Michigan Department of Transportation
Michael Eacker	Michigan Department of Transportation
Larry Galehouse*	National Center for Pavement Preservation
Will Hansen	University of Michigan
Tom Hynes*	Michigan Department of Transportation
James Lynch	University of Detroit Mercy
Robert Risser	Michigan Concrete Paving Association
Roy Townsend	
Tom Van Dam	Michigan Technological University

Name	Organization
Chuck VanDeusen	Consultant
H.C. Wu	Wayne State University
Sherif Yehia	Western Michigan University

*Task force chairs

A.7 Traffic Safety and Operations Committee

The Traffic Safety and Operations Committee had a very fluid membership. There was one large meeting and then the majority of the business was done by e-mail. In addition to those people who attended the first meeting, several other lists were added/merged. The latter included, for example, members of the GTSAC advisory teams and an ITS-related group. So, the list below is inclusive rather than exclusive in that some were very active and some never participated. However, all were kept up to date on the committee's activities and invited to participate.

Name	Organization
Rick Lyles (Chair)	Michigan State University
Pietro Semifero (Co-chair)	Michigan State Police, OHSP
Andre D. Clover (E.C. Rep.)	MDOT
Ghassan Abu-Lebdeh	Michigan State University
Ahmad Jawad	Road Commission for Oakland County
Tom Krycinski	Michigan State University
Lidia Kostyniuk	UMTRI
Dale Lighthizer	MDOT
Kunwar Rajendra	MSU
Dave Morena	FHWA (Lansing)
Dave Allyn	Road Commission for Oakland County
Scott McCormick	Connected Vehicle Trade Association
Francois Dion	Michigan State University
Jun-Seok Oh	Western Michigan University
Tim Colling	LTAP, Michigan Technological University
Dick Beaubien	Hubbell, Roth & Clark, Inc.
Paul Bocci	Motorola
Tapan Datta	Wayne State University
Snehamay Khasnabis	Wayne State University
Marsha Small	MDOT
Richard Wallace	Altarum Institute
Bill Taylor	Michigan State University
Ralph L. Robinson	Infotronics Technologies Scientific Research Laboratories
John C. Rempala	Road Commission of Macomb County
Paul Hamilton	Tri-County Regional Planning Commission
Sgt. Lance Cook	Michigan State Police
Wes Butch	DLZ
Jeff Bagdade	AAA Michigan
John Abraham	City of Troy
Kathy Farnum	OHSP
Homer Smith	MADD
Steve Schreier	OHSP
Heather Hockanson	MDCH
Michael Prince	OHSP/MI Truck Safety Commission
Thad Peterson	MSP
Ron Wilson	DOS

Name	Organization
Lisa Grost	MDCH
Todd Kauffman	MDOT
F/Lt. Thad Peterson	MSP
Kim Lariviere	MDOT
Jim Culp	MDOT
Tom Bruff	SEMCOG
Paul Steinman	MDOT
Gary Bubar	AAA
J Juhasz	
Scott McCormick	AMICA
Gary Streelman	Delphi
Mark K. Krage	Delphi
Miyoko Honma	Denso-Daim
R Robins	Ford
C. Sehmer	
Dick Beaubien	HRC Engineering
J. Zhu	IVHS
D.L. Christeller	
J. Schultz	State of Michigan agency
Milt Baker	Motorola
Scott Propp	Motorola
S. Hogan	PB World
A. Jawad	Road Commission of Oakland County
N. Komoda	???
T.E. Borton	???
Jerry Landt	Transcore
Michael Hoffman	Motorola
G. Krueger	State of Michigan agency
W. Tansil	MDOT
Dave Anderson	Motorola
T. Engles	NTCNA-Nissan USA
P. Hind	Results-Systems
B. Bair	Road Commission of Oakland County
J. McNew	Technocom Wireless
C.S Moore	MCHSI
R. Klucens	State of Michigan agency
Richard Wallace.	Altarum
Laci Jalics	Delphi
Michael J McKale	Delphi
Morris Hoevel	FHWA
Kirk Luckscheiter	GD-AIS
C. Sehmer	
Martin Ferman	GM
Kevin McMahon	Martec Group

A.8 Public Transportation Committee

Name	Organization
Bill Sproule (Chair)	Michigan Technological University
Clark Harder (Co-chair/E.C. Rep.)	Michigan Public Transit Association
Tandy Bidinger	Michigan Developmental Disabilities Council
John Czarnecki	Michigan Economic Development Corporation
Francois Dion	Michigan State University
Rick Lyles	Michigan State University
Barbara Schoen	University of Michigan
Risa Wilkerson	Michigan Governor's Council on Physical Fitness, Health, and Sports

A.9 Planning, Land Use, and Environmental Impacts Committee

Name	Organization
Jerry Rowe (Co-chair/E.C. Rep.)	Southeast Michigan Council of Governments
Paul Hamilton (Co-chair)	Tri-County Regional Planning Commission
Brian Barkdoll	Michigan Technological University
Rick Lilly	MDOT
Rick Lyles	Michigan State University
Walter McManus	University of Michigan
Carol Miller	Wayne State University
Jun-Seok Oh	Western Michigan University
Ramakrishna Pochiraju	Orchard Hiltz & McCliment
Marsha Small	MDOT
Lou Lambert	Cambridge Systematics
Terri Blackmore	Washtenaw Area Transportation Study
Dennis Randolph	Calhoun County Road Commission
Jay Hoekstra	Grand Valley Metro Council
Bill Hartwig	TEA Inc.
G. Robert Adams	

A.10 Border Issues and Homeland Security Committee

The Border Issues and Homeland Security Committee has maintained a relatively small and constant membership since its inception. While efforts have been made to increase membership from both the American and Canadian sides of the border, these efforts did not lead to any new active membership participation, although interests were expressed in work of the committee. Attempts were for instance made to recruit individuals from the Detroit Regional Chamber of Commerce, the Ministry of Transportation of Ontario, Transport Canada, and the Department of Homeland Security.

The table below presents the current membership of the committee. The membership currently includes representatives from public transportation agencies, academic institutions, and private border crossing operators. The breakdown of representation on the committee is as follows:

- Public transportation agencies
    - Michigan Department of Transportation (MDOT)
    - Federal Motor Carrier Safety Administration

- Academic institutions
  - Michigan State University
  - University of Michigan
  - Michigan Technological University
- Private border crossing operators
  - Detroit-Windsor Tunnel
  - Ambassador Bridge

Name	Organization
François Dion (Chair)	Michigan State University
Tess Ahlborn (E.C. Rep.)	Michigan Technological University
Neal Belitsky	Detroit-Windsor Tunnel
George Costaris	Canadian Consulate (Detroit)
Tim Cotter	Federal Motor Carrier Safety Administration
Sherif El-Tawil	University of Michigan
Pat Holland	Consultant representing the Ambassador Bridge
Snehamay Khasnabis	Michigan Department of Transportation
Sara Moore	Michigan Department of Transportation
Laura Nelhiebel	Michigan Department of Transportation
Kunwar Rajendra	Michigan State University
Stan Vitton	Michigan Technological University

The appearance of an individual's name in the above list does not necessarily constitute endorsement of any of the materials presented in this report.

A.11 Aviation, Maritime, Rail and Freight

Name	Organization
Philip Tartalone (Chair)	Eastern Michigan University
Rick Hammond (E.C. Rep.)	Michigan Department of Transportation
Lisa Whittaker	Western Michigan University

A.12 Non-Motorized Transportation

Name	Organization
Aarne Frobom (Chair & E.C. Rep.)	Michigan Department of Transportation
Deb Alfonso	Michigan Department of Transportation
Brian Blaesing	The Road Commission for Oakland County
John Czarnecki	Michigan Department of Labor and Economic Growth
Paul Hamilton	Tri-county Regional Planning Commission
Nancy Krupiarz	Michigan Trails and Greenway Alliance
Bill Sproule	Michigan Technological University
Ron Van Houten	Western Michigan University
Risa Wilkerson	Governor's Council on Physical Fitness

Appendix B
Charter of the Michigan Transportation Research Board

Overview

The Michigan Transportation Research Board (MTRB) is a voluntary advisory body to Michigan's transportation agencies, led by the Michigan Department of Transportation (MDOT), that will assist in identifying and prioritizing transportation research needs, interact with organizations that conduct and support research, and champion the value of research to improve Michigan's transportation system. The Board initiatives will support all efforts to improve the quality and effectiveness of transportation services in Michigan through research. MTRB will promote an exchange of information, ideas, and knowledge benefiting transportation stakeholders through open discussions. The Board will help set broad direction for the annual research programs, and evaluate progress on an annual basis consistent with MDOT's and other agencies' business plans. This charter is a living document and will be revised as needed.

Mission

Promote active and effective research that will lead to the highest quality transportation services for economic benefit and improved quality of life.

Vision

Michigan's transportation research program will be a premiere program in the US having high visibility and producing innovative and effective solutions to practical problems. MTRB will develop and utilize all resources effectively and focus its research efforts to have broad impact on local, regional, and national issues.

Goals

The Michigan Transportation Research Board will pursue the following goals:

- Ensure the transportation community is proactive in research development, open to change and innovation, aggressive in implementation of research results, and supportive of training and continuing professional development of personnel.
- Include innovative and long-term research in the development of Michigan's transportation vision.
- Support development of emerging technologies.
- Effectively leverage funding from a variety of federal, state, private and local agencies.
- Clearly articulate the benefits of research results.
- Identify and create mechanisms that will make data and research findings understandable and accessible to end users in a timely manner.
- Foster a better awareness and visibility of existing research programs to the public. This should include educating the public about the importance of research so there is a corresponding political will at all levels to support research with adequate resources. Disseminate research outcomes widely.
- Promote evaluation of research results and support implementation.

- Foster research programs that integrate broad based stakeholder involvement and partnerships, including regional collaboration and coordination with other states.

Membership

All members of the Board will be on a volunteer basis from the Transportation Stakeholder Groups (shown in the Attachment) and will be experts in fields relevant to the activities of the Board.

The Board will consist of an executive committee, which is responsible for administering the policies and operation of the Board, and a broad based participation of all interested stakeholders. The executive committee will establish committees as necessary to execute the objectives of the Board.

A membership solicitation will be sent out for participation in the Board, excluding the executive committee.

The executive committee will meet twice a year and the Board as a whole will meet twice a year. The members of the executive committee are expected to attend all meetings.

The executive committee will be appointed and limited to up to 20 members from the following stakeholder groups:

- MDOT – 3 representatives, including at least 1 from senior management (3)
- Universities – 1 from each of the identified universities that pay the annual contribution established by the Board (Michigan State University, Michigan Technological University, Lawrence Technological University, University of Detroit Mercy, University of Michigan, Wayne State University, Western Michigan University) (up to 7)
- Federal Highway Administration (FHWA) - 1
- Industry – consultants, contractors and suppliers (2)
- Local governments – Michigan Municipal League (MML), Michigan Township Association (MTA), and County Road Association of Michigan (CRAM) (3)
- Public transportation – Michigan Public Transit Association (MPTA) (1)
- Regional planning – Michigan Association of Regions (MAR), Michigan Transportation Planning Association (MTPA) (2)
- Michigan Office of Highway Safety Planning (1)

Each entity will select representation. The executive committee will include a chair, vice chair and secretary/treasurer. These officers will be appointed by the executive committee for a two-year term with the possibility of renewal for a second term. The chair and vice chair will be from different stakeholder groups.

Values

The Michigan Transportation Research Board will adhere to the following set of values as it conducts its business:

- The Board acknowledges the values and principles of each represented organization and will work in a professional and collective manner to provide reasonable representation of all modes of transportation to meet the stakeholders' needs.

- Will engage in regular and effective communication with customers and stakeholders through active listening and information sharing to build trust and awareness, and solicit feedback, to show that we care about their needs.
- Be focused on transportation research serving the stakeholders.
- Be honest, open, and fair.
- Use everybody's talents and work as a team to solve problems.
- Be information driven and not based on perceptions, rumor, or personal agendas.
- Will resolve conflicts by reaching consensus on how best to report the scope of opinions.
- Will treat each other with respect, listen to all ideas, and communicate openly and candidly.
- Will follow all state and federal statutes.
- The members of the Board and all associated attendees will work together irrespective of their personal or professional affiliations.
- Everything the Board does will have a value-added component.

Actions to Achieve Goals

The Board believes it is important to establish a formal process or mechanism for stakeholder input into a multimodal research program that is synergistic with national initiatives. This includes regular meetings with advocates of Michigan transportation research, MDOT senior management, and research managers. The Board will keep the transportation community informed of its activities and issues. The Board will perform periodic self-evaluations to ensure it is meeting the research needs of the transportation community.

The Board will have a mechanism for input into the research program, which will assist in identifying needs and soliciting problem statements in specific research areas. The Board will encourage the seeking and leveraging of alternative funding sources, such as submittal of research ideas to the National Cooperative Highway Research Program (NCHRP).

The Board will identify research partners/stakeholders, and establish a process for stakeholder input and will promote the coordination of research with other states and stakeholders. Research will have reporting requirements for program evaluation and accountability, which includes stakeholders, and the publication of an annual research accomplishment report. Individual research projects will be effectively managed with individuals having the appropriate technical expertise with the ability to disseminate research findings including the deployment and evaluation of research results.

The Board will advocate the need for an appropriate level of research funding to meet the needs of the Michigan transportation community.

The Board will develop a formal mechanism to promote the implementation and evaluation of research results.

NOTE—A listing of the stakeholders under the categories of Research Sponsors, Scientific and Technical Experts, Users, and Affected Parties is provided below as an attachment to the charter.

Attachment to MTRB Charter

Michigan Transportation Research Board Stakeholders

Research Sponsors
(people who pay)

MDOT
Local governments
FHWA
NCHRP / TCRP / ACRP
TRB
AASHTO
OHSP
Trade suppliers
Regulators
Legislatures
NCTRP
Private Industry

Scientific and Technical Experts

MDOT
Michigan Department of Information Technology
Local governments
Universities
Trade suppliers
Consultants
Transit Agencies

Users
(implement the research)

MDOT
Local governments
Maritime
Aviation
Railways
Transit Agencies

Affected Parties
(impact from the research, but do not pay for it)

Automotive industry
Trucking industry
Contractors
Regulators
EPA
Michigan Bicyclist organizations
Insurance industry
Business and commerce

Appendix C
Draft Charter of the Transportation Research Institute of Michigan

Overview

The Transportation Research Institute of Michigan (TRIM) is a non-profit organization established to promote transportation research in cooperation with the Michigan Department of Transportation (MDOT), other Michigan transportation agencies, Michigan universities, and the private sector. TRIM will help build and maintain an effective research program and champion the value of research to help improve Michigan's transportation system. The executive committee of the Michigan Transportation Research Board (MTRB) will serve as the Board of Directors for TRIM and provide guidance and direction to the institute.

Mission

To facilitate research that is effective in addressing Michigan's present and future transportation needs; to promote transportation excellence through objective research; to provide the foundation for long-term visionary transportation research in Michigan; to broaden the participation of state, federal, and private research sponsoring agencies; and to promote implementation and dissemination of research.

Vision

Michigan's transportation research program will be a premiere program in the U.S. having high visibility and producing innovative and effective solutions to practical problems.

Goals

TRIM will pursue the following goals (in no priority order):

1. Support the development of a systematic and unified framework for identification and prioritization of research needs for all stakeholders of the transportation community of Michigan
2. Help reduce the potential for duplication of transportation research performed at Michigan universities through interaction and coordination with stakeholders across different focus areas
3. Facilitate interaction between universities, other research providers, MDOT, and other transportation agencies, so that research products generated are aligned with the agencies' strategic directions
4. Promote interaction of researchers in order to draw upon their collective expertise and stimulate productive research partnerships
5. Increase regional and national visibility of the research sponsored by MDOT and other transportation agencies, the research products delivered by universities, and the value of research to the general public
6. Foster cross-disciplinary, high risk, high impact research
7. Leverage alternative funding sources, including federal sources, to solve Michigan's transportation problems
8. Improve and facilitate implementation of research findings

9. Collaborate with Michigan universities, industry, and other research providers to facilitate the provision of applied and short-term research, and technical assistance to Michigan's transportation community
10. Make research investments more effective and efficient through broad-based stakeholder involvement
11. Facilitate periodic research conferences, technical presentations, and MTRB committee meetings

Staff, Organizational Structure, Relationship to Agencies, and Funding

TRIM will initially include a director and an administrative assistant. The director will report to the MTRB Executive Committee and shall be a champion of transportation research as a vehicle for addressing Michigan's transportation needs. No TRIM personnel shall be an employee or an employee on leave from one of the Michigan universities, or be serving on the advisory board of any. The director will be selected based on qualifications compatible with the job requirements established by TRIM's Board of Directors. TRIM will interact with the MTRB committee structure and respective stakeholders on the Board of Directors to achieve its goals. MDOT will interact with TRIM through its Office of Research & National Best Practices.

TRIM will not be involved in setting the research directions of transportation agencies, prioritizing research proposals, selecting research proposals for funding, performing research, evaluating research team qualifications, or allocating funds. TRIM may, however, coordinate calls for proposals, assist in the establishment of research advisory panels, and provide stakeholder inputs to agencies and universities.

TRIM will initially be funded by MDOT, university and other stakeholder contributions. The TRIM office will be located at MDOT facilities and not on a university campus.

Values

- Listen to transportation system owners and users about their needs and work to solve their problems
- Be focused on transportation research serving the stakeholders
- Be objective in research
- Be honest, free of conflict of interest, open and fair
- Follow all state and federal statutes
- Commit to excellence and be impartial to all Michigan universities

Appendix D
Recommended Research Solicitation, Prioritization and Selection Process

Roger Till, Head of Structures Research at MDOT, developed the research solicitation, prioritization and selection process described below. The MTRB recommends this process be adopted by all research groups within MDOT, and customized by other transportation agencies to serve their own organizational structures. However, the MTRB Executive Committee recommends the use of an annual process rather than the present biennial process to keep problem statements fresh and the research community engaged.

1. Announce annual call for research.
2. Hold annual research meeting to define current research needs. Invite MDOT focus area personnel from central office and regions, Engineering Operation Committee (EOC) focus area committee, and all universities. Review recently completed research, current research, current investigations and problem areas. Establish rules for problem statement submittal, e.g., if the problem statement is selected for further development, then only researchers submitting the problem statement or similar problem statement may submit a full proposal for possible funding. This latter rule prevents ideas proposed by researchers from being plagiarized.
3. Distribute summary of annual research meeting to those invited to the meeting.
4. Obtain problem statements one month after the annual research meeting.
5. Distribute problem statements to MDOT focus area personnel from central office and regions, along with focus area EOC subcommittee members. Involve as many interested technical personnel as possible and rank problem statements as high, medium, or low according to the needs of the department.
6. Ranking of problem statements reviewed by the EOC focus area subcommittee. This subcommittee sets the criteria for selecting problem statements. Complete initial problem statement selection.
7. Selected problem statements prioritized by the EOC focus area subcommittee.
8. Submit prioritized problem statements for SPR advisory committee approval.
9. Submit the SPR program to FHWA for approval.
10. Request proposals from researchers who submitted the selected problem statements. When more than one proposal is received, use the Guidance Document G9100.07, Contracting for Research, to evaluate the proposals. A technical advisory group formed by the project manager evaluates the proposals and selects one for funding.
11. Notify the Central Selection Review Team of the selected proposal.
12. Process the proposal for contract authorization.

(Note: EOC focus area subcommittees exist for Pavements, Traffic, and Bridges.)

Appendix E
Current Practices in Research Implementation

E.1 Research Administration Process

MDOT's current research administration process is discussed in a report entitled "Research Administration Manual."[*] The report indicates that MDOT's Research, Development and Technology (RD&T) Program consists of research efforts in applied research and development, technology transfer and consultant service. The research program areas are pavements, materials, bridges and structures, and technical assistance.

The research products are expected to have a high likelihood for implementation. Examples of research products are: new specifications and standards, guidelines, testing and evaluation results, and new technologies or materials. The Construction and Technology (C&T) Division is responsible for the overall management of the RD&T program and develops the biennial RD&T program through research solicitations. The research is solicited from all MDOT technical offices including the regions and the transportation service centers (TSCs), and from university partners. Area experts review ideas in each of the focus areas of pavements, bridges and structures, traffic and safety and appropriate research is incorporated into the final program.

The project selection for the RD&T program is based on the following factors:

- Relevancy to the department's mission, goals and objectives
- Technical merits
- Cost estimates and time required
- Available resources within MDOT and universities

It is also assured that the research addresses a critical need and that it has a high probability of successful completion.

The plan for implementation of research results is identified as a research deliverable. The Engineering Operations Committee (EOC) may review the implementation plans and assign expertise to facilitate implementation. The implementation plan is to include anticipated applications and potential use scenarios, potential user groups, identification of product champions, cost, funding source, risks and anticipated barriers to implementation and strategies to overcome, implementation and evaluation timeframe and measures. Technology transfer methods are also a part of research deliverables. These may include literature dissemination, training requirements, demonstration or pilot projects, conferences and other presentations, library display, and entry of results into national databases. The Research Administration Manual provides a more detailed description of implementation and technology transfer activities.

It is worthwhile to note that according to the Research Administration Manual, implementation of research results is the most tangible means of measuring the effectiveness of the research unit's performance. The planning for implementation also is expected to start as early as the development of the problem statement.

[*] Michigan Transportation Commission (2003). "Research Administration Manual- Research, development and technology transfer program, subset of SPR program," Construction and Technology, Michigan Department of Transportation, Lansing, MI.

E.2 Committee Discussion

The Research Implementation and Communications (RIC) committee discussed possible impediments/obstacles of research implementation into practice. Inertia was identified as one of the obstacles. Inertia, within the engineering community, is a notion that engineers are most comfortable with projects or methods they have successfully completed, and therefore do not like change. Another impediment was identified as risk, since engineers, designers, and contractors, do not want to assume the additional risk associated with something that is new and may also be costly. Overcoming inertia and risk will need much more effort and often may require a champion within MDOT or other organizations. This champion will take on the role of primarily overcoming the inertial resistance.

One aspect of dealing with the perception of research implementations being costly is to perform longer-range life cycle analysis (LRLCCA). Risk analysis can improve the accuracy of LRLCCA by yielding appropriate safety and reliability factors that can reduce the risk concern of engineers and help adoption of new ideas.

In some cases implementation projects are not undertaken only because of a lack of funding for such projects. For example, the CFRP bridge – Bridge Street Bridge had about double the design cost and about triple the bridge construction cost compared with traditional prestressed concrete reinforced bridge.

In order to overcome the inertia, risk and cost issues, a type of innovation award may be created throughout Michigan to recognize the best new implementation project for contractors, designers, and researchers similar to awards given by ACEC, ASCE, and others.

It is estimated that 25% of research findings currently are being implemented by MDOT, while 75% of them are not incorporated. This percentage is derived from the data that on the average two among eight research findings are being adopted by MDOT for implementation. The 25% rate appears positive, but it would be helpful to have data on implementation rates of other State DOTs for bench-marking purpose. In a 2001 MDOT report[†] a survey question "What percentage of research results in implementation changes completed?" was posted. The reply by about 10 DOTs ranges from 30 to 80%. MDOT indicated that "majority of the research projects follow in this category, as the projects are need based."

The project findings from the State DOT's are pooled and AASHTO selects 3 out of 50 research projects for national exposure annually in the Technology Implementation Group. AASHTO collects these research ideas from State DOT's that also serve as the champions. AASHTO solicitation form for projects to be highlighted nationally is included in Appendix F.

Communicating the research findings appears to be a viable means of improving the implementation potential. The Local Technical Assistance Program (LTAP) may be a conduit for communicating the research results. The Michigan LTAP at Michigan Tech University has promoted communication between researchers and practitioners through the Michigan Bridge Conference, the Michigan County Engineer's Conference, other workshops for county and municipal engineers, and the program's quarterly newsletter "The Bridge." Additionally, MTU publishes the "Research Record" for MDOT. This publication highlights research funded by MDOT and

[†] Michigan Department of Transportation (2001). "Marketing and Implementation of research results (MIRR) Best practice Review".

conducted at Michigan's universities. Currently 700 copies are distributed to MDOT for internal use in State government, and 4000 copies are distributed within "The Bridge." Circulation of the "Research Record" can be expanded. MDOT has provided LTAP with contact information for all of its university researchers. These names will be added to the distribution list.

Another means of disseminating research results would be through a Web-based platform for collection and dissemination of research/technology development and needs. The Web-platform may also double up as a library system, with all the finished and ongoing research books and reports ready to be downloaded. Old documents should be scanned to a search-friendly format, and the new documents can be transformed to searchable PDF files. LTAP staff at Michigan Tech could be used to help operate this Web site.

A more detailed analysis of selected DOT processes for the marketing and implementation of research results are discussed in a report by MDOT entitled "Marketing and Implementation of Research Results."[‡] This report is the result of a study by Michigan Department of Transportation and the Missouri Department of Transportation, under the auspicious of the Federal Highway Administration. Questionnaires and visits to other DOTs were instruments for the study. The executive summary of the report states:

> "The successful research program seems to have marketing and implementation practices as a part of the business process. This integration has helped the programs to best utilize the available funding, and human resources.

The report also indicates that while marketing and implementation has been an integral part of the RD&T program, MDOT wants to move it up a level or two. The marketing effort should go beyond the transportation and research community and include the general public.

A study on the best practices of research implementation by various State DOTs was carried out by one of RIC committee members. A brief summary on important findings is included in Appendix G. The study was conducted based on information on DOT Web sites, and serves to highlight different approaches used by various DOTs in translating research into practice.

[‡] Michigan Transportation Commission (2003). "Research Administration Manual- Research, development and technology transfer program, subset of SPR program" Construction and Technology, Michigan Department of Transportation, Lansing, MI.

Appendix F
AASHTO Solicitation Form

24

AASHTO Technology Implementation Group
Nomination of Technology Ready for Implementation
2005 NOMINATIONS DUE BY FRIDAY, SEPTEMBER 9, 2005

Sponsoring DOT	1. Sponsoring DOT (State): Michigan
Primary Technical Contact	2. Name: William Tansil Organization: Michigan Department of Transportation Address: P. O. Box 30050 City: Lansing State: Michigan Zipcode: 48909 E-mail: tansilw@Michigan.gov Phone: 517-335-2639 Fax: 517-373-9255
Technology Description	3. Name of Technology: Truck Weight Information System
	4. Briefly describe the technology. Michigan Department of Transportation connected the dots between MDOT's Weigh Station and Pavement Design programs, State Police/Motor Carrier Division's truck weight enforcement activities with MDOT's Traffic Monitoring System's Truck Weight Data Collection program. This is supported by the development of the Truck Weight Information System (TWIS) to assist with a shift from traditional weight enforcement strategies and provide the ability to analyze pavement design strategies. The TWIS is a computer application that provides analysis and access to MDOT's truck weight data resource. By providing this linkage, MDOT will be better aligned to develop, maintain, and protect its highway assets.
	5. Briefly describe the history of its development. Michigan is a national leader in weigh in motion data collection. Since the early 1990's, Michigan participated in the Strategic Highway Research Program, contributing data toward a national pavement performance quality effort. Instrumentation quality evolved over the years with exceptional reliability achieved in some of the harshest environments. MDOT decided to develop a system to support its highway design and weight enforcement efforts through the use of this weigh-in-motion truck weight data. Processing and storing the huge volume of truck weight data was stymied prior to this effort. MDOT's Bureau of Transportation Planning assembled a team to design the Truck Weight Information System (TWIS) in January of 2001. Three major objectives were identified: 1. Make truck weight information available to users. 2. Provide analysis on overweight trucks. 3. Provide analysis for pavement design. A demonstration version of the TWIS was launched in November 2002. This demonstration version is now being field tested by MDOT staff as well as State Police, Motor Carrier Division enforcement staff.

Page 1

State of Development

6. For how long and in approximately how many applications has your organization used this technology?

A demonstration version of the TWIS was launched in November 2002. The Truck Weight Information System enabled MDOT to improve its highway protection strategies by using the truck weight data collected at over 40 sites around the state. The system supports the processes/functions of the following business areas:

Provide Truck Weight Data – Provides the ability to handle large amounts of data for processing, validation, and storage. The system is currently importing around one million individual truck weight records per week. To date, there are about 150 million detailed truck records in the system. Once in the corporate database, the information is accessible for analysis by TWIS, as well as other programs/processes.

Provide Overweight Analysis and Reports – Provides a tool to conduct overweight analysis used by planning and enforcement in identifying incidences of overweight trucks, including their frequency, magnitude, speed, time of day, and type of violation (single axle, tandem axle, and gross overweight). This tool allows the enforcement agencies to identify and "target" the most damaging overweight locations, measure enforcement performance, and monitor the system with regards to other weight enforcement issues.

Analyze Truck Loads– For design purposes, it is necessary to estimate the cumulative number of 18-kip equivalent single axle loads for the design period of the pavement structure under consideration. Truck traffic is the essential information required to calculate Equivalent Single Axle Load (ESAL). This information is critical to assist with recommendations on pavement design and pavement management. The system provides the ability to perform "what if" scenarios measuring the impact using different pavement design opportunities as well as verification of ESAL predictions over the design period thus assisting with the pavement design validation

The TWIS provides for modeling the impact of truck weights on the roadway and provides the flexibility to create different scenarios for pavement design analysis. When assets are designed and built to accommodate these "real life" loads, monitoring the proper system usage with regards to truck weights is necessary to maintain the road's life expectancy.

