# Western Transportation Institute
# University Transportation Center

## 2006 Annual Report
*(For the period October 1, 2005 - September 30, 2006)*

College of Engineering
Montana State University


**Contact Information:**
Western Transportation Institute
P.O. Box 174250
Bozeman, MT 59717-4250

*Phone:* 406-994-6114
*Fax:* 406-994-1697
*Web:* http://www.coe.montana.edu/wti


**Note:**
WTI is a department of the College of Engineering at Montana State University


**Report Staff:**
Carla Little
Carol Diffendaffer


*Photos:*
Front & Back Cover *Neil Hetherington*
Inside photos: *WTI Staff*

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# Mission Statement

*To lead the nation in "making rural travel and transportation across all surface transportation modes safer, more efficient and more convenient."*

# Message from the Director

I am pleased to present the Western Transportation Institute's UTC Annual Report for 2006.

As we look forward to the first year of our renewed UTC designation and grant, this is an exciting time of growth and planning for the future. As we crafted our new Strategic Plan, we worked hard to align our goals to take advantage of our research strengths as well as to address critical emerging issues. As a result, we are conducting nationally recognized research in areas as diverse as road ecology, infrastructure maintenance, and rural highway safety. Some of the new projects we have kicked off for this year include:

•Synthesizing context sensitive design information that can help rural areas conduct environmentally sound transportation planning,

•Expanding our electrochemistry research to investigate fuel cells and motor vehicle rechargeable batteries, and

•Using a high fidelity driving simulator as a tool for evaluating driver behavior and highway design improvements.

In addition to conducting leading-edge research, WTI provides increasing leadership to the transportation community in other ways. I am proud to serve on the Council of University Transportation Centers (CUTC) Executive Committee and look forward to my new appointment as CUTC liaison to the AASHTO Research Advisory Committee. In these roles, I can play an active part in shaping the direction of national transportation research.

As a well-established UTC, WTI offers a wealth of experience and institutional knowledge to share with other centers. By hosting the CUTC Annual Meeting this year, WTI provided a forum for sharing ideas with existing UTC's and for mentoring newly created ones. In particular, we received terrific response and feedback from the two new sessions we initiated: one to introduce best management practices for administering centers and another to guide the creation of successful education programs.

The year ended on a high note when WTI hosted both the National Rural Emergency Medical Services Summit and the National Rural ITS Conference (NRITS) in Big Sky, Montana. Nearly ten years ago, WTI spearheaded and hosted the first NRITS Conference, and it was extremely gratifying to see how the event has grown and how much progress we've made in the field of rural transportation research.

Finally, I would like to personally thank and acknowledge the Research and Innovative Technologies Administration of the U.S. Department of Transportation, as well as our Governing Board members: the Montana Department of Transportation, the California Department of Transportation, and Montana State University's College of Engineering and Civil Engineering Department. Without their support and assistance, the accomplishments described in this report would not have been possible. I look forward to another productive year of working together.

*Steve Albert*
Director

# Message From the Governing Board

The Montana Department of Transportation and the Western Transportation Institute have a successful, synergistic partnership that serves the state well.

At its most basic, this collaboration allows the two entities to work together to improve the transportation infrastructure in the state. MDT and WTI identify challenges, test and evaluate potential solutions, and implement new procedures or technologies based on the findings.

But in a larger sense, our agencies play an important role in promoting a robust economy in Montana. An efficient transportation system is essential to keeping people, goods and services moving through the state, so our joint efforts to keep Montana at the leading edge of transportation improvements will help ensure that we build and maintain such a system.

Conducting transportation research in cooperation with Montana State University also has many long-term economic benefits for the state. By conducting "real-world" research on behalf of MDT, the student research assistants at WTI are getting hands-on experience that will prepare them to be the next generation of transportation engineers, managers, and planners. The growth in research (and related funding) coming into the university has enhanced the reputation of MSU as a leading research center, which attracts an educated workforce and more businesses to the state.

As you read this annual report, you will see how MDT and WTI are working together to advance the latest research on issues that range from road ecology to winter maintenance techniques. I am confident that our partnership will continue to enhance both the mobility and vitality of the state.

*Jim Lynch*
Director, Montana Department of Transportation
WTI Governing Board Member

# Message From the Governing Board

If you're reading a WTI annual report for the first time, you might be surprised to learn that the California Department of Transportation (Caltrans) is on the Governing Board of a university research institute that specializes in rural transportation issues. In fact, Caltrans was a founding member of the organization back in 1994, and has had an active, growing, successful research partnership with WTI ever since.

For many people, transportation in California brings to mind multi-lane freeways and urban congestion. But California also has vast rural regions, where two-lane highways are the lifeline that connect people in small communities to the goods and services they need. The trucking industry depends on these highways, as do the millions of tourists who want to visit our recreational attractions and natural wonders. It is critical for Caltrans to maintain safe and efficient travel on these roads as well.

WTI offers expertise in developing effective transportation solutions tailored to the rural environment, and California offers a large "testbed" in which they can be installed, evaluated, and refined. Through this partnership, Caltrans and WTI are deploying some exciting technologies, including Intelligent Transportation Systems and communication advancements.

In just one example, WTI is developing "Redding Responder," a mobile data communications system centered specifically on the requirements of Caltrans District 2 field personnel and the Redding Traffic Management Center. The tool will allow field crews to use a Tablet PC to exchange detailed information about incidents with the TMC, even when the crews are in remote locations. We are excited that we can now move Responder to the next stage of production and deployment. Here is a quote from one of the pilot users:

"*I used the Responder to send photos and maps to our dispatch after hours and our dispatcher forwarded the info. in an email to the water district to give them an exact location to pinpoint the location. To try and explain the location over the phone or radio would have been difficult at best. The machine is a very useful tool, as a matter of fact can I keep it?*"

California benefits from tangible solutions to specific transportation challenges, and WTI documents findings and develops successful models that can be adapted and applied in other states.

By providing the rural perspective on transportation issues, WTI helps ensure that Caltrans has a comprehensive and effective research and deployment program. I look forward to our continued efforts to improve the transportation infrastructure in California, and to further the state-of-the practice throughout the country.

*Lawrence H. Orcutt*
Chief, Caltrans Division of Research and Innovation
WTI Governing Board Member

# Administration

The following section provides an overview of the administrative functions, structure, achievements and initiatives of the Western Transportation Institute.

## Management Structure

As the Montana State University (MSU) focal point for transportation research and technology transfer, the Western Transportation Institute's (WTI) University Transportation Center (UTC) mission is to lead the nation in "making rural travel and transportation across all surface transportation modes safer, more efficient and more convenient." Established in 1994 by the Montana and California Departments of Transportation, in cooperation with MSU, WTI has focused on rural transportation challenges for eleven years. Now recognized as a leader in rural deployment of Intelligent Transportation Systems, WTI has conducted research projects in over 30 states.

Physically located in the College of Engineering, WTI has a 50 person multidisciplinary research staff of students, professionals and associated faculty from engineering (mechanical/industrial/civil/electrical), computer science, psychology, fish and wildlife, land resources and environmental sciences, biology and economics. Our professional staff alone has more than 150 years of combined experience in the field of rural transportation research, with technical expertise in such areas as rural tourism, traveler information, communications, small transit systems, weather and mobility, corrosion, materials science, and infrastructure design. WTI concentrates on meeting the growing demands for additional transportation professionals by providing students with "hands-on" experience, and conducting research that will make a difference in the everyday lives of the people of Montana and rural America.

The University Transportation Center management approach has been designed to accomplish the following objectives:

- Provide high quality, multi-discipline research, education, and technology transfer;
- Enrich the student, faculty and professional staff experience;
- Provide WTI's sponsor and governing board members with clear, concise and accurate reports of WTI's activities so that they may adequately assess our performance and guide the long-term development of the organization;
- Utilize MSU resources (research and training facilities, human resources, physical facilities and institutional support capabilities) to the fullest extent possible in supporting WTI activities; and
- Promote a productive work environment by establishing clearly defined roles, responsibilities, policies and procedures for all staff.

## Administrative Staff

The administrative staff manages the Center's research, education, and technology transfer activities and utilizes the systems, policies, and procedures already in place at MSU to manage funds, equipment and personnel.