7. What additional development is necessary to enable routine deployment of the technology?

Identify additional site locations and monitoring opportunities.

8. Have other organizations used this technology? If so, please list organization names and contacts.

Organization	Name	Phone	E-mail
Michigan State Police Motor Carrier Division	Captain Robert Powers	517-336-6447	powersr@michigan.gov

AASHTO Technology Implementation Group
Nomination of Technology Ready for Implementation
2005 NOMINATIONS DUE BY FRIDAY, SEPTEMBER 9, 2005

Potential for Payoff	9. What benefits has your organization realized from using this technology? Include cost savings, safety improvements, transportation efficiency or effectiveness, environmental benefits, or other advantages over other existing technologies. The cost to develop and launch the TWIS (less than $250,000) is offset by the significant savings realized by abandonment of only one weigh station upgrade project amounting to $3 million. Maintenance and staffing costs amounting to thousands of dollars annually have been saved at the 5 closed weigh station sites. State Police, Motor Carrier Division can now assign staff to target violators based upon actual documented truck weights collected by site, day of the week and time of day. Tracking the results of weight enforcement operations is also a time and cost saving benefit for enforcement staff. Comparing data from a year ago or even last week is useful for measuring performance of various enforcement techniques. Enforcement staff can target certain unique truck configurations that are prone to being overweight. For example, very few 5 axle semi combinations, traveling during the daytime on the Interstate system are likely to be overweight; on the other hand, 11 axle multi trailer combinations, traveling at night, off the Interstate system are very likely to be significantly overweight. These severely overloaded vehicles cause damage to pavement and bridge infrastructure. Inefficient enforcement creates an uneven playing field between legal and illegal motor carriers. Closing weigh stations eliminates the time wasted by legal motor carriers waiting in queues to enter the weigh station. Shippers and carriers assign a value to increases in travel time, ranging from $25 to almost $200 per hour, depending on the product carried. While it is rare for an individual motor carrier to wait more than a few minutes in line, the accumulated time of all vehicles waiting at all weigh stations at all times is significant.
Implementation Potential	10. Please describe what actions another transportation agency would need to take to adopt this technology. Creation of an Oracle database, use of software developed by MDOT.
	11. What is the estimated cost, effort, and length of time required for procurement or adoption by another transportation agency? Unknown.
	12. What organization(s) currently supply and provide technical support for this technology? Michigan Department of Information Technology (DIT) has staff assigned to maintain computer applications for the Michigan Department of Transportation. This project, along with others, is assigned to one staff person for system maintenance. Also, DIT has resources assigned that perform MDOT's data base operations.
	13. Please describe any legal, regulatory, social, intellectual property, or other issues that could affect ease of implementation. Most states are engaged in WIM data collection activities. Analysis and use of the data for a variety of purposes should be attractive to most states.
Willingness to Champion	14. Is the sponsoring DOT willing to promote this technology to other states, if partially supported by the AASHTO Task Force on Technology Implementation? X Yes ☐ No
Date Submitted	15. Date: September 9, 2005

16. Please include image(s) of sketches or photographs, if available X Image(s) are attached.

AASHTO CONTACT	MARTY VITALE ADMINISTRATIVE COORDINATOR FOR ENGINEERING AASHTO	PHONE: 202.624.5862 FAX: 202.624.5469 mvitale@aashto.org

Appendix G
Brief Overview of Research Implementation in Other State DOTs

This brief report is based on Departments of Transportation research practices presented on their Web Sites and reports on research implementation topics granted by related organizations like TRB (Transportation research Board) and TCRP (Transit Cooperative Research Program).

Putting research findings into practice does not occur automatically. There are many reasons for this. Many researchers do not know how to communicate in non-academic language; research findings are frequently so camouflaged that the busy reader does not see immediate applications; or conclusions are so laced with conditions that implementation would be most difficult. There is a need to find improved research implementation tools, tailored to the special needs of the transit operator. The problem of transit research implementation can be addressed on two fronts: immediate or short-term action, and long-term institutional arrangements. Immediate or short-term: the study should determine the best way of evaluating the products of transit research; long- term institutional arrangements: the research should study existing transit organizations in this country and abroad to determine current industry practices. Finally, the study should evaluate and recommend alternative institutional arrangements, organizational structures and improved ways for transit research findings to be put into practice.

To put transit research findings into practice, state DOTs are creating new and original approaches to the problem. The solution implemented by Illinois DOT was to create special Products Evaluation Unit and Technical Services Unit. Michigan DOT also developed Product Evaluation Unit to process evaluation of new industrial products.

The stated mission of the Products Evaluation Unit is the evaluation and development of new products, materials, and processes, which appear to have potential for improvements in highway construction, maintenance, and operations. Field evaluation of new items is stressed as a particularly important activity. It is expected that evaluation and development studies will produce usable information much faster than the more fundamental, relatively long-term projects.

One of the more important functions of the Products Evaluation Unit is its one stop service to vendors. Before this unit was established, manufacturers' representatives and others with something new to offer the Department were hard pressed to find the proper office or person to present their proposals to, and were often shunted from one office or person to another. They now have a clearinghouse where they can be heard regardless of the nature of the new product. This is good for both the vendor and the Department. Department administrators are pleased to be able to quickly refer vendors to the Products Evaluation Unit. Most vendors soon learn that approaching District or Bureau offices will result only in immediate referral to the Products Evaluation Unit. Now, most vendors approach the Products Evaluation Unit directly.

The Products Evaluation Unit and the Illinois Highway Development Council work together in making the final decision on whether or not a product is approved. The Products Evaluation Unit selects products to evaluate, conducts a pre-investigation of each product to be taken to the Council, conducts laboratory and field tests, prepares reports on product evaluations, and prepares any specifications or standard changes necessary to get approved products into use. The Council studies the information and recommendation provided by the Products Evaluation Unit on each product, and makes a decision. The Council may approve field testing of relatively new and untried products to determine their applicability for IDOT use. The Engineer of Prod-

ucts Evaluation calls and conducts the Council meetings, and forwards Council decisions of a sensitive nature to the Director of Highways for his concurrence. The Products Evaluation Unit, as the secretariat for the Council, is responsible for all communications, reports, implementation documents, and dissemination of news of Council actions.

The current system for products evaluation treats this endeavor as a full time activity. New products are aggressively sought out, and product evaluations are conducted by professional engineers who have extensive materials knowledge and who are experienced in evaluating products. Investigations of uniform high quality produce usable results, which are then implemented. Another advantage accrues from accept-reject decisions being made by the multi-disciplinary Illinois Highway Development Council. This assures a broad perspective and maximum benefits, while minimizing chances for error. A third major advantage is the one-stop service, which benefits both vendors and IDOT management. The vendors have a focal point where they will be given an objective hearing, and the managers have a place to which vendors can be referred if they approach the Director's office, or a District or Bureau office. A fourth advantage of the current system is that news of new product developments, product evaluation results, and product approvals is now quickly circulated throughout the Department and to highway officials in local road agencies throughout the state. This has resulted in increased willingness of individuals to cooperate in evaluation activities, and in speedier and wider use of product evaluation results.

The Technical Services Unit provides the vital link between research and engineering practice. The Unit is responsible for providing rapid solutions to operational problems, technology transfer, and pavement design and materials expertise. Problems encountered by the Unit are complex and highly technical, and generally cannot be solved with technical expertise available elsewhere in the Department. The Technical Services Unit is divided into three Sub-Units: Design and Materials Technology; Research Implementation; and Research Coordination.

The Design and Materials Technology Sub-Unit is responsible for searching out new design and materials technology; and transforming research findings into Department policies, methods, and specifications. This Sub-Unit influences design policy by investigating for example pavement structural design details, solving specific pavement design problems, developing recommendations for updating the "Pavement Design" portion of the Department's Design Manual, and investigating the constructability and early field performance of new technology. The Sub-Unit also conducts special materials investigations, and develops solutions for specific material problems.

The Research Implementation Sub-Unit acts as a liaison between the Research Section, Test Section, and other segments of the Department. To implement research findings, the Research Implementation Sub-Unit reviews research and technology developed by others (in-house and outside the Department); assesses the validity of the findings; and transforms the new technology into procedures, policies, and specifications which can be evaluated through field application. The Sub-Unit functions as a conduit for deploying these procedures, policies, and specifications (developed out of research conclusions) into IDOT construction projects. The Sub-Unit evaluates how readily theses policies, procedures, and specifications are incorporated into IDOT projects by monitoring compliance, and making recommendations for improvements when necessary. This Sub-Unit also recommends solutions to specific new research implementation problems.

The Research Coordination Sub-Unit is responsible for the technology transfer activities of the Bureau. This includes preparation of the annual National Cooperative Highway Research Program (NCHRP) Problem Statement solicitation, second stage submittals, and other associated activities. The Sub-Unit prepares research work, and coordinates studies conducted outside the Physical Research Section. Liaison is maintained with the FHWA to ensure compliance with Federal policies and procedures. The Sub-Unit provides guidance, and reviews projects for compliance with Departmental and contract agreements. The Sub-Unit prepares the budget for studies contracted to outside agencies, and submits the budget to the Engineer of Physical Research for inclusion in the overall program.

Minnesota DOT created separate Research Implementation Funding Program to support the application of results from Mn/DOT research projects. Successful implementation occurs when practical benefits are realized by the application of research. The goal of the Research Implementation Funding Program is to encourage and support activities that apply research results in ways that measurably improve the performance of Mn/DOT's investments in transportation resources.

Florida DOT founded research project on "Review, Analyze and Develop Benefit Cost/Return on Investment Equations, Guidelines and Variables". The main goal of this project was to develop research evaluation system to be used for measuring the benefits of research efforts, post completion. The criteria for successful research evaluation process should meet three fundamental requirements.

- The variables or metrics used must be readily available within the organizational information system. Adding the requirement to generate and collect additional data increases the burden on the organization. Whenever possible, data that already exist within the system should be utilized.
- The measurements must be valid. The evaluations must provide reasonable precise indicators of performance. The system should include validation of reported information.
- The measurement process must provide a balanced assessment. Given a diverse nature of research projects, using a single metric such as cost savings would exclude many important other benefits. Clearly, the evaluation metrics must include both monetary and other, qualitative benefits. The set of benefits should be inclusive rather than exclusive.

Possible benefits can be categorized as follows.

1. **Qualitative benefits** are those benefits that may not be directly quantifiable in economic terms. Research often produces benefits other than economic value. These benefits relate to the general welfare and quality of our community life. Measuring these benefits is a subjective process. Nevertheless, these are real benefits, and they should be recognized. The general categories of qualitative benefits may include:
   - Improvements to Knowledge Base
   - Improvements to DOT Infrastructure (Organizational and Process Structures)
   - Improvements to Quality of Life
   - Improvements to DOT Management and Policy

   For some typical qualitative benefits, models to quantify the benefits in economic terms have been developed. For example, safety benefits can be computed by estimating the cost of accidents that have been avoided.

2. **Economic benefits** suppose to determine the savings per unit by comparing the cost prior to implementation with the expected cost after implementation. Total savings are estimated by multiplying the unit savings by the estimated total number of units. Future cost savings should be converted to present values using appropriate interest rate values (this rate is the value established and used by the DOT for all planning calculations). The calculation can be expressed as follows:

$$\text{Estimated Cost/Benefit Ratio} = \frac{\text{Present Value of Total Savings}}{\text{Present Value of Cost of Research}}$$

$$\text{Total Savings} = \left[\text{Savings per Unit} \times \text{Estimated Number of Units}\right] - \text{Cost of Implementation}$$

Economic calculations can be provided for different economic benefit categories.

Improved Work Efficiency. Research results that offer improvements in organizational productivity. The cost savings generally result from a reduction in labor-hours and/or equipment hours to accomplish an activity. This category is designated for the DOTs and its consultants. Construction contract work activities are included in a separate category.

Reduced Material Cost. Research results that reduce the cost to the transportation user.

Reduced Maintenance Cost. Research results that reduce the cost to maintain DOT facilities.

Reduced Construction Cost. Research results that reduce the cost of construction purchased by the DOT through its construction procurement system.

Reduced Operational Cost. Research results that reduce the cost to the DOT for the operation of its facilities.

In any benefit/cost assessment model three basic phases should be included.

Phase 1 – Research Period

The first phase of the evaluation process occurs during the performance of the research project. Researchers may complete a Research Benefit Report so that they can identify potential benefit and collect cost information. Additionally, appropriate training could be initiated to insure that both DOT managers and researchers are capable of performing the required assessments. At the conclusion of a research project, a research benefit assessment should be made by the principal investigator and the DOT research coordinator. However, benefit assessments done prior to implementation of research results are only estimate of potential benefits.

Phase 2 – Implementation Period

The implementation period is the most critical because very little benefit can be achieved without some measure of implementation. Implementation plans should contain specific items including what must be done and when it must be done. Successful implementation also requires the designation of a manager who is responsible for the implementation effort. Accountability is a key ingredient of successful implementation.

Phase 3 – Post Implementation Period

The true measure of research benefit can only be obtained after implementation. Therefore, it is essential that post-implementation benefit assessment be performed. The exact timing is likely to be dependent upon project specific issue. However, implementation should be complete and a representative amount of production should have occurred.

Reference

Ellis, R.D., Degner, J., O'Brien, W. and Peasley, G., "Review, Analyze and Develop Benefit Cost/Return on Investment Equations, Guidelines and Variables", Final Report, UF Project 4910 45-04-835, BD-013, prepared for the Florida Department of Transportation., March 2003.

Appendix H
Bridges and Structures: Research Themes and Problem Statements

H.1 Process for Developing Overarching Research Topics

There was some discussion about whether the committee should recommend a long range research strategy rather than research ideas and needs, which can be quickly outdated. It was pointed out that the charge required the committee to identify specific needs and that the MTRB committee will meet yearly to update those needs.

The committee agreed that overarching topics should be selected based on consensus. It was decided that the overarching research needs will be limited to 4 or 5. The committee grappled with how to propose broad topics of overarching need. It was finally decided that a variety of broad-based topics would first be proposed and discussed. This discussion produced 16 topics, which were then listed under an umbrella of 5 broad titles. Many of the original 16 topics were considered to fall under 1 or more of the broad overarching needs statements.

The committee stressed the need to promote high risk/high payoff research and to facilitate rapid implementation of research results into practice.

The following broad research topics were proposed (listed as proposed):

1. Materials
2. Cyber and Information Technology
3. Long Lasting, Cheap, Fast
4. Safety and Security
5. Reliability
6. Bridge Systems
7. Asset Management
8. Bridge Loading
9. Load Models
10. Bridge Performance
11. Repair/Rehabilitation/Renewal/Preservation Technology
12. Environmentally Friendly Materials and Construction Methods.
13. Monitoring and Assessment
14. High Risk Emerging Technology with High Payoff
15. IDEAS Concept
16. Design Methods

The following 5 overarching research needs were proposed (listed as proposed):

Overarching Research Need 1: Preservation

Includes: Materials; Long Lasting, Cheap, Fast; Safety and Security; Asset Management; Repair/Rehabilitation/Renewal/Preservation Technology; Monitoring and Assessment; High Risk Emerging Technology with High Payoff; IDEAS Concept; Design Methods

Overarching Research Need 2: New Materials and Systems

Includes: Materials; Information Technology; Long Lasting, Cheap, Fast; Bridge Systems; Bridge Performance; Environmentally Friendly Materials and Construction Methods; High Risk Emerging Technology with High Payoff; Design Methods

Overarching Research Need 3: Performance and Reliability

Includes: Information Technology; Safety and Security; Reliability; Asset Management; Bridge Loading; Load Models; Bridge Performance; Monitoring and Assessment; High Risk Emerging Technology with High Payoff

Overarching Research Need 4: Rapid Construction

Includes: Materials; Information Technology; Long Lasting, Cheap, Fast; Bridge Systems; Repair/Rehabilitation/Renewal/Preservation Technology; High Risk Emerging Technology with High Payoff

Overarching Research Need 5: Information Technology

Include: Cyber and Information Technology; Reliability; Bridge Systems; Asset Management; Monitoring and Assessment; High Risk Emerging Technology with High Payoff; Design Methods

H.2 Process for Prioritization of Individual Research Topics

The committee agreed that while overarching topics should be selected based on consensus, research statement should be prioritized based on a ranking system, where every committee member assigns a number from 0-5 (where 0 is "Not needed" and 5 is "Highest priority for immediate funding.") to each proposed idea. It was decided that there would no limitation on the number of research problems proposed.

The committee discussed how to propose one-line problem statements, which would be used to develop full problem statements. It was decided to review the listing of one-line research problem statements that had been previously submitted and revise/add to the list during the discussion. Each member attending meetings was given the opportunity to add one-line problem statements to the list. About 60 problem titles were generated by the committee members and are listed at the end of Appendix A.

The one-line research titles were then prioritized based on the ranks assigned by the committee members. The rankings for all the one-line research problem statements were summarized by average and the standard deviation computed for each idea and distributed to members prior to the committee making final selections.

There was a discussion of the high standard deviation that was attributed to some ideas. Efforts were made to consider rankings based upon “average + half standard deviation” or “average - half standard deviation”, but it was pointed out that adding/subtracting standard deviations would put more weight on extreme views. In any case, ranking using the modified values did not substantially change the position of the top ideas. It was agreed to base the final one-line problem statement selections upon the average rating.

The committee decided to initially rank as important all topics that achieved an average rating score of 3.0 and above, which yielded 25 ideas. Similar topics were then combined under one title. Based on further discussion it was decided to further eliminate all ideas with average ratings

of 3.29 and below. This brought down the number of important topics to nine, for which detailed problem statements were written up.

H.3 Generation of Problem Statements

It was decided to assign a primary person and one or more secondary persons to each idea to develop it further into a comprehensive problem statement. Attending members volunteered for these positions. The list of problems and the individuals that have already volunteered for writing them was circulated so that all committee members would have a chance to participate in the problem writing process. The problem statements were due to the committee chair/co-chair by December 5, 2005.

The committee met via conference call after the problem statements were submitted to discuss the detailed write-ups. No further changes were made to the submitted statements.

H.4 Committee Recommendations

It is recommended that the nine research problem statements in Appendix B be considered for funding. It is also strongly recommended that all existing research reports in Michigan be converted to electronic format with searchable features for ready access. Although this would not be considered research, it is a worthy task and highly desirable to prevent past mistakes from reoccurring.

H.5 Problem Titles Generated

Statement #	Near Term
1.	Research Statements for High-Risk Emerging Technology: Identification of Test bed Bridges for Advanced Sensing Technology Demonstration
2.	Investigation on the need and benefits of Long-Term Wireless Monitoring Systems for Michigan Bridges
3.	Installation of Long-Term Wireless Monitoring Systems for Michigan Bridges
4.	Concrete consolidation is a problem, especially in areas of heavy reinforcement. Development of self-consolidating concrete mixes and design guidelines.
5.	Develop better procedures, mixes to control quality and curing temperature of cast-in-place decks, especially during very hot of cold weather.
6.	Precast elements and systems for rapid construction. Bridge reconstruction/repair takes too much time, especially in high-traffic areas.
7.	Effects of structural vibration during curing that cause formation of lenses of high-water-content beneath the surface of decks. This causes planes of weakness due to high permeability, trending down the level of the reinforcement, resulting in delamination, pot holes, and repairs.
8.	Corrosion of structural steel, steel rebars, and prestressing strand is still a problem of considerable consequence. Better corrosion-control engineering is needed.
9.	Training bridge engineers in unfamiliar technological areas, new materials and methods.
10.	Computerize existing bridge research in Michigan for ready access.
11.	Develop and validate deterioration models for bridge elements. Are fixes actually lasting as long as they are assumed to last when cost-effectiveness/life-cycle computations are made? Is necessary information available? Is such information being utilized effectively in practice?
12.	Non-destructive monitoring of stress loss and grouting conditions of prestressed/poststressed bridge decks
13.	Repair of Reinforced and Prestressed Concrete Bridge Members Damaged by High Load Hits.
14.	Improving Bridge Inspections using Emerging Technology, such as computer, GPS, bar codes, wireless, PDA, etc.
15.	Repair and Strengthening of Steel Bridges using Fiber Reinforced Polymer Technology.
16.	Methods of Evaluating Bridge Redundancy and its Influence on Inspection Schedules.

17.	Develop methods of risk analysis for scour critical bridges.
18.	Performance and design of FRP decks.
19.	Performance and design of jointless bridges.
20.	Performance and limitations of high strength concrete.
21.	Performance and evaluation of anchorage details of precast beams.
22.	Design strategies for continuous bridges.
23.	Procedures and evaluation of FRP rehabilitation of concrete bridge decks.
24.	Performance and design considerations of soil-structure interaction in bridge foundations.
25.	Holistic design guidelines for high performance concrete bridges.
26.	Residual capacity of bridge elements after fire events.
27.	Durability/deterioration models of concrete bridge elements.
28.	Long term effects of secondary repetitive loads on in place bridge decks. (from vibrations, wind loads, wind loads due to traffic under the structure, live loads not at upper limit, etc.)
29.	Effects of member deflections on bridge life.
30.	Sources of detrimental movements/vibrations in bridge systems.
31.	Methods of evaluating deteriorated bridge decks with stay in place metal forms.
32.	Improving paint removal and handling techniques for field coating.
33.	Methods of early detection of pavement growth issues affecting bridges (Bridge expansion joints being pushed closed)
34.	Use of stay in place deck forms for girder bracing in place of diaphragms and cross frames (must plan for future work such as deck replacement)
35.	Effects of part width construction on the finished product and the corresponding life cycle.
36.	Effects of bridge smoothness/ride quality on bridge life.
37.	Development of cost effective strategies for repair of local agency bridges.
38.	Determination of factors that lead to a short bridge deck life.
39.	Develop guidelines to make bridges rehabilitation friendly. Breaks in system to reduce vibration, over sizing shoulder for future maintenance of traffic needs, utility provisions, etc.
40.	Develop methods for the repair on textured and/or pigmented Structural Concrete. The use of textured concrete is increasing, soon they will be deteriorating, repair techniques that preserve the original aesthetics will be necessary to keep the bridge from looking poor.
41.	Performance of rip rap as a scour measure.
42.	Develop methods for doing risk analysis of bridge network needs. Examples of need are developing plan of action for network of scour critical bridges and protecting piers and abutments from river traffic.
43.	Evaluate the effectiveness and optimize bridge preventive maintenance. Need to better understand how effective the different types of preventive maintenance (PM) are, as it relates to our overall bridge management process. This research should help in understanding how long PM activities last, how they slow the deterioration rate of the bridges, how cost effective they are, and when PM activities should be done.
44.	Evaluate the effectiveness of scour counter measures.
45.	Develop remaining service life (or time to reaching next lower condition state) for bridge elements.
	Long Term
46.	Develop concretes with lower shrinkage, while maintaining strength, durability and low permeability. Methods and materials to minimize concrete shrinkage and cracking, which allows penetration of chlorides and reduces section strength.
47.	Develop concrete decks resistant to cracking.
48.	Development of “smart materials.”
49.	Development and evaluation of new bridge elements and systems made from FRP.
50.	Development, evaluation, and demonstration of self monitoring bridges.
51.	Development and evaluation of all-precast bridge systems.
52.	Nondestructive evaluation methods.
53.	Improving bridge joint technology to resist detrimental leaking.
54.	Development of performance based specifications for structural materials.

55.	Develop reliable, durable and simple to use bridge inspection technologies that increase the information gained and the safety of the inspector. Use of penetrating radar to find and measure delaminations remotely or from vehicle, measuring technologies, equipment technologies, etc.
56.	Develop design procedures based on new materials mechanics.
57.	Develop deterioration models for bridge decks, especially decks having shallow and deep concrete overlays. We have found that often these decks delaminate (separate) from the concrete deck below. When sounding a bridge deck, the delaminations are indicated by a hollow sound. We do not know how log it will take for these delaminations to appear as spalls (potholes) in the deck. An understanding of the factors or variables that control or drive the deterioration process of bridge decks is needed. We need to confirm deterioration rates and, if possible estimate time to dropping into next lower condition state.
58.	Develop optimization strategies using cost/benefit analysis for Michigan's bridge network.

H.6 Detailed Problem Statements

The detailed problem statements generated by the bridge committee are given below.

RESEARCH PROJECT DESCRIPTION
Bridges and Structures

Project Title: Effectiveness of Bridge Preventive Maintenance Activities

Objective and outcomes: MDOT has a list of typical bridge preventive maintenance (PM) work items. The purpose of performing these PM work items is to slow the rate of bridge element deterioration, thereby prolonging the life of the element and the bridge. Examples of these work items are full and zone painting, joint replacement, concrete sealing, and concrete patching. The objective of this project is to evaluate the cost effectiveness and performance of the typical PM work items based on actual MDOT applications, and to develop guidance for optimizing their use.

Expected outcomes for the project include:
Determination of the cost effectiveness and performance of each PM work item. This outcome should include determining the boundary conditions for which each PM work item is most effective.
Methodologies for developing a systematic bridge PM program, based on PM work item cost effectiveness and performance.

Practical importance: MDOT needs to better understand the effectiveness of the different items of bridge preventive maintenance in order to manage its inventory of bridges at the least cost.

Technical importance: Knowing the optimum time to perform and the expected performance of PM work items will help to stretch the limited funds available for bridge PM.

Impact of expected outcomes: The knowledge gained from this research will help MDOT bridge engineers in developing their PM program, giving guidance as when it should be performed as well as when it should not be performed.

Implementation timeline:
Winter 2006 - Solicit & refine research proposals
Spring 2006 - Select proposal
Summer 06-07 - Conduct research
Fall 2007 – Develop report

Duration of project: 2 years

Priority (H,M,L): This project should have a high priority.

RESEARCH PROJECT DESCRIPTION
Bridges and Structures

Project Title: Minimizing the Life-Cycle Cost of Bridge Structures with Corrosion-Susceptible Steel Components

Objective and outcomes: Corrosion of structural steel, steel reinforcement, and prestressing strand is a problem of considerable consequence that requires bridge maintenance and replacement costs measured in billions of dollars. Stainless steel and fiber reinforced polymers are corrosion resistant, but their initial cost is limiting their use. Epoxy coating steel is available for reinforcement steel and prestressing strand; however, the durability of the epoxy may not be as expected. High performance zinc coatings are used for structural steel, but the coatings have a finite life. Basic research will be done to develop methodologies for minimizing the life-cycle cost of bridges with corrosion-susceptible steel components. Specific objectives for this research include:

Develop or identify a corrosion resistant material that has a defined yield point and exhibits a strain hardening property at a reasonable cost.
Review past work and perform new investigation as needed on the fatigue resistance of corroded existing steel components.
Formulate predictive corrosion models and develop optimum corrosion control and repair strategies.

Practical importance: Minimizing the life-cycle cost of bridges with steel components will decrease the overall cost of the civil infrastructure.

Technical importance: Advancement of materials science and engineering would result from the emphasis on the basics of corrosion. Moreover, an improved understanding of the fatigue properties of corroded steel will provide information on the remaining life of bridge structures that have corroded steel components.

Impact of expected outcomes: Billions of dollars in infrastructure savings through longer service life with lower maintenance costs would be recognized.

Implementation timeline: This research will be conducted in two related research projects. Objective one will be addressed in a long term study comprised of three phases as follows. The first three years would be devoted to engineering a new corrosion resistant material followed by two years of environmental testing. Demonstration projects would be built in the sixth year with five years of evaluation. Objectives 2 and 3 will be addressed in a separate 3 year study.

Duration of project: This would be a long term project that would be implemented in phases as discussed above.

Priority (H,M,L): High priority

RESEARCH PROJECT DESCRIPTION
Bridges and Structures

Project Title: Develop and validate deterioration models for bridge deck elements.

Objective and outcomes: The objective of this research is to develop deterioration models for bridge decks. This includes all the deck surfaces included in MDOT's Pontis inspection manual. Some of the areas to be researched include:

Decks having shallow and deep concrete overlays. We have found that often these decks delaminate (separate) from the concrete deck below. When sounding a bridge deck, the delaminations are indicated by a hollow sound. We do not know how long it will take for these delaminations to appear as spalls (potholes) in the deck. An understanding of the factors or variables that control or drive the deterioration process of bridge decks is needed. We need to confirm deterioration rates and, if possible estimate time to dropping into next lower condition state.
Determine how long concrete deck patches last.
Research the deterioration process and effectiveness of epoxy overlays.
Research the deterioration process and effectiveness of HMA overlays with and without membranes.

Compare analytical data to MDOT's bridge deck preservation matrix. Are fixes actually lasting as long as they are assumed to last? Compare cost effectiveness to the different bridge deck fix types, by doing life cycle cost analysis or cost/benefit analysis. Is necessary information available? Is such information being utilized effectively in practice? Develop remaining service life (or time to reaching next lower condition state) for bridge deck elements.

Practical importance: The condition of Bridge decks most commonly drive bridge projects, including preventive maintenance, rehabilitation, and deck replacement. Over $200 Million a year is spent on bridge preservation projects in Michigan (MDOT and Local agencies). It is vitally important that we show that this money is being spent in the most cost effective manner.