**Jeralyn Brodowy**
*Assistant Director of Administration*

**Catherine Heidkamp**
*Assistant Director for Communications and Information Systems Technology Transfer Coordinator*

**Paris Hodgson**
*Accounting Technician*

**Roberta Colvin**
*Accounting Technician*

**Carolyn Marx**
*Administrative Associate*

**Susan Gallagher**
*Education Program Coordinator*

**Carol Diffendaffer**
*Editor I*

**Neil Hetherington**
*Media Specialist*

**Carla Little**
*Proposal Development Manager*

## Administrative Success Story

### Strategic Hires Strengthen Partnership with MSU College of Engineering

As a University Transportation Center, WTI is committed to pursuing multi-disciplinary based solutions to the complex challenges of providing transportation services in the contemporary rural environment. WTI is able to deliver on this commitment by accessing the technical expertise offered by MSU faculty across the university's wide range of academic fields. Typically, faculty involvement has been pursued based on WTI's research needs and faculty interests on a project-by-project basis.

In 2006, WTI further strengthened its ties to the academic community through key personnel hires. In May, WTI selected a new Director of Research, Dr. Jerry Stephens, who is a professor in the MSU Civil Engineering Department. A long-time collaborator with WTI on an individual project basis, he now brings his research and academic experience to our organization at an institutional level.

This summer, WTI and the College of Engineering also jointly appointed Pat McGowen as an Assistant Professor of Civil Engineering. Dr. McGowen, having recently completed his Ph.D. degree at the University of California – Irvine, began his career in transportation at WTI in 1995, starting as a graduate student research assistant and then advancing to Research Associate and Research Engineer. Through the joint appointment, Dr. McGowen will teach transportation engineering classes as well as continue to conduct research projects for WTI.

Formalizing direct ties between Civil Engineering faculty and WTI has the following benefits:

- These positions serve as liaisons between WTI and the university, enhancing communication and information exchange;
- Faculty members help to identify promising students for WTI's education, research and fellowship opportunities; and
- Professors who are also actively involved in research can incorporate the state-of-the-practice into their curriculum

## Administrative Success Story *continued*

### CUTC Annual Meeting Promotes Staff Mentoring

In June, the Western Transportation Institute hosted the Summer Meeting of the Council of University Transportation Centers (CUTC) in Big Sky, Montana. Nearly 100 people attended the event, including representatives from the U.S. DOT Research and Innovative Technology Administration (which administers the UTC program) and directors from UTCs around the country. The meeting offered an opportunity for UTC staff members to come together and discuss the common issues and challenges they face. These interactions were particularly fruitful this year, as staff from newly established centers had the opportunity to learn firsthand about the experiences of existing centers.

Topics of the working sessions at the meeting included "Business/Finance Administration" with an overview of best practices for managing resources, and "Education/Technology Transfer" which addressed a) innovative methods to disseminate research results, b) programs to develop the next generation of transportation professionals, and c) continuing education in the work place. The final session on "Leveraging Dollars" outlined sources of state and private sector/industry funds that may be available to match UTC funds in project partnerships.

These workshops were especially well-received by the management and administrative staff of new UTCs, who benefited from specific and candid accounts of how to establish, manage, and grow a program. Some of the sessions were extended at the request of participants who wanted to hear more lessons learned from presenters. WTI staff members played a leading role in these sessions, providing an excellent opportunity for our Director, Research Director, fiscal administrator, and education program coordinator to serve as mentors for the UTC program. As summarized by Thomas Marchessault, Acting Director of the University Transportation Centers Program at the Research and Innovative Technology Administration (USDOT), "We are grateful to CUTC for the opportunity to describe our vision for this important program, and for the opportunity for UTC managers to share firsthand knowledge on how to run a successful program."

## Administrative Initiatives for 2007

WTI recently completed a Strategic Plan which will guide its activities under the newly approved UTC grant. The Plan not only outlines research, education, and technology transfer goals, but also details administrative activities that promote responsible, efficient and successful management of Center resources.

In 2007, the Center will begin to implement the Strategic Plan. Administrative initiatives for the year include:

- Enhancing technical expertise in each of WTI's revised research focus areas through strategic hires. Program Managers have been selected for each of the primary focus areas; targeted specialists are now needed to provide more comprehensive research capabilities in each area.
- Identifying academic departments to be proactively approached about increased participation by both faculty and students in WTI activities. This is an important step toward increasing the number of faculty and students involved with WTI in research projects and education programs.
- Refining the roles of the Director, Research Director, and Program Managers in WTI's routine administrative activities, as well as in providing higher level input on the overall operation and strategic direction of the organization. The program area based management structure is new at WTI, and came about as a result of our past success and attendant growth as a center. This management structure now needs to be shaped to best serve the needs of the organization.