Technical importance: This research is needed to fully calibrate Michigan's bridge management systems.

Impact of expected outcomes: More cost effective bridge strategies.

Implementation timeline: Upon completion of project, Michigan bridge management systems will be recalibrated using the research results.

Duration of project: 1.5 years

Priority (H,M,L): High

RESEARCH PROJECT DESCRIPTION
Bridges and Structures

Project Title: Crack resistant concrete for bridge decks and pavements (Developed in cooperation with the pavement committee and is rated as high priority by both committees.)

Objective and outcomes: Develop concretes highly resistant to cracking for bridge deck and pavement applications, while maintaining all desirable properties of normal concrete. Methods and materials will be developed to minimize concrete cracking, and therefore reduce the transport of aggressive agents or moisture infiltration into concrete bridge decks and pavement slabs. Emphasis is placed on durability of concrete in bridge deck and pavement slab structures that experience combined traffic and climatic loadings, and are often under restrained conditions.

Practical importance: Elimination of concrete deck and pavement cracking will prolong service life of the structure itself, along with increasing the life of supporting members. Concrete cracking allows direct penetration of chlorides, leading to localize corrosion even when corrosion resistant reinforcement and corrosion resistant coatings are used. In the case of bridge decks, corrosion of steel reinforcements can lead to reduction in section strength. Chlorides leaking through cracks directly on supporting members causes corrosion of the supporting members. Crack resistant concrete should minimize the typically observed distress in concrete pavements, including plastic and drying shrinkage cracking, corner breaks, linear (panel) cracking, and spalling, which may lead to increases in surface roughness and weakening of the slab, thus enhancing riding comfort and safety of the traveling public.

Technical importance: Materials science and engineering will be advanced through the development of new materials and methods for constructing crack resistant concrete.

Impact of expected outcomes: Billions of dollars will be saved in civil infrastructure maintenance costs.

Implementation timeline: The first two years of the project would be devoted to engineering a new crack resistant concrete followed by one year of environmental testing. Demonstration projects would be built in the fourth year with five years of evaluation.

Duration of project: Total duration of the project would be nine years, which would be done in phases. Two years for the research phase, one year for the environmental testing phase, one year for the demonstration project, and five years for the evaluation phase.

Priority (H,M,L): The project is regarded as high priority since economic development could be increased from the savings in civil infrastructure maintenance costs.

RESEARCH PROJECT DESCRIPTION
Bridges and Structures

Project Title: Advanced Technologies for Improved Planning and Execution of Bridge Inspections

Objective and outcomes: In addition to ensuring that Michigan's bridges remain safe and reliable, a key product of bridge inspections is the information needed to assign bridge ratings. Bridge rating data is used in Advanced Bridge Management Systems (ABMS) – such as Pontis – to efficiently and logically manage State of Michigan resources for bridge maintenance. The success of ABMS is dependent on the availability of appropriate rating information, which is in turn dependent on detailed and accurate bridge inspections. The overarching objective of this project is to investigate how new technology can be integrated to develop innovative inspection tools that can make the bridge inspection process safer, faster and more effective. Specific objectives for this research include:

Identify emerging technologies with the potential for improving bridge inspections. Candidate technologies include, but are not limited to, wearable computing, wireless communication, hands-free human-computer interaction, advanced visualization, bar coding, GPS, and rapid non-destructive testing techniques.
Develop a visionary scenario and schematic design for a field-deployable and scalable bridge inspection assisting system.
Resolve hardware and software issues needed to ensure successful implementation of the proposed new technology. Proposed systems should run efficiently on rugged, lightweight, wearable computers with appropriate display, input, and peripheral devices and wireless access to information, whereas developed software should automate and simplify basic bridge inspection tasks and provide for new capabilities.
Integrate the developed hardware and software components to create a working prototype of the bridge inspection assisting system.

Practical importance: Bridge inspections are inherently dangerous and the activities are performed in harsh outdoor environments while the inspectors wear bulky work clothes and gloves. Moreover, inspectors primarily use paper-based media to support and record the results of their inspection processes. As a result, inspectors in the field are limited both in terms of the material they can reference for planning, and in the tools they can use to capture the location and extent of damage/defects found on bridge elements and components. The new technology developed as a result of this project will allow inspectors to fully exploit recent technological advances to make their job faster, safer and more effective.

Technical importance: Even though significant investments have been made in creating and deploying backend ABMS, very little improvement has taken place in the methodology by which inspections themselves are performed in the field. This research will dramatically improve the inspection process, in particular, making it more accurate. Improved inspection processes will ensure that the data used to feed ABMS is as accurate as possible, which will improve bridge management and resource allocation.

Impact of expected outcomes: The product of this research promises to significantly improve the way that bridge inspections are currently being conducted. The developed technology will allow inspectors to conduct their job in a manner that is faster, safer and more effective. The improved inspection process will enhance the accuracy of bridge inspection data, which is used as input to bridge management and resource allocation tools. This will ensure that the State of Michigan uses its resources in the most appropriate and cost-effective manner.

Implementation timeline: The project will be conducted in 4 phases, each addressing one of the project objectives. Following is an estimate required for each of these phases.

Phase I: Survey literature and identify promising technologies: *6 months*
Phase II: Propose a field-deployable system: *6 months*
Phase III: Resolve hardware and software issues: *18 months*

Phase IV: Create working prototype: *6 months*.
Duration of project: 3 years
Priority (H,M,L): H

RESEARCH PROJECT DESCRIPTION FORM
Bridges and Structures

Project Title: Precast elements and systems for rapid construction
Objective and outcomes: Development and evaluation of all-precast bridge systems. Precast substructure elements, precast superstructures, and precast deck panels have been developed and used; however, the use of these concepts has yet to become widespread. Concrete, steel, fiber reinforced polymers, or other new materials need to be combined to form all-precast bridge system. Durability, cost, and construction time considerations must be optimized for an effective bridge system.
Practical importance: Public inconvenience and discontent with traffic disruption are the driving forces behind a rapidly constructed bridge system. The motoring public will not tolerate a lengthy construction schedule. Negative economic impact in the construction influence area is at times drastic and has forced companies out of business. A rapidly constructed bridge system can alleviate these concerns.
Technical importance: New combinations of materials could be an outcome of this project. Lightweight materials could be developed to serve the purpose of a durable construction material.
Impact of expected outcomes: Public inconvenience from traffic disruption during construction will be decreased. Negative economic impact in the construction influence area will be lessened.
Implementation timeline: Research would be completed in two years. A demonstration project would be built in the third year, followed by five years of monitoring. Additional projects using the rapid construction technique could be built in the fifth year provided the demonstration project performs satisfactorily for the initial two years.
Duration of project: Total duration of the project would be eight years, which would be done in phases. Two years for the research phase, one year for the demonstration project, and five years for the evaluation phase.
Priority (H,M,L): The project is regarded as high priority since public convenience and economic development is increased from successful implementation.

RESEARCH PROJECT DESCRIPTION FORM **Bridges and Structures**
Project Title: Design and Performance of Jointless Bridges
Objective and outcomes: This project will evaluate current strategies for eliminating bridge joints; determine the effectiveness of current details, note deficiencies, and propose improvements and alternatives to current practice.
Practical importance: Poor functioning expansion joints are a major cause of bridge deterioration. Methods of eliminating joints from bridge decks can drastically extend the life of a bridge.
Technical importance: Better understanding of structural response to fixed or partially fixed conditions (sliding backwalls, link slabs, continuous for live load etc.) will lead to more efficient, accurate, and viable designs.
Impact of expected outcomes: Improvements to current design practice will lead to reduced life cycle costs. Millions of dollars will be saved annually if deterioration from faulty expansion joints is eliminated.
Implementation timeline: The first six months of the project would be devoted to examining current practice – methods and performance. The next six months would be devoted to determining best current practices, and suggesting improvements to current methods. Based on these recommendations, trial projects would be initiated utilizing the new procedures. The project would continue with an initial evaluation, followed by five years of follow-up evaluation.
Duration of project: This would be a long term project that would be implemented in phases.
Priority (H,M,L): High

RESEARCH PROJECT DESCRIPTION
Bridges and Structures

Project Title: Scour Countermeasures

Objective and outcomes: This project will evaluate risk analysis and mitigation for scour critical bridges. The risk analysis will include an evaluation of methods for calculating scour potential and probabilities of failure. Mitigation methods, including rip rap, will be evaluated for their effectiveness.

Practical importance: This project will increase our understanding of scour and aid in prioritizing scour critical bridges so we can better utilize funding to mitigate scour.

Technical importance: Develop, or verify, analytic tools to more accurately predict scour behavior.

Impact of expected outcomes:
The results of this project will add a level of confidence and safety to the bridge network.

Implementation timeline:
Six month literature review, one year evaluation of analytical tools, scour analysis methods and review of mitigation performance. Propose mitigation methods, implement new methods and evaluate them for effectiveness and viability. Multiple year evaluation of effectiveness dependent on storm occurrence.

Duration of project: The evaluation phase of this project would necessitate a long term duration.

Priority (H,M,L): High

RESEARCH PROJECT DESCRIPTION
Bridges and Structures

Project Title: Development of self-consolidating concrete mixes and design guidelines

Objective and outcomes: The goal is to develop robust self-consolidating-concrete (SCC) mix designs and associated guidelines for their quality assurance and use in structural design. Available approaches to SCC, including different chemical admixtures, will be evaluated and strategies for robust, i.e., highly repeatable, SCC will be identified. The short- and long-term performance of different SCC mixes (including environmental effects) and the influence that different SCC mixes may have on the structural performance of bridge elements will be evaluated. The recommendations and guidelines will be based on the short- and long-term material and structural performance of SCC mixes and SCC bridge elements.

Practical importance: Concrete consolidation is a problem, especially in areas of heavy reinforcement. Self-consolidating concrete (SCC) has been shown to be technically feasible to improve the quality of concrete components with reinforcement congestion while also improving construction speed, minimizing labor, and thus potentially reducing construction cost. In spite of these advantages, wide use of SCC for bridge components has been limited primarily due to concerns on the quality control of SCC mixes and uncertainties about the short- and long-term performance of the material and components built from SCC. Adding to this challenge is that chemical admixture companies and researchers have developed multiple ways to achieve SCC, none of which are commonly accepted as standard. SCC has the potential to improve the quality of concrete elements. However, its wide use and acceptance will depend on developing material guidelines that assure repeatable high-quality SCC and structural guidelines based on the compromises made, if any, when using this new type of concrete.

Technical importance: Self-consolidating-concrete can bring considerable improvements to the quality of concrete products while also improving the efficiency of its production as well as possibly reducing cost. The availability of guidelines for reliable SCC mixes, specifications for its production and quality control, and incorporation in structural design considerations will be essential before the benefits of SCC can be widely and commonly used by bridge engineers, precast producers and contractors.

Impact of expected outcomes: SCC can be considered a type of high-performance-concrete where its flowability and stability are tailored to suit the design construction/reinforcement details. Having such control over material performance during construction/placement can significantly impact construction quality, economy, and efficient structural design. The advantages of SCC seem to indicate that most concrete in the future will feature SCC-type characteristics.

Implementation timeline: Achievement of the research project goals will likely require three to five years of work. However, it should be noted that even if the project research goals are achieved, implementation/use of the technology will depend on the attainment of relevant experience from all of those involved in bridge engineering projects, i.e., contractors, prestressed concrete producers, ready-mix companies, designers, and quality assurance engineers.

Duration of project: The project will require three to five years to complete. Phase I should focus on mix design development and their short- and long-term performance. Phase II should consider the influence of SCC mix design parameters on the structural performance of bridge elements.

Priority (H,M,L): This project is considered to have High Priority. The quality and durability of concrete elements depends to a high degree on the quality of its consolidation during casting. SCC can be a great asset to mitigate this problem while additionally improving construction speed, safety, and cost. These benefits can not be utilized until a better understanding of its behavior and more control of its production is reached.

Appendix I
Pavements and Roadways: Detailed Problem Statements

RESEARCH PROJECT DESCRIPTION **Pavements and Roadways**
Research Problem Title: Low Volume Road Rehabilitation Methods
Project Category: Pavement Maintenance and Rehabilitation
Research Objectives and Outcomes: The objective of this program is to develop pavement repair and rehabilitation methods for the low volume portion of the road system. Portions of the network that are eligible for Federal repair funds have requirements imposed that increase the cost of a project. For portions of the network where Federal funds cannot be utilized, there is a need for developing a pavement repair catalogue to ensure long term pavement performance realizing the low volume nature of the system. The final outcome of this project is to develop a RRR system for the low volume portion of the local road network.
Practical Importance: Local agencies need assistance is assessing and assigning appropriate repair methodologies to the low volume portion of the network.
Technical Importance: The project will provide the information necessary to make informed decisions on the repair of the low volume portion of the network. This will increase the benefit cost ratio of project selection and improve long term performance of the system.
Required Length of Research Project: 24 months
Impact of Expected Outcomes and Implementation Timeline: This project would have immediate impact on the local agency community. It would allow local agencies to optimize their selection of repair methodologies and to eventually optimize performance of the low volume road system.

RESEARCH PROJECT DESCRIPTION
Pavements and Roadways

Research Problem Title: Development of Field Investigative Tools to Detect Asphalt Hardening in HMA Surfaces

Project Category: Pavement Preservation

Research Objectives and Outcomes: The proposed research is aimed at developing a non-destructive diagnosis tool for detecting early signs of hardening in HMA surfaces. The specific objectives of the proposed research are: (i) To investigate the use of image analysis and possibly other non-destructive techniques to detect asphalt aging in the field prior to crack initiation. This will involve establishing relationships between asphalt hardening as measured by conventional rheologic tests and physical changes on the surface of the pavement; (ii) To develop test protocols for early detection of asphalt aging in the field. The test protocols would apply non-destructive testing techniques including high-resolution surface mapping for detailed image synthesis.

Practical Importance: This project is important for the development of a new diagnosis tool that would be very valuable for practical implementation in pavement preservation/preventive maintenance strategies, since it would alert MDOT to the aging/hardening of the asphalt surface, and possibly triggering a PM action to reseal the asphalt surface.

Technical Importance: This project is important for the development of non-destructive field tests/techniques using the latest technologies available that can be used as part of MDOT's PMS pavement surface condition monitoring activities for the purpose of detecting early signs of asphalt aging/hardening.

Required Length of Research Project: 36 months

Impact of Expected Outcomes and Implementation Timeline: (i) Possible implementation of a new NDT technique based on latest technologies for detection of asphalt aging/hardening in the context of preventive maintenance / pavement preservation strategies. (ii) Adoption of a Preventive Maintenance strategy of rejuvenating/resealing asphalt pavement surfaces in time for extending pavement life (retarding future deterioration due to asphalt aging/hardening).

RESEARCH PROJECT DESCRIPTION
Pavements and Roadways

Research Problem Title: Safety Integration with State Pavement Preservation Practices

Project Category: As the highway infrastructure focus shifts from new construction and major rehabilitation to preservation, existing pavement surface characteristics are becoming more important. Despite the increasing use of preservation treatments on pavement sections in good structural condition, many state highway agencies still have no standards or specifications for the improved functional performance of their pavements. They determine functional performance by how well the pavement serves the user. Until now, riding comfort – a concept developed in 1957 – has been the dominant concern. Today, there is a greater need to improve other important functional surface characteristics of pavements. Specific needs include:

Identification of user concerns such as safety, pavement condition, and traffic flow as functional parameters important to the motoring public.

Establishment of relationships between the functional parameters and pavement physical characteristics such as texture and friction.

Derivation of cost-effective ways to measure pavement characteristics.

Development of practical, model standards or guidelines for defining desirable ranges of important parameters.

Development of performance measures to assess potential benefits to be derived from improving pavement physical characteristics such as texture and friction.

Research Objectives and Outcomes: This proposed study has the following objectives related to pavement surface characteristics:

To Increase Pavement Durability: As durability affects all other pavement characteristics, better workmanship and materials will be needed.

To Reduce Crashes: Establish a goal to reduce the number of highway crashes due to sub-standard pavement characteristics, especially in highway work zones and transition areas. Evidence shows high friction / texture significantly reduces fatalities / injuries related to skidding or sliding.

To Improve Marking Visibility: Improve visibility of pavement markings, especially at night and in wet conditions.

To Reduce Highway Noise: Reduce ambient highway noise from improved texturing to mitigate tire-surface interaction.

To Improve Surface Appearance: Improve pavement surface appearance. Specifications should not encourage corrections resulting in poor appearance or differential friction within lanes leading to crashes.

Tasks and Deliverables:

Tasks

1. Literature Search

The literature search would use printed and electronic sources to assemble information related to pavement texture, friction characteristics, and noise. It is important to be aware of work already under way or complete in these areas to avoid duplication and build on existing knowledge.

2. Physical and Functional Relationships

This task would consist of research to investigate the underlying relationships between pavement surface characteristics and the functional parameters important to highway users. An important work product would be the identification of optimal pavement surface patterns.

3. National Model Guidelines

This task would be used to develop national model guidelines or standards for pavement surface conditions.

Proposed Deliverables

Deliverables include:

A report describing relationships between pavement surface characteristics and functional parameters such as

safety and durability,
Model specifications covering
- Desirable ranges of pavement surface condition
- Grinding / repairing pavement irregularities to prevent damage from truck dynamic loadings,

Macro-textures to reduce splash, spray, and hydroplaning, and
Micro-textures to increase friction at low and high speeds.

Practical Importance: Sponsor benefits include the following:
Identification of pavement surface characteristics that
Promote durability
Reduce crashes
Reduce tire noise
Improve visibility of pavement markings
Improve pavement appearance
Ability to measure functional outcomes of pavement surface improvements
Substantiation of improvements to safety and to surface durability – two of the major concerns of highway users. The Federal Highway Administration's emphasis on pavement preservation also should lead to improved surface durability and should minimize the amount of routine or reactive maintenance of pavement surfaces.

Technical Importance: In the past, the major emphasis in the pavement area was on structural design – project specifications addressed the issues of material quality. Today, material properties are being tied directly to structural design and distresses. However, the very surface characteristics that contribute to good functional performance are often ignored until problems become evident.

In 1996, a national survey of highway users showed safety as their primary concern, followed by pavement condition and traffic flow. A follow-up survey conducted in 2000 showed the same three concerns, but traffic flow had risen to the top. The study also discovered overall increases in dissatisfaction with safety and pavement condition, two areas amenable to engineering solutions.

The results of these surveys indicate a need for greater consideration of the functional characteristics of pavements. Safety-related concerns include pavement markings, wet- weather friction, and expedited crash removal. Pavements need more durable surfaces, smoother and quieter riding characteristics, and better surface appearance. Durability is a key pavement characteristic that can be tracked by means of distress surveys. Lack of distress is a general indication of durability.

Ironically, the current staff reductions being experienced at many highway agencies and the increased use of warranties and performance-related specifications can help insure more durable pavement surfaces for highway users.

While pavement texture and friction can serve as warnings, texture has often been overlooked in pavement specifications. In fact, many agencies have no texture or friction requirements for asphalt pavements. The few states that have guidelines typically address the minimum rather than the desirable values.

Other concerns of highway users include work zone safety which is understandable considering that in 2002, 1,083 highway workers and users were killed in work zone crashes. In addition, the Federal Highway Administration reports that more than 40,000 persons are injured each year as a result of motor vehicle crashes in work zones. Unfortunately, the average motorist may assume that highway construction workers are at most risk in work zones, but 85 percent of fatalities in such zones are vehicle drivers or occupants. Undoubtedly, some of these crashes could have been avoided or reduced in severity by improved pavement surface texture and friction characteristics within the work zones. Until now, most emphasis has been on wet weather crashes, but up to 86 percent of all crashes occur in dry conditions. There has been a tendency to assume that friction in dry conditions is generally adequate, which may not always be true. Improved pavement texture can also be used to reduce noise.

Some highway agencies have already begun to look seriously at pavement texture characteristics. For example, the Arizona Department of Transportation has one of the most comprehensive studies under way to evaluate pavement texture characteristics – both friction and noise – on representative surface types in approximately 200

pavement test sections. A goal is to develop ranges of texture – and the resulting friction and noise levels – for a variety of preservation treatments. Additionally, both the Arizona and California Departments of Transportation are pursuing quieter pavement surfaces to reduce noise at the source.

Required Length Project: 36 months

Impact of Expected Outcomes and Implementation Timeline:
The following agencies and organizations are interested in this subject and will be expected to implement its recommendations.
American Association of State Highway and Transportation Officials
Federal Highway Administration
State Highway Agencies
County Road Agencies
Municipal Public Works Departments

RESEARCH PROJECT DESCRIPTION
Pavements and Roadways

Research Problem Title: Impact of Contract Warranty on Life Cycle Cost (LCC) and Road Performance.

Project Category: Vehicle/Pavement Interaction

Research Objectives and Outcomes: The purpose of this proposed research is to review various components of road warranty projects. In this effort, various attributes of materials, workmanship and performance warranties will be identified along with their similarities and differences. Tangible and intangible benefits and cost of warranties will be determined to quantify their effectiveness.
The proposed research will make an attempt to quantify various components of warranty.
This will include but is not limited to

Data requirements (existing as well as additional) and responsibilities.
Identification of cost and benefits warranty jobs by type such as materials, workmanship and performance.
Examination of trade-off cost and effectiveness
Surety bond and its impact on contactors pool

Practical Importance: A preliminary review of USDOT data indicated that warranty related projects cost more than the non-warranty projects. This research will explore the relationship between added cost and improved quality/performance (benefits).

Technical Importance: The science behind the warranty concept is not very well defined. Value engineering of surety bond has not identified thoroughly. Cost-benefits related to different types of warranty need to be quantified.

Required Length of Research Project: 24 months

RESEARCH PROJECT DESCRIPTION
Pavements and Roadways

Project Title: Crack resistant concrete for bridge decks and pavements

Objective and outcomes: Develop concretes highly resistant to cracking for bridge deck and pavement applications, while maintaining all desirable properties of normal concrete. Methods and materials will be developed to minimize concrete cracking, and therefore reduce the transport of aggressive agents or moisture infiltration into concrete bridge decks and pavement slabs. Emphasis is placed on durability of concrete in bridge deck and pavement slab structures that experience combined traffic and climatic loadings, and are often under restrained conditions.

Practical importance: Elimination of concrete deck and pavement cracking will prolong service life of of the structure itself, along with increasing the life of supporting members. Concrete cracking allows direct penetration of chlorides, leading to localize corrosion even when corrosion resistant reinforcement and corrosion resistant coatings are used. In the case of bridge decks, corrosion of steel reinforcements can lead to reduction in section strength. Chlorides leaking through cracks directly on supporting members causes corrosion of the supporting members. Crack resistant concrete should minimize the typically observed distress in concrete pavements, including plastic and drying shrinkage cracking, corner breaks, , linear (panel) cracking, and spalling, which may lead to increases in surface roughness and weakening of the slab, thus enhancing riding comfort and safety of the traveling public.

Technical importance: Materials science and engineering will be advanced through the development of new materials and methods for constructing crack resistant concrete.

Impact of expected outcomes: Billions of dollars will be saved in civil infrastructure maintenance costs.

Implementation timeline: The first two years of the project would be devoted to engineering a new crack resistant concrete followed by one year of environmental testing. Demonstration projects would be built in the fourth year with five years of evaluation.

Duration of project: Total duration of the project would be nine years, which would be done in phases. Two years for the research phase, one year for the environmental testing phase, one year for the demonstration project, and five years for the evaluation phase.

RESEARCH PROJECT DESCRIPTION
Pavements and Roadways

Research Problem Title: Local Agency Specification Interpretation

Project Category: Specifications

Research Objectives and Outcomes: The objective of this program is to provide local agencies with guidance on the use of standard and special provision specifications developed by the MDOT. Local agencies do not always have the resources to investigate the use of new materials or know the pitfalls of utilizing new specifications. The outcome of the project would be a working document that would be updated as new specifications are developed and new information on the use of the specification is obtained through project information.

Practical Importance: Local agencies work with very limited budgets knowing the best materials or procedures to use on the low volume road network would be very helpful

Technical Importance: The project will provide local agencies with the knowledge to make informed decisions on material use.

Required Length of Research Project: Initial project length 18 months annual updates 2 to 4

Impact of Expected Outcomes and Implementation Timeline: This project would have immediate impact on the local agency community. It would reduce the misuse of materials and eventually allow local agencies to optimize their selection of processes and materials to optimize performance of the low volume road system.

Prioritization:

RESEARCH PROJECT DESCRIPTION
Pavements and Roadways

Research Problem Title: Real time quality

Project Category: HMA quality control

Research Objectives and Outcomes: The purpose of this research would be to assemble equipment that could be used to test HMA mixes "on the run" for all the parameters that are important to verifying that the mix being furnished meets the approved mix design.
METHODS-Obtain equipment that can be used to sample, measure asphalt content, aggregate gradation, temperature, and the mix design values for VMA, VF A and Air Voids.

Practical Importance: Much of this equipment is commercially available. This would provide one set of test results that could be used by both the Agency and the contractor. This would provide an instant check on the quality of the mix, rather that wait for results that may be available after many tons of mix have been placed. As long as the equipment performs as it should there would be no basis for any dispute on the mix quality.

Technical Importance: See above

Required Length of Research Project: 24 months

Impact of Expected Outcomes and Implementation Timeline: This research could provide "on the run" results that could be mutually acceptable to the Agency and the Contractor. Implementation would probably require many demonstrations around the country to develop a confidence level for the desired results.

RESEARCH PROJECT DESCRIPTION
Pavements and Roadways

Research Problem Title: Warm Mix

Project Category: Plant Production

Research Objectives and Outcomes: European Agencies are starting to use products that can reduce mixing temperatures by 50-75 degrees. This is their attempt to reduce "green house gases". It is desirable for many reasons to be able to produce asphalt mixtures at lower temperatures. METHODS-There are several products being used in Europe. We need to do research on these products in the laboratory and in the field to determine their effect on mix design, plant production and constructability. Also we need to determine if these products operate differently with different aggregate sources.

Practical Importance: Every 25 degree rise in mix temperature doubles the emissions from the asphalt mix. To be able to drop the mix temperature by 50 degrees would be very significant. With many areas of the country being in non-compliance with PM 2.5 regulations, any method to reduce emissions is helpful. European research has indicated that compaction can be achieved at lower air temperatures. If this is correct, we could extend the paving season with no adverse affects.

Technical Importance: See above

Required Length of Research Project: 24 months

Impact of Expected Outcomes and Implementation Timeline: There are many environmental pluses to be able to produce asphalt mixes at lower temperatures and it is expected that the EPA and others would push for the implementation of this type of mix. It is our goal to demonstrate that the methods will produce high quality, constructible mixtures.

RESEARCH PROJECT DESCRIPTION
Pavements and Roadways

Research Problem Title: Non-Density Methods for Embankment Acceptance

Project Category: Soils and Drainage

Research Objectives and Outcomes: Review strength or stiffness based methods for accepting embankment construction. Review the cost effectiveness of these methods. If cost effective, recommend methods for MDOT to adopt, and develop a process to implement these methods.

Practical Importance: Density is an easy and practical material property to measure, but it has no direct correlation with a material's strength. (As an extreme example, frozen and thawed soil may have nearly the same density, but vastly different strengths.) Yet density is the primary property that is used to determine acceptable embankment construction at MDOT. Investigations with falling weight deflectometers and other equipment have shown that embankments built to density specifications can provide a widely varying amount of support to pavements placed upon them. Numerous non-density based acceptance criteria are being used or experimented with word wide. These include deflection and vibration based methods that measure soil stiffness. Some methods use stand-alone test equipment while others use instrumented construction compaction equipment. Adopting some of these newer methods and moving away from the use of density based acceptance criteria could provide significant cost savings.

Technical Importance: The primary goal of earthwork compaction is to provide a uniform support to the pavement or structure being supported by the earth. Uniform support is easier to achieve if the methods used for construction acceptance correlate well with strength. Deflection and vibration based acceptance methods correlate much better with strength than do density methods.

Required Length of Research Project: Probably 36 months. Could be phased.

Impact of Expected Outcomes and Implementation Timeline: Two benefits could occur from a possible change in methods used to accept embankment construction. First, a more uniform support would likely be provided, resulting in longer, more predictable pavement life. Second, deflection or vibration based testing methods have the potential to speed construction buy eliminating over compaction of many areas within an embankment. This could result in substantial costs savings during construction.

Phasing out density acceptance methods would need to be a gradual process, only started once contractors and construction inspectors had a good understanding and comfort level with new methods.

RESEARCH PROJECT DESCRIPTION
Pavements and Roadways

Research Problem Title: Real-Time Smoothness Field Trails*

Project Category: Pavement smoothness

Research Objectives and Outcomes: The goal of this project is to demonstrate the use of real-time profiling technology in the paving process.

Methods: This research will evaluate equipment and methods to measure profile being produced. This evaluation should be done at the slipform paver and by each of the various pieces of paving equipment and processes used from the deposit of the pavement concrete to the completion of the curing operation.

The project will demonstrate commercial real-time profilers on active paving projects. The demonstration should include the following: (1) a comparison of the existing commercial systems to each other, (2) an assessment of the accuracy of the measured profiles, (3) documentation of roughness detected in real time that may have assisted the paving crew, (4) measurement of smoothness at various stages of the process, and (5) assessment of the feasibility of using an expert system to convert profile data into warnings to the paving crew in English.

Practical Importance: This project will produce multiple products. First, the project will produce estimates of the consequences to smoothness of various stages of the paving process. Second, the project will provide an assessment of the accuracy and relevance of the measurements provided by commercial real-time smoothness measurement devices. Third, the project will provide recommendations for the most useful method of reporting smoothness as feedback to a paving crew.

Technical Importance: see above

Required Length of Research Project: 12 months (This should be planned over the winter, with all experiments conducted in the following paving season.)

Impact of Expected Outcomes and Implementation Timeline: A similar project in Iowa quantified: (1) the impact of hand finishing, (2) the impact of a string line breakage, and (3) the impact of dowel basket ripple on smoothness of the hardened concrete. The project should provide the same type of quantitative information about how various aspects of the construction process affect the smoothness of the final product, and may cover aspects that the original work did not. This will provide a basis for weighing the cost of construction process improvements against the potential benefits to smoothness. The information which is produced should be circulated in a research brief before letting for the next construction season begins.

RESEARCH PROJECT DESCRIPTION
Pavements and Roadways

Research Problem Title: SUPERPAVE for Local Roads

Project Category: HMA mix design

Research Objectives and Outcomes: The purpose of this project is to develop procedures to adapt SUPERP AVE mix design requirements for local roads. This would include the proper mix design criteria including gyrations, VMA, VF A and air voids. One goal is develop aggregate criteria that would allow for the use of local aggregates without sacrificing performance. METHODS-It would be the object of laboratory testing to develop mix designs using aggregate from various areas of the State that would utilize SUPERP A VE design methods modified to suit local conditions. Field demonstrations should be utilized to verify performance.

Practical Importance: This would place all mix designs on the same basis for equipment and methods. The Marshall equipment and procedures would not be utilized. This would simplify training and quality control.

Technical Importance: See above

Required Length of Research Project: 24 months

Impact of Expected Outcomes and Implementation Timeline: This would place all agencies involved in mix designs on the same basis. It would simplify the mix design and quality control for the contractors. The timeline would be very short, as we could shift quickly to the modified procedures.

RESEARCH PROJECT DESCRIPTION
Pavements and Roadways

Research Problem Title: Evaluating the Readiness of MDOT Pavement Management Data for the New Pavement Design Guide (NCHRP 1-37A) – Flexible Pavements

Project Category: Flexible Pavement Design

Research Objectives and Outcomes: The applicability and usefulness of the "new" pavement design guide can be determined by comparing actual performance data from in-service pavements and data from the pavement design guide predictions. However, before such predictions can be made it is necessary to take inventory of all the information that is available (and not available) in the MDOT pavement management database. This inventory will provide guidance with respect to inputs that are readily available from the MDOT database and will identify inputs that are not directly available from the database. The product(s) form this study can be used in future phases with a goal that a database can be used to validate and calibrate the new design guide (for Michigan conditions) within parameter limits.

The objective of this project is to demonstrate to MDOT the readiness of the pavement management database for the New Pavement Design Guide (NCHRP 1-37A). Based on the findings of this 24 month study provide recommendations for data to be collected at various levels for the design of new flexible pavements and design of rehabilitation strategies.

Practical Importance: The importance of this project is four fold (i) develop an inventory of parameters used in the current pavement design and identify additional parameters needed for the New Pavement Design Guide; (ii) develop an inventory of the various pavement performance parameters listed in the current pavement management database, the data elements not found in the pavement management database will be flagged and alternative sources will be investigated; (iii) to make recommendations for data to be collected at various levels and identify sensitive data elements used for each type of input, the framework used to collect the elements critical to the calibration and validation; (iv) Develop technology transfer material for a pilot workshop based on the information learned from the research and demonstrate to the various pavement professionals from the regions on the synergy between pavement management data and design.

Technical Importance: This study will recommend data elements required to calibrate the performance models in the new design guide to reflect Michigan conditions.

Required Length of Research Project: 24 months

Impact of Expected Outcomes and Implementation Timeline: The calibrated performance models will assist in determining the timing of pavement preservation techniques.

RESEARCH PROJECT DESCRIPTION
Pavements and Roadways

Research Problem Title: Evaluating the Readiness of MDOT Pavement Management Data for the New Pavement Design Guide (NCHRP 1-37A)-Rigid Pavements

Project Category: Rigid Pavement Design

Research Objectives and Outcomes: The applicability and usefulness of the "new" pavement design guide can be determined by comparing actual performance data from in-service pavements and data from the pavement design guide predictions. However, before such predictions can be made it is necessary to take inventory of all the information that is available (and not available) in the MDOT pavement management database. This inventory will provide guidance with respect to inputs that are readily available from the MDOT database and will identify inputs that are not directly available from the database. The product(s) form this study can be used in future phases with a goal that a database can be used to validate and calibrate the new design guide (for Michigan conditions) within parameter limits.

The objective of this project is to demonstrate to MDOT the readiness of the pavement management database for the New Pavement Design Guide (NCHRP 1-37A). Based on the findings of this study provide recommendations for data to be collected at various levels for the design of new jointed concrete pavements and design of rehabilitation strategies.

Practical Importance: The importance of this project is four fold (i) develop an inventory of parameters used in the current pavement design and identify additional parameters needed for the New Pavement Design Guide; (ii) develop an inventory of the various pavement performance parameters listed in the current pavement management database, the data elements not found in the pavement management database will be flagged and alternative sources will be investigated; (iii) to make recommendations for data to be collected at various levels and identify sensitive data elements used for each type of input, the framework used to collect the elements critical to the calibration and validation; (iv) Develop technology transfer material for a pilot workshop based on the information learned from the research and demonstrate to the various pavement professionals from the regions on the synergy between pavement management data and design.

Technical Importance: This study will recommend data elements required to calibrate the performance models in the new design guide to reflect Michigan conditions.

Required Length of Research Project: 24 months

Impact of Expected Outcomes and Implementation Timeline: The calibrated performance models will assist in determining the timing of pavement preservation techniques.

RESEARCH PROJECT DESCRIPTION
Pavements and Roadways

Research Problem Title: Development of a Remaining Service Life for Pavement Smoothness and Ride Quality

Project Category: Pavement Management – Pavement Preservation

Research Objectives and Outcomes: The Michigan DOT uses different measures of pavement performance in managing its pavement network including: (1) the *Distress Index*, DI, which is a measure of the extent of surface distress; (2) the *Ride Quality Index*, RQI, and the International Roughness Index, IRI, which are a measure of surface roughness and ride quality. At present, only the DI is used to determine the *Remaining Service Life* (RSL) of a pavement, and (3) rut depth for flexible pavements. The RSL is defined as the number of years left to reach the threshold DI-value (equal to 50). The calculation of RSL is based on the DI prediction model developed by MDOT, which uses a logistic function with age as its independent variable. MDOT also uses a roughness threshold (RQI=70) for triggering corrective maintenance or rehabilitation action to restore ride quality (serviceability). However, at present there is no capability to predict the number of years left to reach the threshold RQI or IRI-value. This is so because MDOT does not have a model for predicting RQI or IRI growth with time. Such a model would enable MDOT to predict future RQI or IRI-values given a current RQI or IRI or trace of past RQI or IRI-values. The RSL for pavement smoothness and ride quality would be the number of years needed to reach the RQI or IRI threshold-value. This would enable MDOT to plan roughness-related PMS actions a number of years prior to the pavement reaching the RQI or IRI threshold-value. The objective of this research is to develop a new RQI and/or IRI growth model that can be used to determine the RSL of a pavement section based on pavement smoothness and/or ride quality.

Practical Importance: The importance of this project is three fold (i) develop a roughness model that is consistent with observed performance of Michigan pavements; (ii) use the model as PMS tool to predict future RQI or IRI-values given a current RQI or IRI or trace of past RQI or IRI-values; (iii) enable MDOT to plan roughness-related PMS actions a number of years prior to the pavement reaching the RQI or IRI threshold-value.

Technical Importance: This study will recommend a new RQI and/or IRI growth model that can be used to determine the RSL of a pavement section based on pavement smoothness and/or ride quality. This model will reflect Michigan conditions, since MDOT PMS data will be used for its development.

Required Length of Research Project: 18 to 24 months

Impact of Expected Outcomes and Implementation Timeline: The new roughness-based RSL model would be used for both pavement management and preventive maintenance purposes.

RESEARCH PROJECT DESCRIPTION
Pavements and Roadways

Research Problem Title: Optimization of Mechanical Load Transfer Devices for Transverse Joints in Jointed Plain Concrete Pavements (JPCP)

Project Category: Rigid Pavement Design

Research Objectives and Outcomes: MDOT specifies the use of dowel bars across contraction joints in concrete pavement slabs thicker than 150 mm (6 in.). The dowel bars are required to provide structural continuity across the joint and to minimize slab deflections at the joints. The current practice for pavement joint design recommends the use of solid circular steel dowel bars with diameter ranging from 32-38 mm (1.25-1.50 in.), spacing up to 305 mm (12 in.) on center, and dowel length equal to 458 mm (18 in.) with 229 mm (9 in.) embedded on either side of the joint. However, the impact of dowel bars placed outside the wheel paths on critical pavement response is still unclear. Moreover, recent European research suggests that shorter dowels maybe as effective as long dowel bars. Other European studies have also suggested that smaller diameter dowel placed more closely together (e.g. at 10" on center) may result in improved pavement performance and reduced cost.

In addition to investigating alternative dowel bar layout several studies are underway investigating alternative dowel bar materials, these include, fiber glass dowel, solid stainless steel bars, concrete filled stainless steel tubes and a variety of dowel bars with a corrosion resistant covering. The primary objective of all these studies is to improve joint performance within the economic constraints.

The objectives of this are to (i) characterize and model the theoretical behavior of these alternative dowels and include these models in the new M-E design guide; (ii) study the load transfer characteristics of these alternative dowel bars under accelerated traffic and environmental loads; (iii) evaluate the performance of the alternative dowel bars under "in-service" pavement conditions; and (iv) calibrate the theoretical models using the laboratory and field data.

Practical Importance: The benefits of this study will include cost effective, reliable and durable load transfer devices for long life concrete pavement joints. .

Technical Importance: The successful completion of this project will result in recommendations and guidelines for mechanical load transfer devices for LTE of joints, calibrated models that can be included in the new M-E Design Guide for Pavements

Required Length of Research Project: 36 months

Impact of Expected Outcomes and Implementation Timeline: The calibrated joint design models will be included in the new design guide.

RESEARCH PROJECT DESCRIPTION
Pavements and Roadways

Research Problem Title: Micro Piles or Other Deep Foundations for Roadway Embankments

Project Category: Soils and Drainage

Research Objectives and Outcomes: Determine the cost effectiveness of using micro piles or other deep foundation solutions for supporting roadway embankments. Identify typical site situations where deep foundation options may be cost effective for providing embankment support.

Practical Importance: MDOT has typically removed and replaced soils that are not capable of supporting roadway embankments for major trunkline roads. Many local highway agencies often try to "float" lower traffic volume roadway embankments over weak soils. Removal and replacement can be a very expensive treatment and "floating" embankments over weak soils usually results in pavement settlement over time. However these two methods have traditionally been the most cost effective treatments available for the class of roadway being built. Technical advancements and increased usage of deep foundation methods, such as micro piles, may have impacted costs enough that deep foundation methods may be cost effective to construct for supporting roadway embankments.

Technical Importance: It is desirable to review methods typically utilized in structure foundations to determine if they economically justified for expanded use in embankment support.

Required Length of Research Project: 18 months

Impact of Expected Outcomes and Implementation Timeline: Potential for significantly lowering embankment construction costs. Recommendations could be implemented within months of reporting, if suitable projects exist.

RESEARCH PROJECT DESCRIPTION
Pavements and Roadways

Research Problem Title: Effectiveness of Pavement Drainage Systems

Project Category: Soils and Drainage

Research Objectives and Outcomes: Determine the effectiveness of pavement under drains as currently constructed. Determine design details, specification thresholds, and inspection methods needed to ensure that durable, functional under drain systems are installed. Quantify the types and amount of maintenance that under drain systems will need over their lifetime.

Practical Importance: Investigations have shown that under drain systems, as currently designed and constructed, are often improperly installed and are susceptible to damage during subsequent construction activities. Given the fact that under drains are buried, damage or improper installation is often difficult to observe and correct. In addition, physical damage, such as slightly crushed pipe, may visually look bad, but might not have a significant effect on the overall performance and life of the drainage system. By determining practical specification limits for under drains, road authorities can be reasonably assured of the long term performance of their under drains.

Technical Importance: Pavement designers assume that when an under drain system is installed, it will uniformly and consistently drain the pavement for its entire life. Investigations have shown this not to be the case. The true cost of providing an effective under drain system needs to be determined. This will allow the pavement designer to decide of under drains should be utilized of if other design methods may be more cost effective.

Required Length of Research Project: 24 months

Impact of Expected Outcomes and Implementation Timeline: Better performing pavements and more cost effective designs. Design and construction recommendations could be implemented within months of reporting and maintenance recommendations could be implemented within one or two years.

RESEARCH PROJECT DESCRIPTION
Pavements and Roadways

Research Problem Title: Early-Age Behavior Jointed Concrete

Project Category: PAVEMENT SMOOTHNESS

Research Objectives and Outcomes: The purpose of this project is to study the effect of early-age behavior on the long-term performance of jointed concrete.

Methods: This project will be mostly experimental. Detailed measurements of maturity, temperature profile, weather, joint behavior, and surface profile will be collected on selected pavement projects. It is recommended that these measurements are performed frequently. For example, measurements could be done with the frequency of one per hour for a day or two, four times per day for a week, etc. As the results reveal the pace of changes in smoothness or joint behavior, the measurements can be scheduled (less frequently) to capture the relevant behavior. However, diurnal and seasonal changes are anticipated. The appearance of cracks at the joints is of particular interest, and an important observation may be the long-term performance of the joints that produce a crack before the others around it.

Practical Importance: This project will produce a link between early-age pavement behavior and long-term performance. It is expected that the knowledge from this project may produce a methodology for optimizing concrete curing methods without the need for long-term observations.

Technical Importance: If the paving projects are carefully selected, this measurement effort can serve as a platform for studying critical design and construction variables. Of course, the results may only have regional implications.

Required Length of Research Project: 12 months for set-up, 36 months for monitoring

Impact of Expected Outcomes and Implementation Timeline: This project should produce improved design guidelines by including empirical observations of performance with regional relevance. The project should also produce local guidelines for curing methods and construction timing, should the projects under study be selected properly. The most important findings with regards to curing should be available in draft form within 18 months. Other findings will require long-term (at least 36 months) monitoring to develop.

RESEARCH PROJECT DESCRIPTION
Pavements and Roadways

Research Problem Title: Pavement Distress as a Result of Lift Axle Usage

Project Category: Vehicle/Pavement Interaction

Research Objectives and Outcomes: In Michigan, maximum vehicle loads are restricted by the Michigan Vehicle Code on the basis of axle weight. Pavements are also designed on the basis of axle weight. When a vehicle is equipped with lift axles, the driver has the ability to lift one set of axles in order to increase vehicle maneuverability. This is most often done when a multi-axle vehicle is turning a corner at an intersection. When the lift axle is raised, additional weight is transferred to the remaining axles.
The recommended research would determine the amount of additional stress and the potential damage to the pavement. It would also review newer technologies, such as steerable axles, to determine if use of them would provide the desired maneuverability without overstressing the pavement.

Practical Importance: Significant pavement damage may result from vehicles traveling at axle weights above the legal maximum.

Technical Importance: Understanding the stresses associated with this issue may provide insight into better pavement design strategies, particularly at intersections.

Required Length of Research Project: Unknown

Impact of Expected Outcomes and Implementation Timeline: Implementation of the results of this study would be in the form of new guidelines for truck maneuvering and possibly new truck weight and dimension regulations.

RESEARCH PROJECT DESCRIPTION
Pavements and Roadways

Research Problem Title: How Quiet is Quiet Enough?

Project Category: Pavement texture and traffic noise

Research Objectives and Outcomes:
The purpose of this research is to define goals for tire/pavement noise levels that are needed to sufficiently satisfy the public. This study may involve a survey of the roadside noise and occupational health literature, a limited focus group, and a study of existing noise abatement thresholds and procedures.
Threshold noise levels will be defined in light of the public's perception of noise at the roadside, as well as the noise caused by other mechanisms that may overshadow tire/pavement noise. It is expected that separate threshold values of roadside noise may be established for each class of surrounding land usage. Further, the level of noise generated at a tire that may be tolerated for a single vehicle may depend on the expected traffic density for a given road segment.

Practical Importance: Noise regulations are not necessarily uniform from one agency to the next. Further, intervention for noise abatement is often the result of politics, rather than objective measurements and procedures. Research is needed to identify public goals in pass-by noise, potential for interior noise, and noise generated at the tire. (Note that noise generated at the tire may be considered the least relevant, because it is not a direct measurement of what a person may hear. On the other hand, it may have strong relevance to both interior and pass-by noise.) Close proximity noise also includes a shorter list of mechanisms. It may, therefore, constitute a good benchmark and help systematic study .

Technical Importance: This study will recommend context-sensitive goals for interior, close-proximity, and pass by noise levels.

Required Length of Research Project: 18 months

Impact of Expected Outcomes and Implementation Timeline: These target values will serve as the basis for weighing the potential benefits of improving a pavement's noise characteristics against the cost, and will help ground the work that is done to eliminate noise in an absolute scale.

RESEARCH PROJECT DESCRIPTION
Pavements and Roadways

Research Problem Title: How Smooth is Smooth Enough?*

Project Category: Pavement smoothness

Research Objectives and Outcomes: The purpose of this project is to identify the new pavement smoothness level needed to (1) satisfy the public and (2) sufficiently reduce truck dynamic loading.
User Perception: The IRI has served as the most common general pavement ride quality indicator for two decades. Although it has well-established relevance to vehicle dynamic response, it was developed on roads that were extremely rough. The ability of the IRI scale to distinguish between subtle differences in smooth road, therefore, has never been established. *Truck Dynamic Loading*: The relationship between truck dynamic loading and road roughness for rougher roads has been well documented (Ervin 1983; Sweatman 1983; Gillespie 1993; Cebon 1993). However, little information has been reported about the dynamic loading imposed by trucks on very smooth pavement. Frictional behavior of truck suspension springs causes them to appear stiffer when the deflections are small (Sayers 1982; Fancher 1980). This means that as the road gets smoother, the severity of truck dynamic loading will diminish more and more slowly. The point of diminishing marginal returns has never been reported–in part, because it has never been investigated, and in part, because of disagreement in the most appropriate way to translate truck dynamic loading into usage of pavement life (Cebon 1989). **Methods**: *User Perception*: It is recommended surveys of user perception of ride quality be conducted. These surveys should seek to establish threshold for user satisfaction with new roads. The study should focus on setting IRI thresholds. However, the data collection must include longitudinal profile. At some level of smoothness, the IRI will no longer explain the differences in user perception of a road. The profiles will be needed to discover what aspects of the pavement surface shape contribute to user perception beyond the IRI. Further, selection of pavements for the study must include some groups of roads that have the same overall IRI level, but have (1) long-wavelength content, (2) chatter, and (3) localized features as their primary sources of roughness. Differences in noise level between pavements within the study are expected to confound the results. It is therefore suggested that standard noise measurements be made on all test pavements. *Truck Dynamic Loading*: An initial simulation phase of this study is recommended. Truck dynamic loading by a population of common vehicles should be simulated over progressively smoother roads. The change in pavement life should be estimated with the most common pavement damage laws. It is expected that this exercise will reveal the point of diminishing marginal returns for smoothness. The effect of variations in the pavement damage criteria on the results should be investigated.

Practical Importance: to identify the new pavement smoothness level needed to (1) satisfy the public and (2) sufficiently reduce truck dynamic loading.

Technical Importance: to identify the new pavement smoothness level needed to (1) satisfy the public and (2) sufficiently reduce truck dynamic loading

Required Length of Research Project: 24 months

Impact of Expected Outcomes and Implementation Timeline: The project should produce the basis for smoothness targets that will ensure user satisfaction and mitigation of truck dynamics loading. It is likely that the targets will be expressed in terms of cost functions, rather than as hard limits. However, this may still serve as the justification for progressive smoothness incentive schedules.

RESEARCH PROJECT DESCRIPTION
Pavements and Roadways

Research Problem Title: The Use of In-Situ Field Test Data to Validate the New Dynamic Load Roughness Index

Project Category: Truck-Pavement Interaction; Pavement Management and Pavement Preservation

Research Objectives and Outcomes: The objective of the proposed research study is to validate results from the MDOT/MSU PRCE study No. 99-2-1, entitled "Development of Roughness Threshold d for the Preventive Maintenance of Pavements using Dynamic Load and Pavement Damage Considerations". This would be done using field data from instrumented trucks and pavements in National Pool Study 2(203). The validation involves: (i) Verification of the newly developed Dynamic Load Index (DLI) using measure pavement profiles and dynamic wheel loads; (ii) Verification of the roughness thresholds established in MDOT Project No. 99-2-1 using detailed measured distress and roughness data from accelerated pavement tests. The proposed research will use test data obtained from the SHRP Test Road 23, US-33, State Route 2, and US-50 in Ohio. The data include measured truck wheel loads, pavement strain and surface deflection under moving trucks with various axle configurations. In addition, the pooled fund study may have available additional data from other accelerated pavement tests including MnRoad, Westrack and other APT facilities. The field data from the pool study is uniquely useful to MDOT since it would allow the field validation of results from PRCE study No. 99-2-1.

Practical Importance: This project is important for the implementation of the results from MDOT Project No. 99-2-1. Without field validation of the DLI index using measured profile and axle load data from accelerated pavements tests, it would be hard to include the DLI in the MDOT PMS system for use in pavement management and preservation strategies.

Technical Importance: This study will validate the Dynamic Load Index for the purpose of using the new index in the context of pavement management and preservation strategies. Once the relationship between the DLI index and truck loads generated by roughness events is verified for pavement management purposes, the new index could be included in the MDOT PMS system a roughness/profile based index that can be used to identify pavement sections that are vulnerable for accelerated distress/damage growth caused by higher dynamic truck loads.

Required Length of Research Project: 24 months

Impact of Expected Outcomes and Implementation Timeline: (i) Possible implementation of a new Preventive Maintenance strategy of smoothening pavements in time for extending pavement life (retarding future deterioration due to higher dynamic loads). (ii) Improved pavement management planning (for roughness-based threshold)

RESEARCH PROJECT DESCRIPTION
Pavements and Roadways

Research Problem Title: Spring Weight Restrictions

Project Category: Vehicle/Pavement Interaction

Research Objectives and Outcomes: The Michigan Vehicle Code specifies that the State transportation department or other road authority shall reduce allowable loads during the months of March April and May each year for portions of the highway that are considered seasonal. The required reduction is 25% for rigid pavements and 35 % for all other types. The Michigan Department of Transportation (MDOT) also does not issue any overweight permits, or permits for vehicles or objects greater than 14' in width for any routes, whether seasonal or not. The proposed research would focus on the restriction of overweight permits during the weight restriction period.

Practical Importance: Non-divisible overweight load transport is required for many types of construction activities. Not issuing permits for these loads requires many construction operations to wait until weight restrictions are lifted to perform many activities. This is a significant financial burden to the State.

Technical Importance: Understanding the stresses associated with this issue may provide insight into better pavement design strategies.

Required Length of Research Project: Unknown

Impact of Expected Outcomes and Implementation Timeline: If restrictions are restricted/limited (upon technical validation from this study) then construction operations would not be (unnecessarily) hampered, thus potentially reducing financial burdens to the State. Implementation could be immediate, upon validation of the research results.

Appendix J
Traffic Safety and Operations: Detailed Problem Statements

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Virtual Testbed for Vehicle Infrastructure Integration (VII)

Project Category: Intelligent Transportation Systems

Research Objectives and Outcomes:
Vehicle Infrastructure Integration (VII) based on wireless communication technology is under development and the Michigan Department of Transportation is developing a VII Testbed. The Testbed is to provide the necessary facilities to establish a focal point for VII technology development, VII applications development, and VII field operational tests. Even though many technologies are applicable to VII and various user applications are expected, their system requirements for successful deployment has not been yet fully determined. Most technical components can be tested within the field Testbed; however, many benefits from VII cannot be achieved until reaching a reasonable level of market penetration. Another issue at the beginning stage is the inaccuracy of traffic data due to the lack of samples. Under such circumstances, there is need for developing method to improve data quality by fusing VII probe data and existing sensor data. Recent advances in microscopic traffic simulation models allow researchers and practitioners to test their non-existing technologies, and such an approach is directly applicable to VII Testbed particularly for testing performances under various market penetrations. Therefore, along with MDOT's VII Testbed, a virtual Testbed within a microscopic traffic simulation model is proposed as a complementary component.
The main objective of the project is to build a virtual VII Testbed within a microsopic traffic simulation model in order to evaluate various options that cannot be tested in real field. This project is to provide such "a virtual Testbed" not only to support the field Testbed but also to test various applications developable by the public sector and other related industries. Allowing testing various scenarios, the virtual Testbed is expected to effectively visualize unanticipated issues in VII development and to quantify expected benefits from various applications. The virtual Testbed within simulation environment includes VII components, such as communication components, VII control center, traffic control center, and public agencies and related private industries, in order to replicate the field Testbed. This virtual Testbed will help: 1) verify concepts and ideas before field implementation; 2) evaluate various algorithms to improve data quality under low market penetration by incorporating existing public sensor system; 3) quantify the user benefits under various market penetrations; and 4) develop specifications of the VII components.

Practical Importance: The virtual Testbed, as a replication of field Testbed, saves physical investment by providing simulation testing environment for examining quality of data and estimation, user benefits and system performances based on the actual technical performances experimented from the field Testbed.

Technical Importance: This research will help develop traffic management strategies and various algorithms for estimating and predicting traffic conditions by providing an evaluation framework.

Required Length of Research Project: 24 months

Impact of Expected Outcomes and Implementation Timeline: The virtual Testbed will play a complementary role as a part of the VII Testbed. The flexibility of the virtual Testbed will allow researchers to test unknown scenarios and unproven technologies with low cost and no danger of failure.

Potential Funding Source: MDOT, Auto Manufacturers, USDOT-ITS Joint Program

Prioritization: **2.9** (on a scale from 1 = low to 5 = high), overall rank = 25, lower third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Development of an Intelligent Transportation Systems (ITS) Maintenance Plan for Michigan

Project Category: Intelligent Transportations Systems

Research Objectives and Outcomes: To involve ITS stakeholders throughout Michigan to develop a strategic plan for maintaining ITS technologies that are currently implemented and those that are planned for implementation.

Practical Importance: The earlier a Maintenance Plan is developed, the earlier maintenance can become an integral part of every ITS deployment. In many state DOT's central office and district personnel are already feeling the strain of having systems deployed without adequate consideration of maintenance requirements. Without a maintenance plan, this situation will only worsen with time.

Technical Importance: An ITS Maintenance Plan is critical to proper functioning of deployed ITS technologies. It also ensures that hardware and software maintenance and replacement activities are conducted in an optimal fashion.

Required Length of Research Project: 1 year

Impact of Expected Outcomes and Implementation Timeline: Even the best technology is only as good as the maintenance it receives. Unfortunately, when ITS technologies are deployed, maintenance is often an afterthought. Deploying new technologies can place additional burdens on District Offices which are already understaffed. Also, MDOT employees often are not be prepared to do the specialized required maintenance of ITS technologies. When maintenance is not properly performed, the results can include diminished system performance, equipment failures, and increased life-cycle costs.

Developing a Maintenance Plan can help to ensure that maintenance is a key consideration when implementing any ITS technology. It provides a set of guidelines and procedures to make sure maintenance is performed effectively and without excessive cost. This leads to improved system performance and maximized value for the citizens of the State.

Potential Funding Source: MDOT

Prioritization: 2.8 (on a scale from 1 = low to 5 = high), overall rank = 28, lower third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Development of an ITS Management Plan for the Michigan Department of Transportation

Project Category: Intelligent Transportation Systems

Research Objectives and Outcomes: To develop recommendations and strategies for how Intelligent Transportation Systems activities should be supported and coordinated throughout the Transportation Cabinet.

Practical Importance: ITS activities within MDOT and the State of Michigan involve multiple agencies, including Operations, Information Technology, Vehicle Enforcement, Motor Vehicles, and Traffic. This sometimes results in confusion as to how tasks and responsibilities should be allocated and how activities should be coordinated. An ITS Management Plan would provide a clearer understanding of the best way to allocate responsibilities and provide coordination.

Technical Importance: An ITS Management Plan will help ensure that coordination and execution of tasks is done seamlessly and at optimal cost. It will help ensure that limited resources are optimally allocated and that redundancies are removed.

Required Length of Research Project: 9 year

Impact of Expected Outcomes and Implementation Timeline: Development of the ITS Management Plan will provide the necessary framework and define working relationships and hierarchies between different entities. Implementation of the Management Plan will result in more efficient implementation and execution of activities. Involved agencies and the general public will be positively impacted. Implementation of the Management Plan can take place shortly after its development and its evaluation by the impacted agencies.