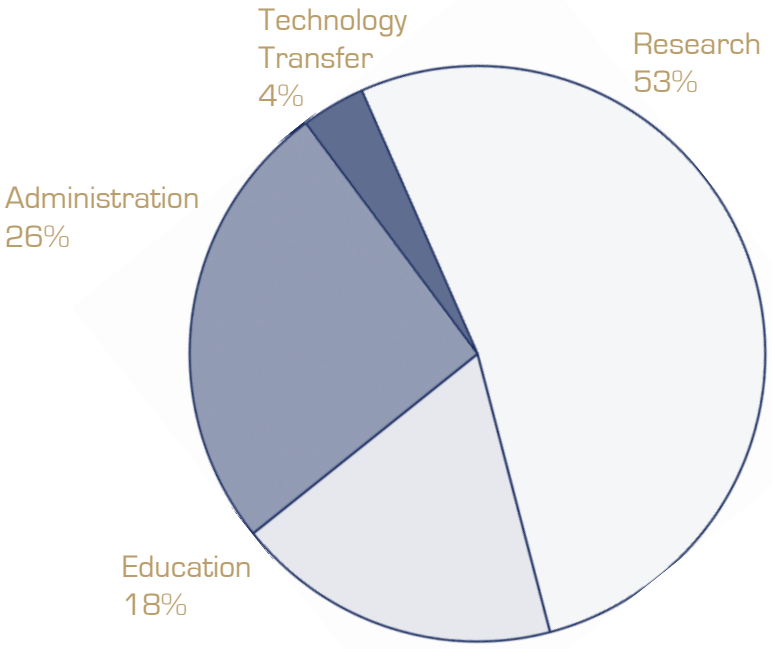
# Financial Statement

The following pie charts illustrate allocations and funding sources for the Western Transportation Institute's UTC programs during year 8. Figure 1 shows the breakdown of expenditures and allocations of the Federal portion ($1,560,000) of the UTC program for Year 8. Approximately $286,000 was allocated for the Education Program, and $819,000 has been committed for research funding. The remaining $455,000 supports the administrative and technology transfer function of WTI.

The second figure depicts the Year 8 funding sources for the WTI UTC program. The match for the USDOT portion is provided by the MSU Civil Engineering Department, pooled research and demonstration projects, individual state Departments of Transportation and Foundation support.

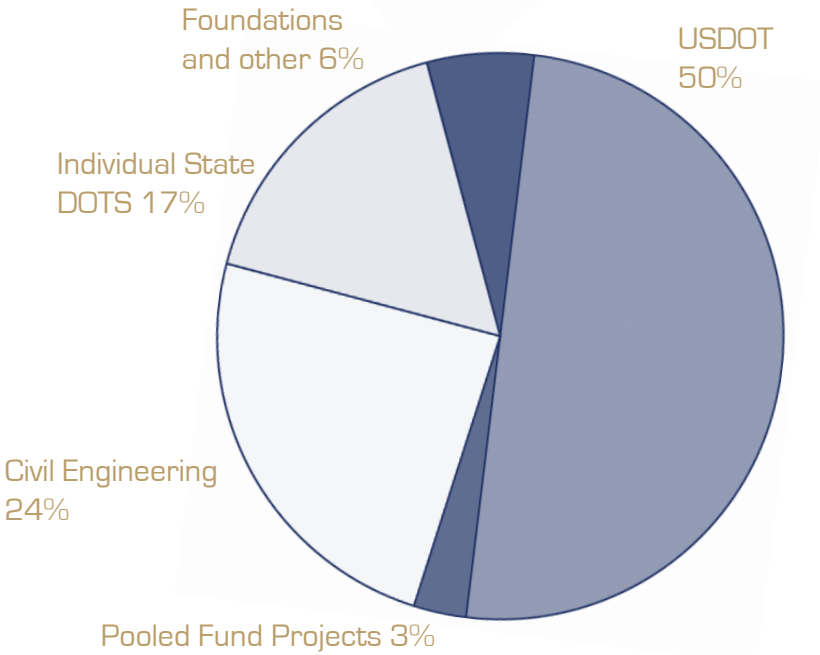
## Allocations for Year 8:

**October 1, 2005 - September 30, 2006**




## Funding Sources for Year 8:

**October 1, 2005 - September 30, 2006**



# Research Staff

***Stephen Albert***
*Director*

***Ed Adams***
*Professor, Civil Engineering*

**Michelle Akin**
*Research Associate*

**Ahmed Al-Kaisy**
*Assistant Professor, Civil Engineering*

**Rob Ament**
*Research Coordinator*

**Matt Blank**
*Research Ecologist*

**Joel Cahoon**
*Associate Professor, Civil Engineering*

***Tony Clevenger***
*Senior Research Scientist*

**Mike Cole**
*Assistant Professor, Mechanical Industrial Engineering*

**Eli Cuelho**
*Research Engineer*

**Jaime Eidswick**
*Research Engineer*

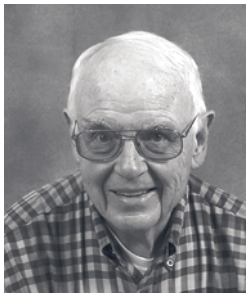
**Laura Fay**
*Research Associate*

**Doug Galarus**
*Senior Research Associate*

**Sean Graham**
*Research Associate*

**Amanda Hardy**
*Research Scientist*

**Marcel Huijser**
*Research Scientist*



**Bill Jameson**
*Senior Research Scientist*

**David Kack**
*Research Associate*

**Mike Kelly**
*Senior Research Scientist*

**Manju Kumar**
*Research Engineer*

**Rob Larson**
*Assistant Professor,*
*Mechanical Industrial Engineering*

**Suzy Lassacher**
*Research Associate/*
*Information Systems*

**Robert Marley**
*Dean, College of Engineering*

**Pat McGowen**
*Assistant Professor,*
*Civil Engineering*

**Ladean McKittrick**
*Associate Research Professor,*
*Civil Engineering*

**Robert Mokwa**
*Assistant Professor*
*Civil Engineering*

**Tongyan Pan**
*Research Associate*

**Steve Perkins**
*Associate Professor,*
*Civil Engineering*

**Xianming Shi**
*Research Scientist*

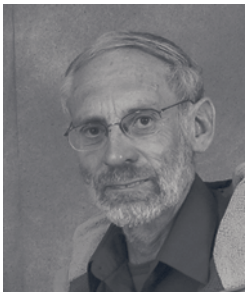
**Otto Stein**
*Associate Professor,*
*Civil Engineering*

**Jerry Stephens**
*Research Director*

**Christopher Strong**
*Research Engineer*

**David Veneziano**
*Research Scientist*

**Shaowei Wang**
*Research Associate*



**Richard Wolff**
*Professor*

## Program Managers

*Chris Strong*
***Safety and Operations***

*Xianming Shi*
***Winter Maintenance and Effects***

*Rob Ament*
***Road Ecology***

*Eli Cuelho*
***Infrastructure Maintenance and Materials***

*Doug Galarus*
***Systems Engineering Development and Integration***

# Research

*"To create areas of excellence with a multidisciplinary focus that will produce high quality research that leads to a demonstration of solutions and to invest in laboratories to perform better research that will meet our mission."*

## Message from the Research Director

As the new Research Director, I'm very excited that WTI has once again been designated as a University Transportation Center, and will continue to receive federal funding to support its research, education and tech transfer programs. The renewed four-year grant provides WTI with a stable funding base from which it can move forward and address national research priorities in the context of rural transportation issues.

We recently completed an extensive review of SAFETEA-LU legislation and a variety of national strategic planning documents to understand the federal agenda and identify national research priorities. These priorities were further examined to determine how the resources available at WTI can best be leveraged and applied to address them. Through this process, WTI has refined its research direction and established program areas to focus on topics that match the most relevant transportation needs to the organization's strongest capabilities as shown in the table below.

The rural transportation challenges of today are

### Relationship between National Strategic Goals and WTI Research Areas

| *NATIONAL STRATEGIC GOALS* | *RURAL CHALLENGES* | *WTI FOCUS AREAS* |
|---|---|---|
| *Safety* | • *Crash Prevention and Security - 60% of fatalities*<br>• *Emergency Services - 30% longer response*<br>• *Operation and Maintenance - local responsibility* | • *Safety and Operations*<br>• *Infrastructure Maintenance and Materials* |
| *Mobility* | • *Rural Transit and Mobility - 38