Potential Funding Source: MDOT

Prioritization: 3.1 (on a scale from 1 = low to 5 = high), overall rank = 21, middle third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Determination of Interdisciplinary Ways to Reduce Congestion & Increase Transportation System Capacity— Phase-I

Project Category: Intelligent Transportation Systems

Research Objectives and Outcomes: The objective of this research is to determine and/or develop methods and techniques (perhaps in combination with technologies) to manage congestion and preserve capacity. Tentatively explore and recommend long term policies to manage and reduce congestion.

This research will explore ways to combine advancement in technologies (sensors, computation, ramp metering, and communications, much of which has taken place in the recent past) and understanding of the root causes and mechanics of congestion to devise and suggest ways and, in some cases, policies to manage congestion and effectively using current system capacities. In this sense, this research will go beyond traditional methods that are currently contained in some standard documents published by FHWA and ITE—in most cases these tools and techniques deals with the symptoms and ignore the root causes of congestion. It is envisioned that this research will have more than one phase. The work described here is that of phase 1.

Practical Importance: Negative impacts of congestion go beyond wasted time and fuel, and increased harmful emission. Economic wellbeing of an area can severely suffer if congestion is serious. Yet many see congestion as a sign of healthy economy. There is merit to both, but striking a proper balance is not a simple matter. Therefore it is critical that congestion be managed and if possible reduced so as not to impede economic progress. A good start for managing congestion is ensuring that existing system capacities are optimally utilized before new capacities are added. It is often the case that more of the existing system capacities can be utilized by marrying information, communication, and computation technologies.

Technical Importance: Although congestion may be a sign of vibrant economy, too much of it can be costly in both short and long terms. And it is well accepted now that eliminating congestion is not a feasible goal—managing or reducing it through appropriate demand and supply measures is more attainable and should be pursued. Adding new system capacity and managing existing one are essential supply measures. Since congestion reduction and capacity increases are two interrelated actions, undertaking one almost inevitably leads to changes in the other. Therefore, as the objectives of congestion management/reduction and capacity increase are pursued in a systematic way, it is necessary that that accounts for their interrelatedness. And of course this will have to take into account the uniqueness of individual geographic areas.

Required Length of Research Project: 1.5 years

Impact of Expected Outcomes and Implementation Timeline: The outcome of this research will help focus attention on new and most effective combinations of technologies, ramp control, engineering, and policy measures that can bring about desired change in travel conditions. In the medium and long terms this research will lead to cost effective combinations and implementations of congestion and capacity enhancement measures, savings of resources, more satisfied travelers including businesses, and more business friendly environment.

Potential Funding Source: NCHRP, State DOTs Pooled Fund, F-SHRP

Prioritization: **3.5** (on a scale from 1 = low to 5 = high), overall rank = 7, upper third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Evaluation of New Concepts and Technologies in Traffic Signal Control

Project Category: Intelligent Transportation Systems

Research Objectives and Outcomes: The objective of this research is to determine the most cost effective approaches to modernizing traffic signal control systems. Determine the most promising technologies (hardware, including communication protocols) to improve operations of signal systems.

This research will provide answers on the best and most suitable ways to proceed with upgrading of signal systems. Will provide answers as to the conditions (network, traffic, other) under which different options to improving signal systems are feasible and/or cost effective. Will help agencies decide on how to proceed with modernizing their signal systems.

Practical Importance: Important to help agencies select the most effective approaches to modernizing and updating their signal systems and signal timing plans. Will help to ensure that agencies get the most return on their investment in their signal systems.

Technical Importance: Improvements in signal systems can be brought about using combinations of traditional and more technology-based improvements. Given the diversity, and, in many cases the lack of conclusive evidence on effectiveness of recent technologies, it is important that agencies approach this area with some assurance as to the reliability and potential effectiveness of candidate improvement strategies.

This subject may also involve issues related to staffing and technical training specially as more electronics and communication technologies are becoming an integral part of traffic signal systems--a field that until recently was dominated by traditional traffic engineers with only civil engineering backgrounds.

Required Length of Research Project: 1 year

Impact of Expected Outcomes and Implementation Timeline: In the medium and long run will help agencies be more cost effective in their investments in signal control. Will help them be more responsive to emerging needs. Outcome of this research can be put into practice immediately after completion of research.

Potential Funding Source: NCHRP, USDOT-ITS Joint Program

Prioritization: 3.5 (on a scale from 1 = low to 5 = high), overall rank = 7, upper third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Prediction and Characterization of Freeway Congestion

Project Category: Intelligent Transportation Systems

Research Objectives and Outcomes: The proposed effort will examine various types of detector data on freeways around the Detroit Metro area and develop procedures that will reliably and accurately determine: 1) if congestion has started, and 2) what type of congestion it is (spatial and temporal extents.)

Practical Importance: Traffic congestion causes major problems to commuters and fright delivery in many urban areas and it is a daily challenge to freeway management operators. Most approaches to date focus on managing congestion once it has occurred. A more effective approach would be to prevent or lessen the impact of congestion through preemption. That is, to deal with congestions before it actually starts. This, however, requires that we reliably "see" congestion and classify it before it commences and reaches its peak. In such case, system operators can put in place measures that will help either circumvent congestion completely or, at least, reduce its severity.

Technical Importance: In many instances it is difficult to ascertain if, when, and what type of congestion has started. Answering these questions is important to design and execute effective freeway management actions including dispatch and distribution of patrol/assist vehicles and displays of appropriate contents in the variable message signs. However, there is significant uncertainty about these questions in part because of limited data on traffic flow and/or lack of clear relationship between observed data and corresponding field conditions. This research will help address these concerns.

Required Length of Research Project: 1year

Impact of Expected Outcomes and Implementation Timeline: Although the focus of this effort will be recurrent congestion, patterns of traffic data will be examined to determine if recurrent congestion and non-recurrent congestion can be distinguished. In other words, do different types of congestion have "signatures" that we can identify? This distinction in necessary since each type of congestion implies different response actions. The outcome of this research can be implemented immediately after completion of research.

Potential Funding Source: NCHRP, MDOT, USDOT-ITS Joint Program

Prioritization: 3.1 (on a scale from 1 = low to 5 = high), overall rank = 21, middle third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Using Dedicated Short-Range Communications Technology for Incident Detection on Rural Interstates

Project Category: Intelligent Transportation Systems

Research Objectives and Outcomes: To evaluate and assess the potential for using Dedicated Short-Range Communications (DSRC) technology (i.e., vehicle-mounted transponders and roadside readers) as a cost-effective alternative for continuous travel time monitoring and incident detection on rural Interstate highways in Michigan.

To develop design guidelines and decision algorithms for implementing a DSRC-based incident detection system for a rural Interstate environment. To develop recommendations for operational testing and deployment of such systems in Michigan.

Practical Importance: As Michigan moves forward with plans for more ITS implementations, it is vital that decision-makers are well informed of the technologies available to enhance traffic management and traveler information. As DSRC-based systems are deployed throughout the country, Michigan has a unique opportunity to leverage that investment for traffic management purposes through its strategic implementation in rural areas.

Technical Importance: Use of DSRC technology for incident detection can potentially be an effective mean to reduce frequency and severity of incidents and improve quality of traffic operations. While initial investment in implementing DSRC may be high , the payoff can potentially be substantial in the long run specially when more vehicles will have the DSTC enabling technology.

Required Length of Research Project: 1.5 years

Impact of Expected Outcomes and Implementation Timeline: The ability to monitor travel times and quickly detect incidents is of immense value for traffic management purposes and for providing accurate, real-time information to travelers. To accomplish this, technologies such as video cameras, detector loops, and other sensors are often deployed in urban areas. However, it is usually cost-prohibitive to deploy such technologies in rural areas. Thus, a lower-cost alternative is needed for rural areas that will not be covered by the urban surveillance systems.

DSRC technology has already been deployed for electronic toll collection, commercial vehicle screening, and other purposes. It is possible to exploit this prior (and ongoing) investment in DSRC by using the same technology for an additional purpose. It is envisioned that a DSRC-based system for travel-time monitoring and incident detection can be deployed at a relatively low cost. This would greatly enhance Michigan's statewide traffic management and traveler information capabilities.

Potential Funding Source: MDOT, AAA, NCHRP

Prioritization: 3.3 (on a scale from 1 = low to 5 = high), overall rank = 12, middle third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Optimizing Investments in Rural ITS Applications in Michigan

Project Category: Intelligent Transportation Systems

Research Objectives and Outcomes: To look at different possible rural ITS implementations and determine which are the best for the State of Michigan. To look at different possible rural ITS implementations and evaluate the potential "reward" associated with each (or a group thereof) to the State of Michigan. To do the evaluation such that technical, non-technical, societal, political, and other relevant considerations are accounted for.

Practical Importance: There is a need for implementing rural ITS technologies in Michigan. However, with the limited resources and variety of applications, it is critical that the right decisions be made regarding which rural ITS technology/application(s) to adopt. Identifying and evaluating potential benefits of each of these applications for the conditions in the State of Michigan will be vital for this decision making.

Technical Importance: As resources are limited, it is critical that investment in rural ITS in Michigan be done in an optimal way to ensure success both in technical and non-technical aspects. This is critical for both maintaining the investment and expanding the coverage.

Required Length of Research Project: 9 months

Impact of Expected Outcomes and Implementation Timeline: Careful evaluation of different suitable, and competing rural ITS applications will ensure that the investments are appropriate to the State's need and are sustainable. In addition, this approach will also ensure reasonable political and societal support.

Potential Funding Source: MDOT

Prioritization: **3.2** (on a scale from 1 = low to 5 = high), overall rank = 14, middle third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Exploration of Potential for Electronic Identification of Hazardous Material Vehicles

Project Category: Intelligent Transportation Systems

Research Objectives and Outcomes: To assess the feasibility of using advanced technology to provide real-time tracking of hazardous material shipments traveling through or within Michigan. To develop recommendations on whether such a system should be deployed and, if appropriate, how it should be done.

Practical Importance: An early feasibility study will enable decision-makers in the DOT make well-informed decisions on the best available approach to tracking hazardous material shipments.

Technical Importance: It is important to explore all means and know what can and cannot be done in relation to tracking hazardous material and managing and/or preventing incidents involving vehicles carrying hazardous materials.

Required Length of Research Project: 9 months

Impact of Expected Outcomes and Implementation Timeline: Real-time tracking of hazardous material shipments would allow responsible agencies to monitor the movement and route choice of such shipments, detect incidents if they occur, and provide rapid response to the exact location of the incident, with prior knowledge of the type of hazardous material involved.

Potential Funding Source: MDOT, NCHRP

Prioritization: **2.9** (on a scale from 1 = low to 5 = high), overall rank = 25, lower third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: In-vehicle technology and cognitive loads

Project Category: Intelligent Transportation Systems

Research Objectives and Outcomes: An increasing amount of technology is available from the driver's seat. In-car systems offer climate control, cellular communication, driving directions, radio and recorded audio, videos, and more, all in addition to dials like the speedometer or fuel gauge that actually help to operate the vehicle. Some of these things can improve the driving experience, but all of them increase the cognitive load on the driver. Driver awareness and reaction time measurably drop when cognitive load increases. Popular worries about the use of cellular phones while driving are the forerunners of potential issues with emerging in-vehicle technology and its effect on driver behavior.

The objectives of this are to: (i) identify current and emerging in-vehicle technologies that increase cognitive load on drivers, as well as activities that could easily extend into vehicles the way that drive-through food and cellular phones have; (ii) estimate the degree of cognitive load each factor creates, at least to the extent of ranking how distracting a given factor is (by severity, not commonality – everyone has a radio, but that makes it the most common distracter rather than the most distracting factor); (iii) develop a list of recommendations for drivers for maintaining effective driving attention in the face of expanded technological opportunities behind the wheel (this may address questions such as whether variations on a system might be less distracting, which traffic situations demand additional attention, etc.); (iv) potentially develop recommendations for vehicle and technology producers on how to create devices with lower cognitive loads for drivers.

Practical Importance: Driver distraction is a significant factor in many crashes. As more technology becomes available behind the wheel, the importance of being able to deal with it increases.

Technical Importance: As vehicles become more equipped with technologies intended to help drivers, it will become more critical to evaluate and quantify the impacts, both positive and negative, of those technologies. This could have far-reaching implications including those on licensing procedures and provision/implementation of roadside safety devices.

Required Length of Research Project:

Impact of Expected Outcomes and Implementation Timeline: Public information materials could be developed immediately upon the production of recommendations.

Potential Funding Source: AAA, NCHRP, NHTSA

Prioritization: **2.7** (on a scale from 1 = low to 5 = high), overall rank = 29, lower third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Older Driver Behavior

Project Category: Driver Behavior and Safety

Research Objectives and Outcomes: As people age, physical changes associated with ageing and disease often affect perceptual, motor, and cognitive abilities required for safe driving. In addition, many conditions associated with aging require medications which also affect these abilities. Our current transportation and land use system are so very automobile oriented that driving one self is not only associated with transportation but also with independence and quality of life. Some older drivers compensate for some declines by driving less, and by limiting their driving in conditions where they are uncomfortable (for example avoiding driving at night, during peak periods, on congested freeways, busy intersections). However, despite this compensation, older drivers have higher crash rates per vehicle mile driven than all other age groups of drivers, with the exception of the very youngest. There is much that is not known about the behavior of older drivers in Michigan. What are characteristics of older drivers who compensate, and those who do not? Which are the most common compensatory behaviors? How do older drivers reduce their driving? How do they decide to stop driving? What is the extent of dementia in the older driver population? How does it affect driving?

The objective of this research is to examine older driver behavior in the state of Michigan; specifically how does driving change with age and with physical and cognitive abilities? The suggested methodology is a longitudinal panel study of older drivers over a five year period. A panel of older drivers (age 65 - 85) will be recruited and followed over the five-year period. They will be surveyed once every year about their mobility and activities, amount of driving, driving experiences, health medications, alternative transportation used. The survey instrument can include the telephone version of the mini-mental test. Alternative ways to assess the cognitive status of the subjects can be proposed.

Practical Importance: The results will help understand what older Michiganders face with respect to driving.

Technical Importance: Identify the changes in driving behavior with age

Required Length of Research Project: 6 years

Impact of Expected Outcomes and Implementation Timeline: This will provide much needed information about the process affecting a large portion of the state's population - policy implementation timeline unknown at this time.

Potential Funding Source: NIH (NIA), CDC, NHTSA

Prioritization: 3.2 (on a scale from 1 = low to 5 = high), overall rank = 14, middle third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Older Drivers: Impacts on Traffic Safety and Operations

Project Category: Driver Behavior and Safety

Research Objectives and Outcomes: Michigan can expect a shift in the demographics of drivers, particularly an increase in the number of older drivers as well as in the proportion of drivers over age 65. Furthermore, because of increased lifespan, the number of drivers in their 80s and even older will increase. As people age physical changes associated with aging and disease often affect perceptual, motor, and cognitive abilities required for driving safely. Furthermore, use of medications increases with age, and medications further exacerbate these problems. Older drivers tend to drive fewer miles than younger drivers, but their crash rate per mile driven starts increasing at about age 60 and increases nonlinearly.

Modifications in geometry of roadways, signage, and traffic engineering have been recommended by the FHWA to help older drivers. Among these are larger lettering on signs, larger signal heads on traffic signals, and offsets on left turn lanes at intersections. However, changing the states roadway infrastructure to accommodate older drivers will entail a large expenditure of funds. Needed is an assessment of the size of the older driver population in Michigan, projections of the impact of this population on the crash rates in Michigan if no changes are made to the infrastructure, and estimates of the safety benefits of the implementation of various older driver friendly designs.

The objectives of this research are to
Estimate the projections of older drivers (by age) in the population of Michigan drivers for the next 20 years.
Estimate the effect of this population on traffic crashes with no older-driver specific changes in traffic designs, policies, and operations.
Examine literature and FHWA recommendations for older-driver friendly designs, polices, and operations and identify those appropriate for Michigan.
Estimate the costs and safety benefits of implementation of older-driver-friendly designs, policies and operations over the next 20 years.

Practical Importance: Identifies costs and benefits of traffic engineering modifications to accommodate older drivers.

Technical Importance: methods can b used by other states

Required Length of Research Project: 18 months

Impact of Expected Outcomes and Implementation Timeline: Results will work themselves in traffic engineering decisions - probably over 5 years

Potential Funding Source: MDOT, FHWA, NHTSA

Prioritization: 3.5 (on a scale from 1 = low to 5 = high), overall rank = 7, upper third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Effective components of graduated driver licensing (GDL)

Project Category: Driver Behavior and Safety

Research Objectives and Outcomes: Graduated driver licensing (GDL) has improved traffic safety in Michigan and in other states where it has been implemented by decreasing the number of crashes among young drivers. However, the effects of GDL on traffic safety are still unclear, and there are many unanswered questions. For example:

To what degree are the GDL safety benefits from safer driving of novice drivers, and to what degree are they attributable to the delayed start of driving?
Is GDL only effective with teenage drivers, or is it effective with all novices benefit?
How effective are nighttime driving restrictions and passenger restrictions?
GDL has been implemented differently by various states in the U.S. and also in other countries. How does the effectiveness vary across the different implementations?

The objectives of this research are to:
Identify different implementations of GDL
Quantify the benefits of different GDL implementations
Estimate the impact of each component of GDL on this total effectiveness, (include interaction effects of the components)
Estimate the effects of specific implementations of each component, such as differing nighttime or passenger restrictions or numbers of hours at each driving stage
Identify components for which insufficient evaluation data exists, including potential GDL components that have not been implemented in any jurisdiction.

Practical Importance: Identification of effective GDL components would allow for improvement of existing laws and increased safety of (and from) novice drivers.

Technical Importance: The successful completion of this project will result in improved guidelines for the training of novice drivers and identify shortcomings of existing GDL programs and research.

Required Length of Research Project: 2 years

Impact of Expected Outcomes and Implementation Timeline: Recommended changes to GDL could be integrated into the program the next time the legislation faces renewal. Teen drivers' parents could enforce the recommended restrictions in advance of a legislative mandate, provided popularization efforts.

Potential Funding Source: NHTSA, NIH, CDC

Prioritization: **2.7** (on a scale from 1 = low to 5 = high), overall rank = 29, lower third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Beyond Skills: Driver Education for Safety

Project Category: Driver Behavior and Safety

Research Objectives and Outcomes: Research has consistently shown that driver education improves driving skills without making novice drivers safe drivers. Training focuses on skills without sufficiently imparting the necessary knowledge and motivation to make novice drivers drive more responsibly and crash less often.

The objective of this project is to establish a model driver education program that goes beyond imparting skills to increasing driver safety. Training should impart the necessary knowledge and motivation to reduce high-risk driving behavior. Most student drivers will be teenagers who would be expected to enter the graduated driver licensing program, but it may be worthwhile to have recommendations specific to older novice drivers, such as recent immigrants. The model should identify minimum and ideal amounts of time needed in the classroom and in supervised driving to create safe drivers.

Practical Importance: Novice drivers, particularly teen drivers, are most at risk of vehicle crash and associated injury, and death. Improved driver education could significantly reduce crashes, injuries, and lost years of life.

Technical Importance: Program can be used as model for other states

Required Length of Research Project: 2 years

Impact of Expected Outcomes and Implementation Timeline: The model program will be promoted to public and private driver education programs and recommended as an alternative or supplement to existing skills-based programming to improve safety.

Potential Funding Source: commercial driver education programs, Michigan Department of State

Prioritization: **2.4** (on a scale from 1 = low to 5 = high), overall rank = 32, lower third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Role of driver distraction in vehicle crashes in Michigan

Project Category: Driver Behavior and Safety

Research Objectives and Outcomes: A large proportion of vehicle crashes in Michigan occur in daylight, in good weather, and on good roads. Although it can be argued that this is just a matter of exposure, that is that more VMT is generated in daylight, good weather and good roads, questions about the role of driver distraction in such crashes have been raised. Driver distraction includes in-vehicle activities that take a portion of the driver's attention from the driving task. Not much is known about the role of these distractions on crash incidence in Michigan. However, the rapid increases in cell phone use and electronic communication devices inside vehicles have brought this issue to the fore front. Beside use of cell-phones, activities such as eating, smoking, drinking, grooming, reading maps (or other material), sending/receiving fax and email are sources of distraction to drivers. Distractions are also caused by interactions with passengers, (for example, unruly children or pets), and falling objects (cigarettes, spilled drink, packages). In some situations, these take up enough of the driver's attentional resources, that not enough is available to deal with attention demanded by the driving situation, which can lead to crashes.

The objectives of this research are to investigate the role of driver distraction in vehicle crashes in Michigan by identifying the proportion of all crashes attributed to driver inattention and by exploring the types of crashes, circumstances of crashes, and characteristics of crash-involved drivers. Another objective of the research is to quantify the amount of distracted driving by drivers in Michigan, and to identify the types and amounts of distracted driving, and to rank the distractions by their effects on safe driving, i.e., which are the worst distractions with respect to crash causation, to which ones are mostly benign.

The suggested methodology for this research includes, literature review of distracted driving and distracted driving crashes, analysis of Michigan crash data, and a direct observational survey of distracted driver behavior. The direct observation survey would have to be designed so that it is statistically valid and representative of the State of Michigan.

Practical Importance: Knowledge of its on effects on crash causation would help formulate policy or regulations about the use of these technologies inside vehicles. Knowing more about the amount of other distractions (for example, eating, smoking, grooming), and their effect on crash causation would help to develop public information programs that would help to minimize the frequency of the behaviors which are found to have the most influence on crashes.

Technical Importance: The research would quantify the effect of emerging communication technology which is finding its way into vehicles and is increasingly being used by drivers while driving.

Required Length of Research Project: 1.5 years

Impact of Expected Outcomes and Implementation Timeline: Outcomes could influence policy and legislation - this may take some time. On the other hand, results could be included in PIE programs almost immediately.

Potential Funding Source: NHTSA, MDOT, USDOT

Prioritization: 3.2 (on a scale from 1 = low to 5 = high), overall rank = 14, middle third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Safety Improvements For Older Drivers

Project Category: Driver Behavior and Safety

Research Objectives and Outcomes: Fatality rates in the U.S. and in Michigan calculated per vehicle miles of travel for drivers 75 years of age and older are about seven times the rate for drivers age 25 through 69. Furthermore, the involvement rate of older occupants in traffic crashes has been increasing at an increasing rate during the last ten years. Because older persons are more fragile, the likelihood of a fatality involving an elderly occupant is much higher than that involving an occupant in the other age group. These trends together with the increasing growth rate in the proportion of the oldest age group are cause for alarm. Research conducted on the behavior of older drivers indicates that higher reaction time, reduced visual acuity, inability to execute appropriate actions in a timely manner, and a general decline in cognitive abilities are factors contributing to their disproportionately high involvement rate in crashes. Sedans, the type of vehicles preferred by older drivers, place older drivers at operational and visual disadvantage in a vehicle fleet of with proportions of SUVs and vans as do vehicle interior design and ergonomics that typically cater to younger drivers. Current licensing procedures in many states do not require a driver retest until age 80, even though the age range from 70 to 80 years is associated with the greatest decline in driving skills.

There is a need to continue implementing roadway safety improvements to accommodate older drivers. However, it is necessary to first determine whether existing highway and vehicular design standards meet the needs and capabilities of older drivers. There is also a need to re-evaluate licensing, screening and testing practices to better identify older drivers who have physiological and functional impairments that may affect their ability to drive safely, as well as a need for a systematic procedure to "remove" drivers from the highway as their driving skills deteriorate beyond a certain point. There is also a need to provide mobility for those older drivers who no longer drive.

The purpose of this study is to identify specific reasons for the higher involvement rate of the older driver in highway crashes from a detailed review of the UD- 10 reports, and to develop countermeasures directed toward preventing such future crashes. The countermeasures will include: roadway improvements, driver retraining, license renewal requirements. The study will also explore the feasibility of a driver removal program and explore alternate ways of meeting the travel needs of the affected group.

Practical Importance: A reduction in number of fatalities and injuries to the elderly people, as well as driving population at large

Technical Importance: Successful completion of the project may include changes in the driver licensing procedure, changes in the interior design of the vehicles and changes in roadway geometric and operational features.

Required Length of Research Project: 36 months

Impact of Expected Outcomes and Implementation Timeline: Can serve as a "blue print" for a national program to meet the safety needs of the older driver.

Potential Funding Source: Michigan Department of State, NHTSA

Prioritization: 3.1 (on a scale from 1 = low to 5 = high), overall rank = 14, middle third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Safety Improvements For Younger Drivers.

Project Category: Driver Behavior and Safety

Research Objectives and Outcomes: Population based fatality and injury rates for drivers age16-20 are among the highest all age groups. The primary problems of drivers of this age appear to be related to lack of experience, immature judgment, and risk taking. Younger drivers have limited life experience to rely upon in developing responses to the driving environment. Some researchers contend that younger persons have a sense of immortality and invulnerability to danger that carries over into their driving behaviors. Some younger individuals also tend to display other characteristics that foster unsafe driving. Younger drivers perceive risk differently than older drivers. Research has shown that younger drivers rate speeding as less dangerous than do other drivers, and that teenage drivers and passengers use belts less often than older occupants do. Personality factors, particularly among males, may also contribute to the young driver problem. The literature includes references to over-expression of impulsiveness, reckless driving and anger in traffic situations. There is also some correlation between various "anti-social" personality traits (more common among the young than other age groups) and higher crash rates.

The rate of crashes of younger drivers is likely to increase in the future and the issue needs to be addressed with the following countermeasures.

1. Implement effective methods to restrain impulsive, risky behaviors by law enforcement such as primary seat belt use, speed laws, license restriction or denial, or other aversive controls.
2. Develop new laws for Blood Alcohol Concentration (BAC) limits that may result in reduction in drunk driving.
3. Adopt graduated licensing systems that directly involve parents in the learning-to-drive process, by requiring parents to certify that a certain minimum number of miles have been driven during the learning stage.
4. Address risk factors underlying their high crash rates and assess the extent to which existing graduated driver licensing programs address these risks and whether improvements to these programs should be considered.
5. Develop programs to reduce vehicle distractions, such as use of cell phone while driving.
6. Make the driving license test more stringent.

Practical Importance: Reduction in number of fatalities and injuries to the younger riders, as well as driving population at large.

Technical Importance: Successful completion of the project may include changes in the graduated drivers licensing procedure, implementation of some new enforcement laws and training courses, changes in roadway geometric and operational features.

Required Length of Research Project: 36 months

Impact of Expected Outcomes and Implementation Timeline: Can serve as a “blue print” for a national program to meet the safety needs of the younger drivers.

Potential Funding Source: Michigan Department of State, NHTSA, CDC, NICHD

Prioritization: 2.6 (on a scale from 1 = low to 5 = high), overall rank = 31, lower third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Development of Work Zone Speed Limit Methodology

Project Category: Work Zone Safety

Research Objectives and Outcomes: There are no uniform guidelines for determining work zone speed limits in the United States. A reduction of 10 mph below the posted pre-construction speed limit is used by a majority of agencies, but a significant percentage of state highway agencies determine the reduction in speed limit based on the conditions of the construction project. Most agencies do not perform pre-construction speed studies for consideration in setting reduced speed limits, nor do they consult with law enforcement officials. Results of nationwide surveys have indicated that approximately half of the responding state agencies believe that current industry practices are not adequate to control speeding in work zones.

As stated in NCHRP Research Results Digest 192, "work zone safety problems are aggravated by inconsistencies in the methods used to determine work zone speed limits, motorists noncompliance with the posted work zone speed limits, and the growing practice of setting work zone speed limits through legislative or administrative decisions without the benefit of an engineering study". Thus, a need exists to establish a procedure for determining work zone speed limits to address these problems.

The objective of this study is to develop a procedure to be used by MDOT and the local road agencies in setting appropriate reduced speed limits in work zones. The procedure will be based on various factors which influence traffic crashes in work zones such as speed limits in advance of the work zone, type of roadway facility, etc. The procedure is envisioned to 1) identify if a highway work zone location is a candidate for reduced speed in work zones and 2) if so, determine the appropriate speed limit reduction for the work zone based on the highway/environment conditions. This procedure will also specify techniques to encourage motorists to travel at or near the selected reduced speed limit throughout the work zone, based on the findings of research from the state-of-the-art literature review.

Field studies will be performed to validate the effectiveness of the designed speed limits on traffic crashes and operations.

Practical Importance: The benefits of this study will include highway work zone crash reductions by improving motorists compliance with the posted work zone speed limits and reductions in traffic flow interruptions from high speed variances.

Technical Importance: The successful completion of this project will result in a procedure MDOT can utilize to set appropriate speed limits in work zones.

Required Length of Research Project: 12 months

Impact of Expected Outcomes and Implementation Timeline: MDOT will be able to implement the work zone speed limit model for the 2007 construction season.

Potential Funding Source: MDOT and other organizations with an interest in roadway construction

Prioritization: 3.7 (on a scale from 1 = low to 5 = high), overall rank = 3, upper third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Countermeasure Development for Work Zone Speed Control

Project Category: Work Zone Safety

Research Objectives and Outcomes: As work zones become more numerous, identification of safety issues and countermeasures has become more important. Construction activities usually reduce the number of travel lanes, creating an unfamiliar environment for crashes and contributing to crashes. Reduced work zone speed limits seek to reduce speeds and speed variance, both significant factors in the number and severity of work zone crashes.

Although every work zone includes temporary traffic control devices, in accordance with MMUTCD guidelines, motorist adherence to those controls and regulations is sporadic at best. Common observations show two distinct groups of motorists on the road; one group driving at a comfortable free flow speed irrespective of the posted limit and the other group closely following the posted speed limit. When normal wide lanes (12 feet) are maintained within the work zones, the first group of drivers may comfortably drive at a speed much higher than the posted speed limits. The other group tries to drive around the posted limit. This results in a relatively high speed variance, which is a major causal factor for work zone crashes. Redesigned work zone traffic controls could increase motorists' perception of risk and motivate them to abide by the lowered limits, to ensure their own safety as workers'.

The objective of this study is to test the effectiveness of candidate countermeasure treatments to improve adherence to the safe travel speed within construction zones. Two speeding countermeasures may be identified, such as narrow lanes and rumble strips, and tested in the field as a part of several projects and in a controlled laboratory experiment with a driving simulator. For each of the improvements, a control site and a test site may be used for comparison between sites with the countermeasure and those without the countermeasure to determine their effectiveness.

Practical Importance: The benefits of this study will include highway work zone crash reductions by improving motorists compliance with the posted work zone speed limits.

Technical Importance: The successful completion of this project will result in proven countermeasures that MDOT can implement in highway work zones to reduce speeding.

Required Length of Research Project: 12 months

Impact of Expected Outcomes and Implementation Timeline: MDOT will be able to implement the speeding countermeasures in the 2007 construction season.

Potential Funding Source: MDOT and other organizations with an interest in roadway construction

Prioritization: 3.6 (on a scale from 1 = low to 5 = high), overall rank = 5, upper third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: The Impact of Vehicular Speed on Safety and Traffic Crashes in Highway Work Zones

Project Category: Work Zone Safety

Research Objectives and Outcomes: Hazards inherent to highway work zones are heightened by frequent and excessive speeding through them. Several studies have shown the link between excessive speed in work zones and traffic crashes, and it is widely accepted by law enforcement and traffic safety professionals that high speeds and speed variance are contributing factors in a significant percentage of traffic crashes, injuries, and fatalities.

While all highway work zones are either marked for a reduced speed limit or are covered by statewide law, the adherence to such reduced speed limits in work zones is sporadic at best. Driver perception of heightened risk is probably the most influential factor in achieving compliance to lowered speed limits in work zones. Excessive speed in highway work zones is a primary cause of construction worker injuries and fatalities as well as work zone crashes.

The objective of this study is to investigate all crashes in highway work zones and determine the crash causation for each of the crashes, particularly for those crashes involving excessive speed. Relationships will be identified between speed, crash type, crash location and crash severity.

Practical Importance: Identifying the causes of crashes in highway work zones will allow for an appropriate selection of countermeasures, which provide the greatest potential for crash reductions.

Technical Importance: The successful completion of this project will provide MDOT insight to the relationship between vehicular speed and traffic crashes in highway work zones.

Required Length of Research Project: 12 months

Impact of Expected Outcomes and Implementation Timeline: MDOT will be able to utilize the information obtained in this research for construction work zone designs in 2007.

Potential Funding Source: MDOT and other organizations with an interest in roadway construction

Prioritization: 3.8 (on a scale from 1 = low to 5 = high), overall rank = 2, upper third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: What specific traffic control devices should be required for short duration work zones?

Project Category: Work Zone Safety

Research Objectives and Outcomes: Temporary maintenance work zones often pose a unique set of traffic control and safety issues that are different than the typical highway construction work zones. As highway professionals continue to focus on work zone safety, there is a critical need to develop and implement a traffic control plan that will improve work zone safety at maintenance work zones.

Temporary traffic control devices provide for safe and efficient movement of traffic through work areas while protecting workers, but it is impractical to spend hours setting up MMUTCD-compliant controls when the project or maintenance will last a few hours at most. The MMUTCD does, however, recognize such transient projects and attempts to differentiate this will a certain amount of flexibility in traffic control strategies for a given situation.

The MMUTCD regards short duration activities in Section 6G as follows:

> *"Safety in short-duration or mobile operations should not be compromised by using fewer devices simply because the operation will frequently change its location.*
>
> *Option:*
> *Appropriately colored or marked vehicles with high-intensity rotating, flashing, oscillating, or strobe lights may be used in place of signs and channelizing devices for short-duration or mobile operations. These vehicles may be augmented with signs or arrow panels.*
>
> *Support:*
> *During short-duration work, it often takes longer to set up and remove the TTC zone than to perform the work. Workers face hazards in setting up and taking down the TTC zone. Also, since the work time is short, delays affecting road users are significantly increased when additional devices are installed and removed."*

The objective of this study is to develop temporary traffic control standards and procedures for work zones with short-duration and mobile operations and for five typical work locations such as outside the shoulder, on the shoulder with no encroachment, on the shoulder with minor encroachment, within the median and within the traveled way. Temporary traffic control plans and written procedures should be developed for the various combinations of the above-noted situations.

Practical Importance: Better application of traffic control devices in short duration work zone operations would provide greater uniformity and thus increased safety for the traveling public.

Technical Importance: Specific requirements for short duration work zone operations would clarify confusion in the field as to what specific traffic control devices are needed.

Required Length of Research Project: 12 months

Impact of Expected Outcomes and Implementation Timeline: Typicals developed in cooperation with the standing MMUTCD Committee could be provided to the field by the committee and through outreach classes.

Potential Funding Source: MDOT and other organizations with an interest in roadway construction

Prioritization: 3.0 (on a scale from 1 = low to 5 = high), overall rank = 24, lower third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Development of Statewide Traffic Data Management System

Project Category: Data Collection, Retrieval, and Management

Research Objectives and Outcomes: Existing traffic data collection systems vary from manual data collection to sensor-based autonomous data collection. In many cases, traffic data are collected limitedly for their own purpose and wasted without sharing between agencies. The collected data are often incompatible due to the lack of consistency. Most traffic data for traffic operations are similarly wasted without being stored despite their usefulness in many applications. Permanent traffic recorders (PTR) along statewide trunk lines have been the main source of historic traffic data, but they are mainly gathering traffic volumes in a transportation planning context. In addition to conventional data collection systems, recent Intelligent Transportation Systems (ITS) include real-time traveler information systems with high fidelity traffic data in real time. However, even these data are not fully utilized due to the lack of data integration efforts, and recent vigorous deployment of traffic sensors also requires systematic data management. Therefore, this project is for development on an integrated traffic database based on existing and future traffic data collection systems.

The goal of this project is to develop a statewide traffic database to collect and store historic and real-time data in order to measure state-wide roadway performance and to provide a user-friendly data retrieval system. To achieve the goal, this project should be conducted in two phases. The first phase is a review of existing systems and the development of guidelines for traffic database; and the second phase is the development of a web-based statewide traffic database system. Objectives for the first phase include: 1) compilation of information on existing data collection systems; 2) identification of data needs by agency and program; 3) development of a unified data collection and storage method for local agencies; 4) identification of additional sensor needs for statewide performance measurements; and 5) classification of sensor stations by data fidelity. Objectives for the second phase include: 1) development of a web-based traffic database; 2) incorporation of this traffic database into MDOT's Transportation Management System (TMS); 3) development of a cross-reference system to crash data; 4) development of algorithms to calculate travel time and travel reliability using the data; and 5) development of a data analysis and reporting system for various performance measures. The traffic database will become a statewide standard data collection and management system.

Practical Importance: This project is expected to: 1) to reduce data collection efforts by maximizing utilization of existing data; 2) to provide continuous roadway performance measures; 3) to improve quality of traffic data for better understanding of traffic phenomenon in Michigan trunklines; 4) to enhance performance of models for transportation planning and traffic operations by providing high quality data; and 5) to identify sensor locations in a cost-effective manner.

Technical Importance: This project will identify new performance measures, and the algorithms developed for state estimation and prediction will play an important role in enhancing ITS applications.

Required Length of Research Project: Phase I: 18 months; Phase II: 30 months

Impact of Expected Outcomes and Implementation Timeline: The first phase of this project will enhance usefulness of traffic by integrating traffic collection systems. The completion of the second phase will lead to development of statewide traffic data management system incorporated with MDOT's TMS. The system will become the backbone of system evaluation and traffic operations with ITS.

Potential Funding Source: MDOT

Prioritization: **4.2** (on a scale from 1 = low to 5 = high), overall rank = 1, upper third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Investigation and Assessment of New Technologies for Data Collection for Asset Management Activities

Project Category: Data Collection, Retrieval, and Management

Research Objectives and Outcomes: The proposed effort will examine various types of detector data on freeways around the Detroit Metro area and develop procedures that will reliably and accurately determine: 1) if congestion has started, and 2) what type of congestion it is (spatial and temporal extents.)

Practical Importance: Traffic congestion causes major problems to commuters and fright delivery in many urban areas and it is a daily challenge to freeway management operators. Most approaches to date focus on managing congestion once it has occurred. A more effective approach would be to prevent or lessen the impact of congestion through preemption. That is, to deal with congestions before it actually starts. This, however, requires that we reliably "see" before it commences an reaches its peak. In such case, system operators can put in place measures that will help either circumvent congestion completely or, at least, can reduce its severity.

Technical Importance: In many instances it is difficult to ascertain if, when, and what type of congestion has started. Answering these questions is important to design and execute effective freeway management actions including dispatch and distribution of patrol/assist vehicles and displays of appropriate contents in the variable message signs. However, there is significant uncertainty about these questions in part because of limited data on traffic flow and/or lack of clear relationship between observed data and corresponding field conditions.

Required Length of Research Project: 1 year

Impact of Expected Outcomes and Implementation Timeline: Although the focus of this effort will be recurrent congestion, patterns of traffic data will be examined to determine if recurrent congestion and non-recurrent can be distinguished. In other words, do different types of congestion have signatures that we can identify? This distinction in necessary since each type of congestion implies different response actions.

Potential Funding Source: MDOT

Prioritization: **3.4** (on a scale from 1 = low to 5 = high), overall rank = 10, upper third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Mining the Michigan Traffic-Crash Database to Extract and Discover New Useful Correlations

Project Category: Data Collection, Retrieval, and Management

Research Objectives and Outcomes: The objective of this research project is to perform an in-depth analysis of the Michigan traffic-crash database in order to extract and discover new useful correlations between crashes and prevailing traffic and roadway characteristics.

Practical Importance: The proposed research is in direct response to MDOT's desire to discover new reliable correlations between crashes and prevailing traffic patterns and roadway characteristics, which will help focus efforts aimed at improving roadway safety conditions in the State. Additionally, MDOT will most likely be among the first few states to utilize the Statistical/Artificial Neural Network mining approach to extract new and reliable traffic-crash correlations from historical databases.

Technical Importance: Currently, MDOT does not perform an in-depth analysis (i.e., mining) of its traffic-crash historical database. Such an in-depth analysis can be performed by mining the database using statistical and/or neural network approaches. The employed mining process usually yields new useful correlations between crashes and prevailing traffic and roadway characteristics. Without such an in-depth mining process, these new correlations will most likely stay hidden within the databases. Therefore, MDOT may never be able to capitalize on the richness of the available traffic-crash historical database in order to make more cost effective decisions in regard to future traffic planning operations.

Required Length of Research Project: 1.5 year

Impact of Expected Outcomes and Implementation Timeline: The extracted or discovered new correlations will help MDOT in better understanding the interaction between crashes and prevailing traffic and roadway characteristics. Moreover, availability of such new correlations could aid MDOT in obtaining reliable estimates of anticipated number and/or type of crashes on specific highway system during the coming years. This information could serve as an early warning if estimates are higher than expected. Consequently, this may allow MDOT to take appropriate actions such as the implementation of various safety measures on specific highway sections in order to reduce the anticipated traffic-related crashes. This will help MDOT prepare for things before they actually happen.

Potential Funding Source: MDOT (could also be any multi-state consortium or NCHRP)

Prioritization: **3.4** (on a scale from 1 = low to 5 = high), overall rank = 10, upper third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Improving Reliability of Transportation Systems—the Case of Travel Time Predictions and System Condition Assessment

Project Category: Data Collection, Retrieval, and Management

Research Objectives and Outcomes: The objective of this research is to develop a practical and more focused understating of reliability in the context of transportation systems and traffic networks, with the ultimate objective being to improve the reliability of transportation system assessments and predictions so that decisions can be made and appropriate information disseminated to system users. This research is motivated by the fact that in many cases agencies are reluctant to disseminate information on travel time predictions and alternate route conditions either because they are not sure about the reliability of the information and related projection they have or the proper format to disseminate it.

The research will focus on reliability of travel time estimates and assessment of system conditions (including alternate route designation). These two points are particularly critical since system users (travelers) use them to make decisions on travel choices (i.e., route, time, and mode). Travelers would lose faith in information they receive if it turns out incorrect. In addition, freight delivery services use this information to schedule their activities. There are several areas in Michigan that will benefit from this research: the metro Detroit area, and the I-75 corridor to northern Michigan.

Practical Importance: Important to help agencies decide on how specific they can be in disseminating information to users on travel time and system conditions. Will help agencies identify what information can be used to build reliability in their travel time and route conditions predictions

Technical Importance: Reliable assessment of transportation system conditions, of which travel time estimates is an example, are necessary aspects of managing a transportation network. As more demand is placed on reliability of the transportation services and also on the results of the analysis, many questions arise: What is reliability? How do we measure it? How level of reliability is necessary? What are the costs of reliable data and/or using unreliable data? How is reliability achieved by redundancy? Answering these questions in the context of travel time and alternate route designation is necessary for the proper functioning and management of the roadway network.

Required Length of Research Project: 1.5 years

Impact of Expected Outcomes and Implementation Timeline: This research will make it easier for agencies to determine the level reliability that is both necessary and possible with current data. Agencies will be more comfortable to disseminate information, and to express it in more descriptive fashion to system users.

Potential Funding Source: MDOT, NCHRP

Prioritization: **3.2** (on a scale from 1 = low to 5 = high), overall rank = 14, middle third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Pedestrian crash location identification

Project Category: Operations and Safety Issues

Research Objectives and Outcomes: The FHWA has identified Michigan, and Detroit in particular, as a focus area for pedestrian safety, due to the high number of pedestrian fatalities. In a broad sense, it is well known where pedestrian crashes tend to happen: in and around cities and colleges/universities. The specifics are less well known. Causes could be better identified and countermeasures applied if high pedestrian crash locations were identified at the intersection and road segment level.

The objective of this project is to identify high pedestrian crash intersections and road segments, within the city of Detroit, other cities, and statewide. This study will also attempt to identify factors common to such crashes or at least compile information that could be used for such an identification. For example, it would be helpful to note particular times of day, age ranges of pedestrians, and travel destinations involved in pedestrian crashes in an area.

Practical Importance: There are approximately 150 pedestrian traffic fatalities in Michigan each year, and many more with serious injuries. Identifying where crashes are most likely to occur is a necessary step to developing specific countermeasures.

Technical Importance: Past research has focused on pedestrian characteristics and behavior rather than considering the richer crash picture that local practitioners need to develop specific countermeasures.

Required Length of Research Project: 1 year

Impact of Expected Outcomes and Implementation Timeline: Research results could immediately be integrated into ongoing consideration of problem and countermeasure identification, and would reduce pedestrian crashes.

Potential Funding Source: MDOT, AAA safety Foundation

Prioritization: 3.2 (on a scale from 1 = low to 5 = high), overall rank = 14, middle third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Motorcycle Exposure Study

Project Category: Operations and Safety Issues

Research Objectives and Outcomes: Exposure measures, such as the number of drivers and the number of vehicle miles of travel are very important in the quantification of crash risk of specific modes. Yet, most measures of exposure for travel by motorcycle in the state of Michigan are not known. For example, there is no accurate estimate of number of people who operate motorcycles in the state of Michigan. Although there are accurate numbers of vehicle operators with motorcycle endorsements on their drivers' licenses, a recent investigation of trends in motorcycle crashes in Michigan found that 44% of crash-involved motorcyclists were not licensed to operate a motorcycle. The crash risk of unlicensed motorcyclists relative to licensed motorcyclists is not known. People who ride motorcyclists without valid licenses may be more likely than those who are licensed to be involved in crashes because of lack of skill, knowledge, or a propensity toward risky behavior. Thus, the validity of simply assuming that 44% of Michigan's motorcyclists are unlicensed is questionable, and the motorcycle crash rates per motorcyclists cannot be calculated. There are also no accurate estimates of the vehicle miles of travel (VMT) by motorcyclists in the state of Michigan. Thus, the crash rate per vehicle mile of motorcycle travel also cannot be accurately determined. Without these exposure measures it is difficult to determine if interventions, policy changes, and efforts to increase licensing are having any effects.

The objectives of this study are to obtain estimates of the number of people who operate motorcycles in the state of Michigan, and to estimate the vehicle miles of travel by motorcycle and also by the various major types of motorcycles. The suggested methodology for this study is a statistically valid survey of motorcyclists using registered motorcycles as the basis of a sampling frame. The survey could have two waves. Recruitment, user and motorcycle information as well as the mileage could be gathered in the first wave. Another short survey after 6 months would collect mileage information. The sample would be expanded to represent the state. The outcome of the study would provide estimates of the number of licensed and unlicensed motorcyclists, and the vehicle miles of travel by motorcycles, as well as by the major types of motorcycle.

Practical Importance: Knowing the number of motorcyclists, licensed and unlicensed, and the VMT of motorcycles will provide the baselines for evaluation of interventions, policies for licensing of motorcyclists as well as a basis to determine changes in crash rates.

Technical Importance: Provide the exposure measures needed to determine changes in crash risk.

Required Length of Research Project: 1 year

Impact of Expected Outcomes and Implementation Timeline: The outcome would provide a much needed way of measuring progress in the field or motorcycle safety.
Implementation - because the outcome is a measure, it could be used immediately in assessments of programs intended to enhance motorcycle safety.

Potential Funding Source: MDOT: AAA Safety Foundation: IIHS

Prioritization: 2.4 (on a scale from 1 = low to 5 = high), overall rank = 32, lower third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Resource Allocation to Optimize Safety Improvements

Project Category: Operations and Safety Issues

Research Objectives and Outcomes: The objective of this research is to determine the most effective ways to allocate available resources (technical, human, financial, etc.) to improve safety on different roadway facilities. Determine ways (actions; policies, long term and short term;) to bring about reduction in accident numbers and severity.

Practical Importance: With limited resources, it is critical that such resources be allocated in a way that produces the most return on investment. It is important that actions and resources allocated be as effective as possible and at the same time meet other constraints such as equity. This research will help achieve these goals.

Technical Importance: Agencies that deal with safety improvements have limited resources and at the same time are faced with the challenge of having to improve safety by reducing both the number and severity of accidents. Allocating available resource, financial and otherwise, in an optimal way is not always a straightforward endeavor. There are many constrains, some are quantifiable and expressible in monetary units but others are neither expressible by measurable units nor easily quantifiable (i.e., they involve subjectivity). In addition, often multiple objectives are desired which may not be compatible, or, in some cases are in conflict--where pursuing one inevitably leads to undermining the other. In this case traditional formal multi-objective optimization becomes necessary.

This research will develop guidelines/principles that are general in nature which can guide agencies in their allocation of safety resources. The research will identify combinations of conditions and the corresponding actions that are most suitable and will determine and note conditions that are unique and where agencies have to examine their own conditions more closely. Depending on the scope of the research (i.e., the number and diversity of conditions studies), it is possible that decision trees will be developed to guide agencies in their safety improvements decision making process.

Required Length of Research Project: 1.5 years

Impact of Expected Outcomes and Implementation Timeline: In the short term, the outcomes of this research will make it possible for agencies involved in safety work to streamline their decisions and make them more cost effective, therefore saving resources to do other projects. In the medium and long term, the impact of this research will be less costly and more effective improvements and more satisfied constituents.

Potential Funding Source: NCHRP: MULTI-STATE CONSORTIUM: US DOT Region 5 Research Center

Prioritization: 3.2 (on a scale from 1 = low to 5 = high), overall rank = 14, middle third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Share the Road campaign

Project Category: Operations and Safety Issues

Research Objectives and Outcomes: Passenger cars and pick up trucks are the most common vehicles on Michigan roadways, but they are not the only ones. Large trucks and buses as well as motorcycles share the road with these vehicles, and they also share in crashes. Trucks and motorcycles are both overrepresented in fatal crashes, for different reasons, but cars are a significant cause of these crashes. The majority of truck-car and motorcycle-car crashes involve hazardous action on the part of the car driver. This suggests that the problem is not only with the trucks or motorcycles, but also in teaching car drivers how to share the road with other vehicles, including non-motorized transportation such as pedestrians and bicyclists.

A variety of education campaigns exist under the banner of "Share the Road," most visibly the national effort of the Federal Motor Carrier Safety Administration. It is unclear how effective these campaigns have been in reaching drivers or affecting the behavior of drivers reached.

The objectives of this are to: (i) estimate the impact of ongoing "Share the Road" campaigns in changing driver behavior and preventing crashes; (ii) identify ways of reaching more drivers, particularly car drivers; (iii) identify messages that can effectively change behavior.

Practical Importance: There are over 200 fatal crashes per year involving heavy trucks and motorcycles. The majority of these fatal crashes are multi-vehicle crashes.

Technical Importance: Approximately ten percent of crash fatalities involve a truck or motorcycle.

Required Length of Research Project: 1 Year

Impact of Expected Outcomes and Implementation Timeline: Public information campaigns can be refined quickly upon receipt of new information.

Potential Funding Source: FMCSA: AAA Safety Foundation: MTSC

Prioritization: 2.3 (on a scale from 1 = low to 5 = high), overall rank = 34, lower third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Impacts of alternative designs on transportation safety and operations and non-motorized users.

Project Category: Operations and Safety Issues

Research Objectives and Outcomes: There have recently been many innovative alternate designs introduced into traffic engineering by ITE and the Congress for New Urbanism; such as modern roundabouts, mini-traffic circles, reducing laneage from four to three, sometimes with bicycle lanes, new street design standards for context sensitive thoroughfares, "skinny streets" using narrower lanes and road widths, speed humps, chokepoints, speed tables, short medians, mid-block crossings, two lane slow points, median barriers, various designs for diverters and similar examples of traffic calming. Altered local street designs (such as the alley/lane/street/avenue/Main Street/boulevard/parkway hierarchy developed in the Healthy Neighborhood Street Design Guidelines for the City of San Joaquin, California) or guidelines for local streets (ITE/City of Portland), Traditional Neighborhood Developments (TND's) and other communities (Wilmington, Delaware/Boulder, Colorado) which are being developed and applied around the United States should be evaluated and may be appropriate to consider in Michigan. Most of these have been introduced to enhance safety through traffic calming. While most of these designs are intuitively attractive, there is little information, especially in the Michigan context, as to the extent that these designs enhance safety, ease of movement for pedestrians and bicyclists, or increase the number of people walking and riding bicycles in a community. An objective, well-structured evaluation is needed to examine and quantify the effects of alternative designs on pedestrian and bicycle movement and safety and their impacts on traffic operations.

The objective of this study is to evaluate the effect of alternative designs, including examples listed above and other design innovations on the safe movement of pedestrians and bicycles and on traffic operations and safety. The suggested methodology is a two phased approach. The first phase being a literature review/state-of- the practice review, then before and after studies that control for possible changes in other factors such as demographics and population size. Outcomes of the study would quantify changes in safety with respect to crash and injury frequencies and rates, changes in the ease of movement/delays, changes in the volumes of pedestrians and bicyclists and the impacts on traffic flow and safety. The effects on pedestrians and bicyclists should be differentiated by age. The effects on vehicular traffic, e.g., volumes, speeds, and crashes would also be quantified with a view to identifying potential future guidelines for applying these designs (if appropriate), and/or constraints or impacts for these types of applications, including factors which could be used in a time of return analysis.

Practical Importance: Results of this evaluation study would help communities make informed decisions about investments in alternative designs.

Technical Importance: Quantify the effects of alternative designs on traffic operations and safety.

Required Length of Research Project: 5 years

Impact of Expected Outcomes and Implementation Timeline: Evaluation results would be used immediately by communities making decisions about alternative designs

Potential Funding Source: NCHRP: Multi-State Funding Pool

Prioritization: 3.3 (on a scale from 1 = low to 5 = high), overall rank = 12, middle third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Determine Criteria for Implementing Protected Only Left Turn Phasing instead of Permitted/Protected Left Turn Phasing

Project Category: Operations and Safety Issues

Research Objectives and Outcomes: Improve the safety of signalized intersections that have left turn phasing by determining criteria for introducing protected left turn phasing prior to having crash data showing there is a problem.

Practical Importance: Reducing left turn crashes.

Technical Importance: Giving the engineer supported guidance on when Protected Only Left Turn Phasing should be considered prior to having a crash pattern. At this point in time there are criteria for determining when left turn phasing should be considered, but there is no criteria for when Protected Only Left Turn Phasing should be implemented.

Required Length of Research Project: 1 year

Impact of Expected Outcomes and Implementation Timeline: Improved intersection safety and operations by minimizing left turn crashes before a pattern develops. The sooner the study is done, and assuming that criteria can be developed that don't rely just on crash patterns, the more rapidly protected only left turn phasing at locations will be implemented.

Potential Funding Source: MDOT: AAA Safety Foundation: NCHRP: Multi-State Funding Panel

Prioritization: 3.6 (on a scale from 1 = low to 5 = high), overall rank = 5, upper third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Determining relative safety of box span design and diagonal span design for traffic signals

Project Category: Operations and Safety Issues

Research Objectives and Outcomes: To determine whether the box span design for traffic signals improves the safety of intersections by reducing the number of late entries into the intersection due to the improved visibility of the signal heads to the driver. This study should also be used to determine if improving the signal head visibility for the motorist reduces red light running. The objective is determine whether diagonal span design or box span design should be used in Michigan.

Practical Importance: Improve safety of intersections. In addition to the potential safety benefits for the motorist, the box span design keeps signal crews out of the middle of intersections during installation, maintenance, and relamping/preventive maintenance. The box span design also allows simpler signal head design and makes changes at the intersections easier, improving the ability to stage signals during construction projects.

Technical Importance: To determine whether the box span design is worth the extra cost over the diagonal span design. To document that the box span is more flexible and efficient during staging on construction projects and can then be used for final signals.

Required Length of Research Project: 2 years

Impact of Expected Outcomes and Implementation Timeline: Improved intersection safety.

Potential Funding Source: MDOT

Prioritization: **3.2** (on a scale from 1 = low to 5 = high), overall rank = 14, middle third

RESEARCH PROJECT DESCRIPTION
Traffic Safety and Operations

Research Problem Title: Statewide Commercial Vehicle Crash Analysis and Development of Safety Measures.

Project Category: Operations and Safety Issues

Research Objectives and Outcomes: Commercial vehicles represent four percent of all registered vehicles in the US, and eight percent of total miles driven on public roads. They also account for a significant proportion of all traffic fatalities in the US. In a typical year, more that ten percent of all motor vehicle traffic fatalities involve heavy trucks, and more than two percent involve medium trucks. Typically, severity of injuries suffered in truck crashes is much higher than that in passenger car crashes. Further, two-thirds of all fatalities resulting from truck – related crashes involve another vehicle or a non occupant. Commercial vehicles pose serious safety hazards not only for their own occupants, but also for the driving population at large. The situation is likely to be more critical in Michigan, where large trucks are allowed to carry heavier loads than many other states.

Recent deregulation in the trucking industry has been instrumental in the infusion of many independent trucking companies in the market place competing with the large corporate motor carriers. Whether or not there are differences in the maintenance practices and safety training between these two groups, and whether or not the crash involvement rates of the two groups are significantly different from one another, are important issues in the overall truck safety assessment. Any new knowledge generated in these areas may provide insights to the design of action plans or countermeasures to reduce truck-related crashes. For example, besides mechanical failure, the most common hazardous action of trucks often involves failure to stop within a desired distance, improper lane use, improper backing, and improper turning/encroaching on the adjacent lane. A detailed study of traffic crashes in Michigan will be used to identify safety measures that are cost-effective and can be implemented through the initiatives of the Michigan Truck Safety Commission.

The objectives of this study are to:

- Analyze the involvement rates of these two groups (independent vs. large corporations) of trucks in highway crashes in Michigan from historical accident and Vehicle Miles of Travel (VMT) data.
- Determine if there are significant differences in maintenance practices and driver training between these two groups.
- Examine the predominant crash patterns of these two groups of trucks from UD 10 reports and to determine if there are significant differences in these patterns between these groups.
- Develop countermeasures, including; driver education, enforcement of laws on work hours, weights, etc. and legislative actions, designed to reduce the number of crashes and to reduce the severities of crashes involving commercial vehicle travel in Michigan.

Practical Importance: The benefits will include improved safety for the entire driving community on Michigan highways, as most truck-related fatalities result from multi-vehicle crashes that involve occupants of a non-commercial vehicle.

Technical Importance: The outcome of this study will be a set of action plans targeted toward the two trucking groups to reduce their involvement in highway crashes, and to reduce the severity of injuries resulting from such crashes.

Required Length of Research Project: 24 months

Impact of Expected Outcomes and Implementation Timeline: Will reduce truck-related highway crashes and economic losses from highway crashes in Michigan currently estimated at $20 billion per year.

Potential Funding Source: FMCSA: MTSC: NCHRP: Multi-State Funding Pool

Prioritization: 3.7 (on a scale from 1 = low to 5 = high), overall rank = 3, upper third

Appendix K
Public Transportation: Detailed Problem Statements

RESEARCH PROJECT DESCRIPTION Public Transportation
Research Project Title: Handbook – Introduction to Public Transit for Elected Officials
Project Category: Planning
Research Objectives and Outcomes: Develop a handbook for elected officials that would introduce the basics of public transit planning, operations, and implementation. The handbook would include transit history, issues, terminology, technology, roles of governments, financing, and other resources.
Practical Importance: Handbook would provide an invaluable resource to public officials on public transit and its role for a community. It would also be helpful for citizens to understand public transit and its costs and capabilities.
Technical Importance: Handbook would synthesize materials developed by others for applications in Michigan.
Length of Project: 12 months
Impact of Expected Outcomes and Implementation Timetable: Handbook would provide for a better understanding of public transit particularly for smaller communities
Priority: High

RESEARCH PROJECT DESCRIPTION Public Transportation
Research Project Title: Tools to Assess Transportation Mobility Options
Project Category: Planning
Research Objectives and Outcomes: This project would develop survey tools and techniques for needs assessment and the evaluation of transit options and services in a community. A handbook of tools and techniques would be prepared.
Practical Importance: Guidance for determining needs for transit in a community and for evaluating existing services.
Technical Importance: Adapt procedures and tools used by others for application in Michigan.
Length of Project: 12 months
Impact of Expected Outcomes and Implementation Timetable: Project would provide valuable information and tools for transit providers and communities, particularly smaller communities.
Priority: High

RESEARCH PROJECT DESCRIPTION
Public Transportation

Research Project Title: Who Uses Public Transit in Michigan

Project Category: Planning

Research Objectives and Outcomes: This project would provide an understanding on the number, demographics, and characteristics of transit users in Michigan on both a statewide and community basis.

Practical Importance: Project will provide a better understanding of transit users in the state compared to other states and communities. This will provide valuable planning information.

Length of Project: 12 months

Priority: High

RESEARCH PROJECT DESCRIPTION
Public Transportation

Research Project Title: Impact of Our Aging Population on Future Transit in Michigan

Project Category: Planning

Research Objectives and Outcomes: Seniors are typically important users of our transit systems and this project would examine the demographics of our aging population and how transit systems will need to adapt to this growing user base. The project would also examine approaches taken by other systems in the United States and other countries to accommodate older passengers.

Length of Project: 12 months

Priority: Not rated (could be combined with Who Uses Transit in Michigan)

RESEARCH PROJECT DESCRIPTION
Public Transportation

Research Project Title: Application of GIS/GPS for Michigan Transit

Project Category: Planning

Research Objectives and Outcomes: Many transit systems in the country are using GIS/GPS for a variety of applications to improve operations and user information. This project would be a synthesis of approaches for planners, operators, and users in Michigan

Length of Project: 12 months

Priority: Not rated

RESEARCH PROJECT DESCRIPTION
Public Transportation

Research Project Title: Improving Transit for Users and Non-Users with Disabilities

Project Category: Planning

Research Objectives and Outcomes: This project would identify approaches used for serving users with disabilities and how to attract and serve those with disabilities that are not using transit

Length of Project: 12 months

Priority: Not rated

RESEARCH PROJECT DESCRIPTION
Public Transportation

Research Project Title: Best Practices for Fare Collection

Project Category: Operations

Research Objectives and Outcomes: There are several approaches used for fare collection ranging from cash, tickets, and passes to automated fare techniques. This research would provide a synthesis of techniques and guidelines for transit operators in Michigan.

Priority: Not rated

RESEARCH PROJECT DESCRIPTION
Public Transportation

Research Project Title: Best Practices for Signal Prioritization for Transit Vehicles

Project Category: Operations

Research Objectives and Outcomes: Transit vehicles can often be delayed because of traffic signals and several techniques have been developed and evaluated to provide a prioritization for transit vehicles. This research would examine approaches and provide guidelines for applications in Michigan.

Technical Importance: Opportunity for cooperation with traffic engineering to improve transit operations

Priority: Medium

RESEARCH PROJECT DESCRIPTION
Public Transportation

Research Project Title: Best Practices for Intersection Design for Transit Vehicles

Project Category: Operations

Priority: Not rated

RESEARCH PROJECT DESCRIPTION
Public Transportation

Research Project Title: Best Practices for Bus Stop and Shelter Locations

Project Category: Operations

Research Objectives and Outcomes: Review guidelines and experience for the location of bus stops and shelters and assess application in Michigan.

Priority: Medium

RESEARCH PROJECT DESCRIPTION
Public Transportation

Research Project Title: Guidance for Equipment Selection and Purchase

Project Category: Equipment

Research Objectives and Outcomes: Many small operators are faced with several options when they purchase new transit vehicles. This project would provide guidance for identifying needs, comparing and evaluating alternatives, and options for purchasing or acquiring vehicles

Priority: Low

RESEARCH PROJECT DESCRIPTION
Public Transportation

Research Project Title: Bicycle Racks on Transit Vehicles in Michigan

Project Category: Equipment

Research Objectives and Outcomes: Several operators in the United States have installed bicycle racks on their vehicles to attract riders. This project would examine the use of bicycle racks and provide guidance for the selection of equipment.

Priority: Not rated

RESEARCH PROJECT DESCRIPTION
Public Transportation

Research Project Title: Lifts for Loading/Unloading of Passengers with Disabilities

Project Category: Equipment

Research Objectives and Outcomes: There are several types of lifts available for transit vehicles. This project would examine the range of lifts and provide guidance for selection and operations. This project would be of particular interest for small operators.

Priority: Not rated

RESEARCH PROJECT DESCRIPTION
Public Transportation

Research Project Title: Transit Funding Sources

Project Category: Implementation

Research Objectives and Outcomes: There are numerous programs to assist operators in the purchase of equipment and operations. This project would provide guidance in finding potential sources for Michigan operators, particularly for operators in smaller communities

Priority: Medium

RESEARCH PROJECT DESCRIPTION
Public Transportation

Research Project Title: Alternative Funding and Financing Techniques

Project Category: Implementation

Research Objectives and Outcomes: As transit operators struggle to keep fares low and fund their services, several have developed innovative approaches. This project would share successful approaches and guidance for operators.

Priority: Low

RESEARCH PROJECT DESCRIPTION
Public Transportation

Research Project Title: Information Exchange between Operators and Customers

Project Category: Implementation

Research Objectives and Outcomes: This project would develop tools to improve the communications between operators and customers, both current and potential users, in providing information about services and obtaining feedback.

Priority: Not rated

RESEARCH PROJECT DESCRIPTION
Public Transportation

Research Project Title: Information Exchange between Operators and Government Agencies

Project Category: Implementation

Research Objectives and Outcomes: One of the challenges for small operators is finding assistance and resources to help them make better decisions

Priority: Not rated

RESEARCH PROJECT DESCRIPTION
Public Transportation

Research Project Title: Voucher Systems

Project Category: Other

Research Objectives and Outcomes: A few operators that serve passengers with disabilities are experimenting with a voucher system for users based on miles traveled instead of per trip. This project would examine this practice for application in Michigan. If the approach is promising, guidelines would be developed to assist operators in implementing a system.

Practical Importance: The approach could better reflect the cost of providing service to this sector of user.

Priority: Not rated

RESEARCH PROJECT DESCRIPTION
Public Transportation

Research Project Title: Guidelines for Rail Transit in Michigan

Project Category: Other

Research Objectives and Outcomes: Many cities are building rail systems to serve future travel demands in their communities. This project would provide an introduction to issues, planning tools, and guidelines for a range of rail transit options including Light rail transit (LRT), commuter rail, Metro rail, and others that would assist in future land use/transportation planning decisions.

Length of Project: 12 months

Impact of Expected Outcomes and Implementation Timetable: Will provide a better understanding for planners and communities on the potential applications of rail transit options in Michigan

Priority: Not rated

RESEARCH PROJECT DESCRIPTION Public Transportation
Research Project Title: Rail Access for Michigan Airports
Project Category: Other
Research Objectives and Outcomes: Rail access is provided at many world airports and as ground access congestion grows more airports are examining rail options. This project will review the conditions at Michigan's largest airports and assess the long range potential applications for rail access.
Practical Importance: Will help communities and airports assess long range ground transportation planning alternatives.
Technical Importance: A systems approach for airport ground access planning
Length of Project: 12 months
Priority: NOT RATED

RESEARCH PROJECT DESCRIPTION Public Transportation
Research Project Title: Society Cost of Transit and Automobile Facilities in Michigan
Project Category: Other
Research Objectives and Outcomes: This project is seen as a society comparison of the cost and benefits of transit systems and facilities compared to the costs and benefits of roads.
Priority: Not rated

Appendix L
Planning, Land Use & Environmental Impact Committee: Detailed Problem Statements

RESEARCH PROJECT DESCRIPTION **Planning, Land Use & Environmental Impacts**
Research Problem Title: Treatment of Polluted Urban Runoff*
Project Category: Environmental Concerns
Research Objectives and Outcomes: Objectives include (1) select Michigan roadways for study of polluted runoff, (2) monitor concentration of automobile fluids on and running off of roadway(s), (3) monitor presence of automobile fluids in ground and surface water near roadway, (4) install trench with treated granular material in it that removes contaminants as it passes through, (5) monitor water quality after trench installation.
Practical Importance: Surface water and groundwater are being polluted by leaking automobile fluids when rain water hits the roadway surface and is carried over and into the ground. This pollution can cause negative health effects.
Technical Importance: No studies have been done on pollution modeling for Michigan roadways. Treatment systems are rare for such a prevalent water quality problem given the number of vehicles on the Michigan and US roadways, particularly in urban areas.
Required Length of Research Project: 36 months
Impact of Expected Outcomes and Implementation Timeline: The impact of the expected outcomes would be improved human health and the associated reduction of health care costs. The urgency is high given the high cancer rates in the US. The implementation timeline for Objective (1) to take 3 months, Objective (2) 2 years, Objective (3) 2 years, and Objective (4) 6 months.
Prioritization: High

*The Subcommittee agreed these high priority Research Problem Statements should be grouped together within the Environmental Impacts category and considered as linked efforts.

RESEARCH PROJECT DESCRIPTION
Planning, Land Use & Environmental Impacts

Research Problem Title: Roadside Lead and Salts*

Project Category: Environmental Concerns

Research Objectives and Outcomes: (1) Select sampling locations along roadways of various traffic density and age; (2) Obtain surficial soil samples and samples at depths of 3"and 6" below ground surface; (3) Analyze samples for lead and salt concentration; (4) Determine availability of blood lead data and obtain data; (5) Analyze (graphically and otherwise) the correlation between the soil contaminants and roadway characteristics; (6) Perform isotherm studies of soil lead mobility in the presence of salt; (7) Provide analysis of blood lead contamination and soil lead contamination, (8) Develop a map of soil lead risk.

Practical Importance: Lead poisoning is a known cause for a variety of profound health problems, especially in children, to whom high blood lead levels can impair physical and mental development. Blood poisoning (i.e. elevated blood lead levels) is known to be highly correlated with soil lead contamination. Past use of leaded gasolines has been shown to be a major cause of soil lead contamination in roadside soils. Soils adjacent to roadways are also known to have elevated salt levels due to runoff following deicing operations. The presence of salt may significantly alter the mobility of the soil lead, modifying suggested remedial designs and predicted migration times.

Technical Importance: There has been some research into the correlation of high density traffic areas and childhood blood lead poisoning. However, the available data is very limited and the conclusions from the various research efforts are somewhat conflicting. Data on salt levels in soil are fragmented, with no studies completed evaluating the risk of soil lead mobility in high salt environments. This project will provide specific data on roadside soil contamination with both lead and salt as the measured variables. Laboratory investigations will determine the mobility of the lead in the presence and absence of salt contamination. Data on soil lead contamination will be compared to existing data of childhood blood lead levels to determine possible linkages between the two. This project will create a larger database of soil-lead concentration information, and will produce maps showing high-risk areas and the relationship between blood lead levels and high soil lead concentrations, particularly in urban areas (where blood lead data is available).

Required Length of Research Project: 36 months

Impact of Expected Outcomes and Implementation Timeline: The impact of the expected outcomes is nationwide, with particular focus on Michigan roadside soils. The expected outcomes would lead to a better understanding of existing roadside contamination and the risk of health effects due to the contamination, as well as the mobility of lead in high salt environments. A map of qualitative risk indices would be developed as part of the project. The implementation timeline would be for Objectives (1-3) to be completed concurrently during the first year, Objectives (4-5) would be completed in the 2nd year, Objective (6) would require 1 year, and would be completed during year 1 and 2, Objectives (7-8) would be completed during year 3.

Prioritization: High

*The Subcommittee agreed these high priority Research Problem Statements should be grouped together within the Environmental Impacts category and considered as linked efforts.

RESEARCH PROJECT DESCRIPTION
Planning, Land Use & Environmental Impacts

Research Problem Title: Streamlined Analysis of Contaminated Sites*

Project Category: Environmental Concerns

Research Objectives and Outcomes: (1) Identify Michigan sites of roadside soils contamination including both sites with organic and inorganic contaminants, (2) Compare and evaluate several currently available vadose zone transport models (SESOIL, VLEACH, others) for applicability/ease/reliability in modeling the contaminant problem, (3) Couple the contaminant transport models with software for optimizing parameter estimation (such as PEST), (4) Present a comparison matrix of various approaches for evaluation of roadside contamination, and (5) Develop a guidebook for methodology streamlining the evaluation of Michigan roadside contamination sites.

Practical Importance: Many road projects involve construction in areas of pre-existing soil contamination. Project delays may be extensive due to the efforts involved in adequately defining the contamination problem, selecting a remedy, and completing any necessary remedial action. Often the contamination is confined to the upper level soil horizons. Evaluation of contaminant risk in this zone is complicated by the complexities of vadose zone modeling and the immense data requirements (including climatological) to adequately predict migration in unsaturated soils. However, such predictions are necessary to design of the appropriate remediation in a timely fashion. This project seeks to speed the analysis of roadside contamination by developing a streamlined approach for vadose zone modeling in Michigan soils/climate.

Technical Importance: The objective of this research is to develop a rational, consistent and systematic approach to decision-making related to Michigan sites of roadside contamination. Previous researchers have used parameter optimization strategies with models directed to saturated zones, but such coupling hasn't been attempted for vadose zone applications. This will be one technical advance of the project. In addition, current efforts in modeling the vadose zone rely on an unstructured, fragmented approach with little guidance to model selection and data analysis. The guidebook developed as part of this project will be a second technical advance of the project and will assist in streamlining contamination analysis/remediation efforts.

Required Length of Research Project: 36 months

Impact of Expected Outcomes and Implementation Timeline: The project would impact the analysis and remediation of Michigan sites of roadside contamination. The process of reacting to contamination will be streamlined, affording improved construction schedules or remediation schedules. The urgency is high, given the ever increasing demand on transportation resources and the numbers of sites involving at least some level of soil contamination. The implementation timeline would be for Objective (1) to take 3 months, Objective (2) 1 year, Objective (3) 6 months, Objective (4) 3 months, and Objective (5) 1 year.

Prioritization: High

*The Subcommittee agreed these high priority Research Problem Statements should be grouped together within the Environmental Impacts category and considered as linked efforts.

RESEARCH PROJECT DESCRIPTION
Planning, Land Use & Environmental Impacts

Research Problem Title: Wetland Mitigation Areas/Banking

Project Category: Environmental Concerns

Research Objectives and Outcomes: (1) inventory existing wetlands in Michigan (2) document known effects of roadways on wetland size and hydraulics, (3) set up and calibrate a watershed model for simulating flow in and out of wetlands in a selected Michigan watershed(s), (4) perform modeling simulations to ascertain if wetland banking system will be effective, and (5) make recommendations for wetland banking or other system for wetland policy.

Practical Importance: Wetlands are marshy areas that occur naturally, but humans have been altering these valuable ecological resources for development and transportation. Wetlands are known to reduce flooding and clean up water flowing overland into them.

Technical Importance: Wetlands act as natural flood retention ponds that regulate the flow of surface water. In addition, vegetation in the wetland has the effect of removing toxic constituents in the overland runoff from agricultural and automobile chemicals. Urbanization and transportation development require the re-routing of surface water flow that can destroy these valuable wetlands. It is unclear whether or not a "no net loss" or banking policy for MDOT for wetland development can be en effective way to retain development and wetlands simultaneously.

Required Length of Research Project: 36 months

Impact of Expected Outcomes and Implementation Timeline: The impact of expected outcomes would be an effective modeling tool to aid in policy decisions regarding wetlands. The urgency is high, given the high incidences of cancer in the US, perhaps caused by decreased wetlands. The implementation timeline would be for Objective (1) to take 6 months, Objective (2) 3 months, Objective (3) 1 year, Objective (4) 1 year, and Objective (5) 6 months.

Prioritization: High

RESEARCH PROJECT DESCRIPTION
Planning, Land Use & Environmental Impacts

Research Problem Title: Effect of Roadways on Occurrence of Cardiovascular Disease

Project Category: Environmental Concerns

Research Objectives and Outcomes: Research objectives include (1) selection of urban roadways in the State of Michigan for study, (2) field measurement of particulate matter in various locations around selected Michigan roadways, on people, in homes, and outside homes, thereby getting a better picture of exposure, (3) implication for human health through literature review, and geographic assessment of people suffering from respiratory disease to assess whether there is an elevated connection to place of residence (say near highways) and health and (4) recommendations for reducing human exposure to particulates.

Practical Importance: A few preliminary studies in the past couple years have shown that living near highways or busy streets elevates (a near doubling in one study) your chance of dying from cardiovascular disease. The likely culprit is chronic exposure to fine particulate matter. As industry falls under new regulations to reduce their fine particle emissions, roadway sources will become even more influential.

Technical Importance: Demonstrating this linkage between roadways and cardiovascular disease will lead to new technologies to mitigate adverse effects and therefore increase public health.

Required Length of Research Project: 36 months

Impact of Expected Outcomes and Implementation Timeline: The impact of the expected outcome can lead to improved public health through reduced cardiovascular disease. The urgency is attested to by the fact that cardiovascular disease is one of the leading causes of death in the US. The implementation timeline is for Objective (1) to take 2 months, Objective (2) 2 years, Objective (3) 1 year Objective (4) 6 months.

Prioritization:

RESEARCH PROJECT DESCRIPTION
Planning, Land Use & Environmental Impacts

Research Problem Title: Erosion Control

Project Category: Environmental Concerns

Research Objectives and Outcomes: (1) test existing MDOT erosion techniques and new innovative approaches in both the laboratory and field and (2) produce new MDOT guidelines on erosion control.

Practical Importance: Roadway drainage is crucial to the control of erosion that could cause roadway undermining and failure. Erosion can occur on highways and also in waterways spanned by bridges. Riverbank erosion can cause the waterway to outflank a bridge opening thereby eroding through the roadway on either side of the bridge.

Technical Importance: New methods of erosion protection are emerging. An evaluation of the current MDOT erosion control guidelines are warranted with the consideration of new techniques. Both current and potential new methods should be evaluated in a laboratory and filed study.

Required Length of Research Project: 36 months

Impact of Expected Outcomes and Implementation Timeline: The impact of expected outcomes would be to save the Michigan taxpayers money by the more efficient control of erosion. The urgency is high, given the importance of the transportation system to our economy and safety. The implementation timeline would be for Objective (1) to take 2 years and Objective (2) 1 year

Prioritization:

RESEARCH PROJECT DESCRIPTION
Planning, Land Use & Environmental Impacts

Research Problem Title: Wildlife Preservation

Project Category: Environmental Concerns

Research Objectives and Outcomes: (1) inventory wildlife ecosystem in roadway areas, (2) inventory wildlife ecosystem in non-roadway areas, (3) evaluate effect of roadways on wildlife ecosystem health, (4) investigate possibility of roadway alteration to improve wildlife ecosystem health.

Practical Importance: Roadways can affect wildlife behavior due to their blockage of animal transportation routes, noise, and fatalities by being struck by traffic. Methods need to be sought that allow animals to have safe passage while keeping the roadway functional for human traffic.

Technical Importance: The effect of roadways on animal migration and behavior is

Required Length of Research Project: 36 months

Impact of Expected Outcomes and Implementation Timeline: The impact of expected outcomes would be to increase ecosystem and animal health. The urgency is high, given the negative image of transportation effects on the environment. The implementation timeline would be for Objective (1) to take 1 year, Objective (2) 1 year, Objective (3) 6 months, and (4) 2 years.

Prioritization:

RESEARCH PROJECT DESCRIPTION
Planning, Land Use & Environmental Impacts

Research Problem Title: Right Model with Right Data for Right Studies*

Project Category: Travel Demand Forecasting/Modeling

Research Objectives and Outcomes: Travel demand models have been applied to various transportation planning and design studies. Although there have been many efforts to improve travel demand models, researchers point out the limitation of the conventional static modeling approach. Main deficiencies in the conventional approach are inaccuracy in travel time estimation and its heavy reliance on the inaccurate travel time. Recently much attention is paid to mesoscopic and microscopic traffic simulation models as a way improving travel demand models. While recent microscopic models provide great details of traffic and network performances, these models suffer from the heavy computational burden and the lack of high fidelity time-dependent travel data.

This project investigates what modeling approach is the most appropriate, and what data are required for the model. The decision depends on the scale of the study and the level of precision. Undoubtedly, micro modeling approach will provide more accurate and detailed result than macro models. However, gains and losses have to be understood in applying these models and the proper relationship between macro and micro models has be established whether the micro models will be replacement or supplement of macro models.
Objectives of this project are to establish the relationship between macro and micro models, and to provide a guideline to select the appropriate model by the scale and scope of studies. Tasks in this study include 1) classification of macro, meso, and microscopic models for travel demand analysis, 2) gains and losses by applied models, 3) scalability of micro simulation network, 4) relationship between macro, meso and micro models, and 5) appropriateness of analysis tool by the scope of studies and the level of data precision.

Practical Importance: This project will provide understanding of traffic phenomenon in travel demand modeling context in depth, and the relationship between model, data, and the scope of studies. Such understanding will lead to proper choice of analysis model for various studies. As an immediate application, the guideline will help determine analysis tools for traffic impact review studies by their scale and scope.

This project will also guide proper applications of microsimulation models in conjunction with conventional travel demand model, which will improve performance and forecasting accuracy and also enables evaluating traffic improvement projects with very detailed outputs that were not available in conventional static models.

Technical Importance: Successful completion of this project will lead for agencies to use appropriate model, which will improve the quality and usefulness of analysis output. Various performance measures will be identified from different aspects by understanding the availability of performance measures in different modeling approaches.

Required Length of Research Project: 24 months

Impact of Expected Outcomes and Implementation Timeline: Upon completion of the project, agencies will 1) apply the guideline to their model structures, 2) identify appropriate analysis tool for their studies, 3) begin developing database for microsimulation models, and 4) identify areas to be included in their microsimulation network.

Prioritization: High

*The Subcommittee agreed these high priority Research Problem Statements should be grouped together within the Travel Demand Forecasting/Modeling category and considered as linked efforts.

RESEARCH PROJECT DESCRIPTION
Planning, Land Use & Environmental Impacts

Research Problem Title: Application of Travel Demand Model to Work Zone Coordination *

Project Category: Travel Demand Forecasting/Modeling

Research Objectives and Outcomes: Even though road construction and maintenance (C/M) projects aim to improve transportation infrastructure and travel services, these road C/M projects become one of the main reasons causing traffic congestion on existing road transportation systems as well as traffic accidents in work zone areas. The number of work zones is increasing due to the aging infrastructure, and the increasing number of work zones demands spatial temporal coordination of these work zones for efficient use of the existing transportation network. Individually scheduled C/M projects may prevent drivers from using alternative routes due to another work zone. Consecutive construction/maintenance activities within a corridor, mainly due to the lack of coordination, become a source of public complaints. Spatially temporally concentrated work zones between some locations may lead to a serious problem in economic activities by causing a severe congestion. Furthermore, drivers' tiredness from a series of work zones in a corridor may lead to more traffic accidents.

In this project, the optimal scheduling problem is formulated as a minimization problem. The objective of the problem is to minimize the total system cost for all analysis periods with a constraint guaranteeing the minimum level of travel service between origins and destinations. The traffic pattern during each period can be analyzed by applying general user equilibrium traffic assignment problem. By applying travel demand model to coordinating C/M projects during a given period, this study aims to provide optimal coordination plan for multiple C/M projects.

Practical Importance: This project will extend applications of travel demand model to road construction scheduling. The optimally coordinated road C/M projects will reduce the road user costs by effectively using existing roads, and reduce drivers' complaints.

Technical Importance: The project will provide a tool to optimally coordinate road construction projects from users' point of view, considering both system level performances as well as user level performances.

Required Length of Research Project: 18 months

Impact of Expected Outcomes and Implementation Timeline: Upon completion of the project, agencies will be able to use the model developed in this project in scheduling their road construction projects.

Prioritization: High

*The Subcommittee agreed these high priority Research Problem Statements should be grouped together within the Travel Demand Forecasting/Modeling category and considered as linked efforts.

RESEARCH PROJECT DESCRIPTION
Planning, Land Use & Environmental Impacts

Research Problem Title: Synthesis and collection of speed studies and travel time for application and improvement of Travel Demand Forecasting Models.

Project Category: Travel Demand Forecasting Models

Research Objectives and Outcomes: Speed data are both network inputs and modeled outputs in travel demand forecasting and, since most Michigan traffic models use the traditional four step traffic forecasting model based on Newton's laws of gravity, speed/flow relationships also have a significant bearing on trip distribution, mode split and assignment. This topic has been a long concern in transportation models. Accurate speed estimation will certainly increase the model accuracy. This project is also related to calibration of link performance functions (LPF). In planning models the LPF should be calibrated, but in reality less attention has been paid to such efforts. Success of this project depends on data collection method, and how to deal with speed (or LPF) on signalized arterials where delays are governed by signal lights. However, most network inputs are typically estimates of free flow speed based on posted speed limits and may not be reflective of actual travel conditions or patterns. Similarly, speeds may be somewhat arbitrarily varied to improve model calibration, rather than to calibrate to real world speeds. Yet speed outputs (normalized, using HPMS speed estimates) are a major input into emissions models for air quality analysis, even though they may not match current "real world" travel flow characteristics.

For arterials, travel time may be more important than the speed limit. To address issues associated with travel times may require a unique approach which is related to, but using different methodologies than speeds. Part of this research will also be directed to developing and applying a compatible appropriate methodology (such as floating car studies) for collecting travel time data which is consistent with data gathered from speed studies and developing related default inputs.

This project will review literature on these topics, gather and synthesize existing speed studies and travel time data (where available) and stratify data by facility type, area type and for various sizes of urban communities, small cities, rural areas and all TMA's. It will identify gaps in existing speed and travel time data and develop and implement a data collection plan to fill any gaps identified. It will then identify alternative approaches to apply this newly synthesized speed/travel time data to improve Michigan's travel forecasting models to better match observed speeds and travel times. This applied research will improve model performance, thereby permitting greater confidence in the forecasts used to size new transportation facilities and update speed/flow relationships to improve model performance in emission modeling results. Emission models for certain pollutants are extremely sensitive to speed and most area's models are simply not getting developed based on real world speed or travel time data. This may result in greatly under or over-estimating emissions, the need for pollution control techniques and perceptions about public health impacts of these pollutants.

Practical Importance: A synthesis of speed and travel time data will improve travel model performance, VMT, VHT and related model output, as well as knowledge of actual travel conditions, which may have important safety and other implications besides modeling, such as reviewing speed limits for accuracy in relation to 85^{th} percentile speeds.

Technical Importance: Improving model speed data is critical to improving model performance and emission estimates, which could be over or under-estimated based on today's models. Improving model speed data and travel times should provide added confidence that emission estimates are accurate for quantifying need for pollution controls and health benefits.

Required Length of Research Project: 18 months

Impact of Expected Outcomes and Implementation Timeline: Speed and travel time data could be used to improve performance of Michigan models immediately after research being completed and work probably would be fully implemented within five years as each model is re-calibrated on five year cycles.

Prioritization: High

RESEARCH PROJECT DESCRIPTION
Planning, Land Use & Environmental Impacts

Research Problem Title: Benchmarking, sensitivity testing and backcasting to improve Michigan's Travel Demand Forecasting Models.

Project Category: Travel Demand Forecasting/Modeling

Research Objectives and Outcomes: Travel demand models are used for a variety of planning and design applications, including identifying future deficiencies, testing alternative solutions, sizing of future roadway facilities, analyzing transit demand and alternatives and various other applications.

Other application examples include regional impact assessment of major generators, detour studies, developing inputs for emissions models for air quality conformity analysis, scenario planning and corridor or sub-regional analysis.

While models are typically calibrated to current traffic volumes and to meet state and federal guidelines, little work has been done to test the sensitivity of Michigan's traffic models to variables in networks, demographic inputs, or various other attributes. No efforts to compare earlier forecasts to actual events are typically performed nor are techniques used (such as backcasting) to try to improve closeness of fits with between outcomes and inputs. Benchmarking various models against one another or to those developed using different methods or software is also not typically getting performed.

This lack of sensitivity testing, backcasting and benchmarking raises uncertainty about the validity and comparability of models and their results. Performing a variety of sensitivity tests, backcasting applications and benchmarking tests is generally felt to provide ways to identify where model performance can be further validated and improved.

Objectives would be to thoroughly conduct a series of sensitivity testing runs, backcasting applications and benchmarking studies of various Michigan local area models in representative smaller urban areas, and all TMA's to identify parameters of model performance and mechanisms which can improve both products and outcomes of individual models, but also the state of practice in Michigan models overall.

Practical Importance: Practical benefits will include a better understanding of the model performance and the accuracy of forecasts in various applications. Improving model performance and forecasting accuracy may result in better sizing of future facilities to meet demands and could result in substantial savings on future facility construction costs if research shows models today either over-estimate demand (resulting in excess capacity be built into new projects) or under-estimate demand (resulting in undersizing future facilities) which increases future deficiencies and construction costs.

Technical Importance: Successful completion of this project will identify new measures of model effectiveness (MOE's) and areas where model performance and modeling practice can be most improved on a statewide basis.

Required Length of Research Project: 36 months

Impact of Expected Outcomes and Implementation Timeline: New measures of effectiveness for model performance and better specifications to improve models and the state of the practice can begin being implemented immediately upon completion and would be phased in fully over a five year period as each model is recalibrated.

Prioritization:

RESEARCH PROJECT DESCRIPTION
Planning, Land Use & Environmental Impacts

Research Problem Title: Impacts of alternative designs on transportation safety and operations and non-motorized users.*

Project Category: Travel Demand Forecasting/Modeling

Research Objectives and Outcomes: There have recently been many innovative alternate designs introduced into traffic engineering such as modern roundabouts, mini-traffic circles, narrowing down of lanes from four to three, sometimes with bicycle lanes, new street design standards for context sensitive thoroughfares being developed by ITE and the Congress for New Urbanism, "skinny streets" using narrower lanes and road widths, speed humps, chokepoints, speed tables, short medians, mid-block crossings, two lane slow points, median barriers, various designs for diverters and similar examples of traffic calming. Altered local street designs (such as the alley/lane/street/avenue/Main Street/boulevard/parkway hierarchy developed in the Healthy Neighborhood Street Design Guidelines for the City of San Joaquin, California) or guidelines for local streets (ITE/City of Portland), Traditional Neighborhood Developments (TND's) and other communities (Wilmington, Delaware/Boulder, Colorado) also should be evaluated which are being developed and applied around the United States and may be appropriate to consider in Michigan. Most of these have been introduced to enhance safety through traffic calming. While most of these designs seem to make sense, there is little information, especially in the Michigan context, as to the extent that these designs enhance safety, ease of movement for pedestrians and bicyclists, or increase the number of people walking and riding bicycles in a community and their related impacts on traffic operations and safety. An objective well-structured evaluation is needed to examine and quantify the effects of alternative designs on pedestrian and bicycle movement and safety and their impacts on traffic operations.

The objective of this study is to evaluate the effect of alternative designs, including examples listed above and other design innovations on the safe movement of pedestrians and bicycles and on traffic operations and safety. The suggested methodology is a two phased approach. The first phase being a literature review/state-of- the practice review, then before and after studies that control for possible changes in other factors such as demographics and population size. Outcomes of the study would quantify changes in safety with respect to crash and injury frequencies and rates, changes in the ease of movement/delays, changes in the volumes of pedestrians and bicyclists and the impacts on traffic flow and safety. The effects on pedestrians and bicyclists should be differentiated by age. The effects on vehicular traffic, e.g., volumes, speeds, crashes would also be quantified with a view to identifying potential future guidelines for applying these designs (if appropriate), and/or constraints or impacts for these types of applications, including factors which could be used in a time of return analysis.

Practical Importance: Results of this evaluation study would help communities make informed decisions about investments in alternative designs.

Technical Importance: Quantify the effects of alternative designs on traffic operations and safety.

Required Length of Research Project: 12 months (if archival data is used)

Impact of Expected Outcomes and Implementation Timeline: Evaluation results would be used immediately by communities making decisions about alternative designs

Prioritization: High (A joint meeting of members of the MTRB Planning, Land Use and Environmental Impacts, Traffic Safety and Operations and Non-Motorized Committees, along with representatives of the GTSAC Non-Motorized Action Team and representatives for Safe Routes to Schools programs and the user community, concurred that this effort was their highest research priority of mutual concern among those participating.)

* Note: Similar problem statements and needs are also in reports from both the Non-Motorized and Traffic Safety and Operations Committees.

RESEARCH PROJECT DESCRIPTION
Planning, Land Use & Environmental Impacts

Research Problem Title: Evaluating Transportation/Land Use Scenario Analysis Tools for Use in Various Geographic Settings

Project Category: Scenario Planning

Research Objectives and Outcomes: This research project will provide planning entities with insight on the practical application of scenario planning tools in various geographic settings, e.g. multi-county regional, county, subcounty, and local community.

Practical Importance: Numerous scenario planning tools are available and range widely in their technology, purpose, function, and needs. Scenario planning can be an effective tool in making decisions on infrastructure development and maintenance, community service amenities, conservation of vital environmental resources, and overall quality of life issues.

The Michigan Transportation Summit Transportation/Land Use Action Team recommended that the 14 planning regions be required to develop regional multi-modal transportation plans and that such plans be done through transportation/land use scenario planning. While this is certainly a good planning practice, it is a lofty assignment for the state's regional planning regions, many of which do not have the resources to carry out such work. The cost of sophisticated scenario planning tools (models and data requirements) may be prohibitively expensive to many of the regions.

Technical Importance: This project would provide direction on the use of scenario planning in various geographic settings based on purposes, size of area, and budgets.

Required Length of Research Project: six months

Impact of Expected Outcomes and Implementation Timeline: Through a literature search, the project would suggest which suite of scenario planning analysis tools are best suited for the purposes and budgets of various geographic areas. This outcome should be communicated through the preparation of a paper with descriptions of tools available and case examples on their use. A conference or workshop could be convened to present findings.

Prioritization: High

RESEARCH PROJECT DESCRIPTION
Planning, Land Use & Environmental Impacts

Research Problem Title: Development of a Michigan Trip Generation Manual

Project Category: transportation planning, development impacts

Research Objectives and Outcomes: The ITE develops and publishes the "industry standard" for developing trip generation estimates for various land uses and new developments. These estimates are critical in assessing the impacts that various proposed developments are expected to have on the local transportation infrastructure. ITE's rates and equations are often based on relatively few data, rely on overly simplistic univariate relationships, and may be biased for certain regions of the country. Thus, there are questions regarding the applicability of the ITE-based estimates in specific situations. In addition, there is no mechanism for gathering and synthesizing trip generation studies performed in Michigan for some land uses with specific characteristics (e.g., Meijer's) or where national rates are neither available or reliable (e.g., Michigan casinos). Research is needed to validate ITE-based trip generation estimates for selected land uses, synthesize studies performed in Michigan and, if ITE-based estimates are found wanting, develop new models specific to Michigan.

This research should be done in two phases. The first phase has the following objectives: 1) establishing the extent to which there have been trip generation studies done in Michigan, 2) synthesizing those studies, 3) comparing Michigan results with those provided in ITE's standard references, 4) identifying land uses where additional work is needed, and 5) establishing a procedure for maintaining a common resource/reference, the ***Michigan Trip Generation Manual***, that can be used by local jurisdictions and consultants. The second phase is based on the results of the first and is done only if additional work is indicated. Assuming that it is, the second includes 6) undertaking the field studies necessary to establish rates for those uses identified in the first phase and 7) updating the ***Manual***. Wide dissemination of results of both phases of the project to local jurisdictions and consultants in Michigan is imperative.

Practical Importance: The benefits of this study include the establishment of a common reference for assessing traffic-related development impacts in Michigan. As a result, there should be fewer disputes regarding the traffic impacts of new development.

Technical Importance: The common reference should result in more reliable models and dependable assessment of development impacts.

Required Length of Research Project: Phase 1—12-18 months; Phase 2—18-24 months

Impact of Expected Outcomes and Implementation Timeline: Fewer disputes regarding development impacts; implementation should be immediate after completion of the project.

Prioritization:

Note: A partnership with the Michigan Section and/or student chapters of the Institute of Transportation Engineers should be explored to facilitate data collection and summation for the Michigan manual and to assure coordination of submittal of Michigan data with the national ITE Trip Generation Manual. This might be facilitated by a licensing arrangement between ITE headquarters and the Michigan Section of ITE for ITE's trip generation software.

RESEARCH PROJECT DESCRIPTION
Planning, Land Use & Environmental Impacts

Research Problem Title: Development Impact Review Process and Procedure

Project Category: transportation planning, development impacts

Research Objectives and Outcomes: There is a need for a general procedure and guidelines for development impact reviews that is accepted by developers, consultants, and various jurisdictional levels. Currently, it is the view of many local jurisdictions that developers and their consultants will try to get their proposals approved with the minimum amount of information about the comprehensive impacts of the proposed development. Conversely, consultants and developers feel that local jurisdictions are overzealous in the need for information regarding their developments, making the development review process overly complex and time-consuming. While the assessment of development impacts on the transportation system is perhaps most mature, there is need for integration of information on transportation and other infrastructure, health, and economic impacts, among others so that jurisdictions can make development-related decisions in a timely fashion and on the best information possible. In this context, there is the clear need for an objectively-developed procedure and guidelines for assessing the impacts of proposed developments. One model for at least part of this work is ***Evaluating Traffic Impact Studies: A Recommended Practice for Michigan Communities***. However, this document is limited to only traffic impacts. Other, more current, Michigan-based work is addressed to developing a health-impact assessment procedure (Foster and Enslin). These fragmented efforts and others need to be brought together in a procedure/process that is fair to developers and sensitive to the needs of the jurisdictions in which development is proposed. It is also important to evaluate how the development review process affects the progress of development. A differentiation needs to be made between actual and perceived costs of "delays" due to the review process. Having a clear process in place should provide good information in place so that developers can plan their investment strategies rather than having them "delayed" for review.

Objectives for this project include: 1) a review and synthesis of work done within Michigan and nationally in terms of developing development review processes that are either specific to particular impacts (e.g., transportation) or more comprehensive; 2) an assessment (done concurrently) of how well various procedures work and how they impact the time frame for the development process; 3) determination of thresholds for how extensive a review needs to be undertaken (i.e., recognition of the fact that an appropriate review for a 50-unit residential development is different from the review for a regional shopping mall); and 4) the development of a comprehensive model process. A follow-on project could include 1) the development of computer-aided processes that support the model process and 2) model ordinances for development review. The review and synthesis would involve not only a traditional literature review but also survey-based and/or focus group work with Michigan-based developers and jurisdictions at various levels.

Practical Importance: The existence of a "model procedure" for development review would be of significant benefit to local jurisdictions, especially to those without large professional staff. Similarly, having a known "set of rules" would help developers plan their development investments.

Technical Importance: The development of a comprehensive and unified development review process would have local, statewide, and potentially national impact.

Required Length of Research Project: 24 months

Impact of Expected Outcomes and Implementation Timeline: While the impacts of the project would be substantial, adoption of model processes and/or ordinances would take some time.

Prioritization: High

Note: This research supports recommendations from the Michigan Transportation Summit Land Use Action team which has transmitted a draft RFP for MDOT's consideration.

RESEARCH PROJECT DESCRIPTION
Planning, Land Use & Environmental Impacts

Research Problem Title: Transportation Investment and Sprawl in Michigan

Project Category: transportation planning, development impacts

Research Objectives and Outcomes: It is widely assumed that investment in the transportation system is related to sprawl in the proverbial manner of the chicken and the egg. Transportation investment can be used proactively to guide development to selected areas or in reaction to problems caused by development. What is not known for Michigan is the extent to which transportation investment in system expansion (e.g., new roads, substantially widening existing roads) results in sprawl, generally assumed (although questioned by some) to be a negative outcome.

While there are numerous projects that could defined within this general statement, a basic "first step" has the following objectives: 1) a comprehensive literature review must be done that focuses on the impacts of transportation investment on development and sprawl (as opposed to the effect on travel behavior); 2) reliable quantitative definitions of sprawl must be developed (e.g., population density); 3) the nature and extent to which transportation investments can be documented must be determined; and 4) the relationship between these two sets of variables (development/sprawl, transportation investment) must then be developed. This research needs to build upon the recent report, ***Michigan's Land, Michigan's Future*** by Michigan Land Use Leadership Council and other work done elsewhere (e.g., Hartgen in North Carolina, Duecker/Sanchez in Oregon). A second phase (or project) would include using the developed relationship to determine if and how specific asset and/or fund management strategies can be developed and used as effective tools in controlling sprawl and encouraging development in targeted areas. Also as a part of the second phase, the relationship between base year asset/fund investment in an area leads to the need for future investment in the same area. For example, does a proactive investment in an area targeted for development today lead to a required reactive investment in the future?

Practical Importance: Development of a reliable relationship between transportation investment and development/sprawl will lead to better understanding of the impact of different asset/fund investment strategies and would have local and state policy implications.

Technical Importance: Better understanding of transportation investment/development relationship would have national importance.

Required Length of Research Project: 24 months for first phase; 12 months for second

Impact of Expected Outcomes and Implementation Timeline: The expected outcomes are important with potentially very large policy change implications. Implementation of resultant policies could only be measured over the long term and would likely be controversial.

Prioritization:

RESEARCH PROJECT DESCRIPTION
Planning, Land Use & Environmental Impacts

Research Problem Title: Integrating Environmental Mitigation in the Planning Process

Project Category: Environmental Concerns

Research Objectives and Outcomes: Objectives include (1) conduct review of current planning process, (2) if not included, develop Life-Cycle Cost Analysis of MDOT projects, (3) add external costs to environment in life-cycle assessment, and (4) develop guidelines for integrating environmental mitigation in the planning process.

Practical Importance: Many projects are planned based on initial construction costs, perhaps even over the life cycle of the project. This project adds external costs to the environment as well and thus protects the environment as well as providing for safe transportation infrastructure. This is in line with Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU).

Technical Importance: There have been no studies thus far looking at the external environmental costs to transportation projects, either in Michigan or the US.

Required Length of Research Project: 36 months

Impact of Expected Outcomes and Implementation Timeline: The impact of the expected outcomes would be improved human health and the associated reduction of health care costs while maintaining our current high level of transportation safety and reliability. The urgency is high given the high cancer rates in the US. The implementation timeline for Objective (1) to take 6 months, Objective (2) 1 year, Objective (3) 1 year, and Objective (4) 6 months.

Prioritization: High

Appendix M
Border Issues and Homeland Security Committee: Detailed Problem Statements

RESEARCH PROJECT DESCRIPTION
Border Issues and Homeland Security

Research Problem Title: Potential Impacts of the Western Hemisphere Travel Initiative on Border/Traffic Management at Canada/U.S. Land Crossings

Project Category: Border crossing efficiency / Homeland Security

Research Objectives and Outcomes: An estimated 300,000 persons cross land border check points between Canada and the United States every day. Trade between the two countries further accounts for a $2-billion per day commerce. Following the events of 9/11, the United States has been seeking ways to enhance border security. One of the measures that have recently been adopted is to require all travelers entering the United States to show a passport or other documents demonstrating citizenship. This measure, part of the Western Hemisphere Travel Initiative, will require all travelers entering the United States by air and sea from Canada and Mexico to show a passport by December 2006. Land border crossings will require identification documents by January 1, 2008. The same requirements would apply to travelers entering Canada.

One of the main fears regarding the Western Hemisphere Travel Initiative is that it may become a significant inhibitor to the free flow of travel across the land borders between Canada and the United States. This problem stems not only from the potential for additional delays at the border, but also from the fact that it could affect spur-of-the-moment decisions to cross the border. While the form of identification that would be required is still being debated, it is unlikely that the standard driver's license in use today will be allowed. Many travelers who currently frequently cross the border for leisure or business purposes may then decide not to cross anymore due a lack of proper identification.

Currently, frequent border crossers have the option of participating in the NEXUS pre-clearance program to obtain quick and easy access to either the United States or Canada. The United States has already said that NEXUS identification documents will be an acceptable alternative document to the passport. Identification cards from the FAST program, which offers pre-authorized importers, carriers and drivers expedited clearance process for eligible goods will also be accepted. However, for persons not participating in the NEXUS or FAST programs, the cost, and hassles, of obtaining a passport or other appropriate form of identification may still negatively impact travel decisions. The objective of this research would be to assess the potential impacts of the identification requirements imposed by the Western Hemisphere Travel Initiative on travel demand across the Canada-U.S. border. The research may look at the following issues:

- Expected increased in border crossing times due to the need to check identification of all travelers.
- Expected cost for travelers without proper identification to obtain the appropriate documents.
- Impacts of new identification document requirements on leisure and business travel by individuals.
- Indirect impacts of new identification document requirements for casual travelers on truck shipments in the possibility that it may generate traffic backups affecting truck movements.
- Availability of new technologies to expedite identification verification at border crossings.

As there are currently various evaluations being conducted on this matter by the Department of Homeland Security, research efforts will need to be coordinated with this agency to avoid duplication. Research efforts may also need to be coordinated with efforts undertaken by other working groups on border issues, both in Michigan and at the national level.

Practical Importance: The practical importance of this project is associated to the fact that the new requirements for identification at border crossings will apply to every person attempting to enter the United States by land from Canada. These requirements may not only generate more delays at the border crossings but may reduce last-minute trip decisions by individuals not having the proper identification or who cannot afford the costs of obtaining the

proper document. As an example, a family of five who does not have passports may then be required to spend about $100 per person, or $500 total, just for a trip across the border. By requiring identification checks from all travelers, the WHTI may further causes serious backups in auto travel at peak times.
Technical Importance: The research is expected to help assess the potential impacts of the new border initiative on identification documents. In particular, it may help assess what form of travel documents may be best allowed to fulfill the security aspects of the initiative without negatively impacting demand for border crossings. Research results may also complement the various evaluations currently being conducted by the Department of Homeland Security on this matter.
Required Length of Research Project: 12 months
Impact of Expected Outcomes and Implementation Timeline: Depending on the outcomes of the research, new form of identification or new technologies could be implemented in a short to medium term. Information would also be made available to justify or push for modifications to elements of the Western Hemisphere Travel Initiative.
Potential Funding Sources: U.S. State Department, Department of Homeland Security, U.S. Embassy in Canada, Department of Foreign Affairs of Canada (depending on terms of reference), tourism interests in both the United States and Canada.
Prioritization: This project is given a High priority level given the current implementation schedule of the Western Hemisphere Travel Initiative, which calls for all travelers to show proper identification by January 1, 2008.

RESEARCH PROJECT DESCRIPTION
Border Issues and Homeland Security

Research Problem Title: Ownership, Tenure and Governance of the Proposed Detroit-Windsor River Crossing

Project Category: Border Crossing Efficiency

Research Objectives and Outcomes: The United States and Canada share the largest trading relationship in the world. This relationship currently accounts for approximately $150 billion of annual surface trade between Southwestern Ontario and Southeastern Michigan, a figure expected to reach $250 billion by the year 2030. The Central Business Districts (CBDs) of the cities of Detroit and Windsor are currently connected by a bridge and a tunnel, both built during the late 1920s. The Ambassador Bridge is a privately owned and operated four-lane suspension bridge, while the Detroit-Windsor Tunnel is a two-lane facility jointly owned by the two cities and operated by a private corporation. These two facilities currently provide a vital trade-corridor between the US and Canada in the Midwest. Other crossings in the regional vicinity are the Blue Water Bridge between Sarnia, Ontario and Port Huron, Michigan (owned by the state of Michigan), as well as rail tunnels and ferries across the St. Clair and Detroit Rivers, that are mostly privately owned. The vehicular crossings between Southwest Ontario and Southeast Michigan are the busiest of all Canada-US border crossings, and the Ambassador Bridge ranks the highest in commercial vehicles among all US border crossings.

During the last few years, a number of studies have been undertaken by the Michigan Department of Transportation and the Ontario Ministry of Transportation to investigate the need, location and type of a proposed third river crossing connecting the cities of Detroit and Windsor. These studies appear to indicate a need of a river crossing, while the exact location and type (tunnel, bridge, etc) of such a crossing are yet to be determined. An environmental impact study currently underway is expected to address the issues of location and type. To the best of knowledge, no decision has been made on the ownership, tenure and governance of the proposed crossing.

The proposed study is built upon the premise that a new crossing (costing between $400 and $500 million) will be built in the near future. The central question to address is *"Should the new crossing be owned and operated by a public agency (such as MDOT for example), so that the taxpayers can benefit from the revenues likely to be collected over the life of the project? Or, should the ownership and operating rights be left to the private enterprise, thereby protecting the public at large from the risks associated with this investment?"* A third alternative could be joint public-private ownership, with clearly defined rights and responsibilities. It appears that there is a strong interest on the part of the private enterprise on either side of the border to own and operate such a new crossing, if proposed. ***An investigation of the fiscal, institutional and the legal issues associated with ownership, tenure and governance of the new crossing (public vs. private vs. joint) is the question to be addressed in this proposed study.***

Practical Importance: The proposed research, along with a number of other studies (either completed or currently underway), will provide the basis for the construction and ownership of a much-needed river crossing connecting the U.S.A. and Canada to serve the growing freight traffic demand between the two countries in the Southeastern Michigan area.

Technical Importance: The proposed study will explore the application of the concept of investments under uncertainty as a means of decision making for a major infrastructure program.

Required Length of Research Project: 24 months

Potential Funding Sources: Michigan Department of Transportation, Ontario Ministry of Transportation.

Prioritization: Medium

Appendix N
Aviation, Maritime, Rail and Freight Committee:
Detailed Problem Statements

RESEARCH PROJECT DESCRIPTION
Aviation Education / Maintenance Engineering

Research Problem Title: Gap between technology and technology education

Project Category: Technology Education

Research Objectives and Outcomes:
Expanded Problem Description**:** Manufacturing industries continue to be the leading edge of technology with rapid development of increasingly sophisticated and complex products in many domains. As a consequence, technology has increased at a much greater rate than our ability to support it. A serious gap now exists between technology and the support of it and technology education. Customers demand that any manufactured product needs to be designed to include high reliability, maintainability and cost effectiveness. A survey of key aviation industry representatives indicated strong support for development of academic programs in Maintenance Engineering and Technology. In fact, relevant technology education is an important factor for *any industry*, not just aviation.

Research Objectives: Develop this innovative, yet long overdue, educational program.

Research Outcomes: (i) established networks between government, industry and academia; (ii) offering an optimum technology degree curriculum in transporation; (iii) customized technical courses for the high-tech transportation industry; (iv) enlisted student population; (v) formulation of upward articulation agreements with industry for internships, joint research projects, shared expertise.

Practical Importance: By fostering specialized connections between the state government transportation organizations, industry, and academia the transportation industry will benefit from having a qualified workforce. Students benefit from quality education, solid career paths, valuable internships, and research opportunities. Faculty gain subject matter expertise, and create research opportunities.

Additionally, women and minorities make up a very low percentage of the population in technical fields, and underrepresented individuals need to be considered in the development of any new program. The United States is producing a small fraction of the technically educated global workforce. Participation of women, who make up 50% of the workforce in the United States, is a necessity.

Having a strong foundation in automotive design and manufacturing technology places Michigan in the unique position to build on and apply existing expertise toward all other modes of transportation. Materials, manufacturing techniques, smart systems and diagnostics are a few of the technologies that can be evaluated for incorporation into multi-modal transportation systems.

Technical Importance: Currently, university degrees are conferred in engineering disciplines such as aeronautical, mechanical and industrial engineering. These disciplines rarely focus on product support and life-cycle servicing. Maintenance technicians, such as Aviation Maintenance Technicians, are typically trained in community colleges or through practical experience. The requirements for aviation technician programs are governed by federal regulations and have changed little in 40 years. No collegiate degree programs address the expertise required to monitor, evaluate and remediate high tech products during their service life. Thus, associate degree graduates of the technical schools have a very steep learning curve upon entering the workforce which is caused, in part, by the gap existing in technology education. Therefore, necessary skills are acquired through company sponsored training programs and on-the-job (OJT) training. Therefore, there is a need for maintenance engineering technology education. This educational program has intellectual merit and can yield significant benefits to industry as well as provide a logical progression for students from undergraduate Science, Technology, Engineering and Math (STEM) education to highly valued career paths.

Required Length of Research Project: 36 months
Impact of expected Outcomes and Implementation Timeline: Achieving the highest quality transportation services with the goal of economic benefit and improved quality of life is possible with an increased focus on training and education, diversity and job opportunities.
Prioritization:

RESEARCH PROJECT DESCRIPTION

Aviation Safety/Aircraft Surveillance

Research Problem Title: Establishing Automatic Dependent Surveillance-Broadcast (ADS-B) in the State of Michigan

Project Category: Aviation Safety:
Enhanced aircraft traffic surveillance
In-cockpit weather availability
In-cockpit Aircraft Traffic Reporting

Research Objectives and Outcomes:

Automatic Dependent Surveillance-Broadcast (ADS-B) is a new technology that is redefining aviation communication, navigation, and aircraft surveillance. ADS-B is a viable and low-cost replacement for conventional radar that allows pilots and air traffic controllers to monitor aircraft traffic, in real time, with increased precision, both in the air and on the ground. The system uses satellite-based, global positioning system information to determine precisely an aircraft's location. This information, in turn, is continuously transmitted through a digital datalink between ground stations, satellites, and other aircraft. Because of its robust nature, ADS-B's usefulness can be extended to include law enforcement, emergency medical services, and homeland security and defense.

In the late 1990s, the Federal Aviation Administration (FAA) established the Safe Flight 21 program as a joint government/industry initiative to validate the capabilities of the ADS-B system in a real-world environment. Subsequently, the ADS-B system was pilot tested in Alaska under the "Capstone Program." Because of the system's accuracy, and clear benefits over existing radar systems, Capstone found that ADS-B enhanced safety, and increased the efficiency and capacity of the airspace system.

In the first phase of this project, I propose to research the value of establishing ADS-B technology in the State of Michigan. My study will explore the safety and efficiency of air operations, as well as the associated economic benefits for air carriers and general aviation, and the communities they serve. Working in conjunction with the Safe Flight 21 and ADS-B programs in Washington D.C., installation of ground based transmitters, air traffic control units, and aircraft avionics will begin upon completion of the initial study.

Practical Importance:

The primary benefits of ADS-B technology are increased safety, and increased efficiency and capacity of the National Airspace System (NAS). In addition to the surveillance aspect of the ADS-B system, the "bundle" also incorporates Traffic Information Service-Broadcast (TIS-B) and Flight Information Services-Broadcast (FIS-B).
Traffic Information Service-Broadcast provides pilots with real-time awareness of other aircraft in their vicinity. This information is broadcast from a ground facility to the aircraft, from a satellite to the aircraft, or from aircraft to aircraft; and is depicted on a cockpit display. Using TIS-B information, pilots are better equipped to identify visually aircraft that may be a potential hazard.

An additional safety feature of TIS-B is to reduce the frequency of runway incursions, particularly at Michigan's larger airports. Traffic Information Service-Broadcast technology works equally as well on the ground as it does in the air. It provides improved navigation on taxiways and enhances management of surface traffic. The reduction of runway incursions has been first on the National Transportation Safety Board's "most wanted" aviation safety improvement list since the list's inception in 1990.

Flight Information Services-Broadcast provides near-real-time graphical weather and other information, including graphical terrain depictions, to the cockpit display. Pilots will use this information to avoid hazardous weather situations, to maintain situational awareness, and to make critical decisions regarding the safety of flight while en route.
Michigan's unique geography and relatively sparse population in its northern sections, make it an ideal region for implementation of ADS-B. In the northern portions of the state, radar coverage is sporadic for aircraft flying at lower altitudes, and airplanes on the ground often have to communicate with Air Traffic Control by relaying messages through airborne aircraft. ADS-B technology will eliminate these deficiencies and will expedite all-weather instrument approaches into Michigan's northern population centers. In addition, the technology will provide enhanced safety for aircraft flying over the Great Lakes.

On an economic basis, installation of an ADS-B ground based transmitter is about 10 percent the cost of a traditional radar site; and ADS-B is more capable and precise than radar. In addition, ADS-B technology is a logical extension to the Michigan Department of Transportation's All-Weather Airport Access Plan. By extending aircraft surveillance to the ground, all-weather access to Michigan's airports will be significantly enhanced; thereby providing air commerce to communities who are not currently served. Such a service will provide economic benefits to smaller communities throughout the State.
Technical Importance: On the national level, ADS-B technology is vital for homeland security and national defense. Aircraft transponders, which are currently used for air traffic control and surveillance, require the pilot to enter a discrete four-digit code for air traffic identification. A transponder can be turned off, as was made horrifyingly clear on September 11, 2001. The ADS-B system is always on, requires no operator intervention, and continuously broadcasts surveillance data to air traffic controllers and other aircraft, in the air and on the ground.
Required Length of Research Project: 2 to 3 years
Impact of Expected Outcomes and Implementation Timeline: The calibrated joint design models will be included in the new design guide.
Prioritization: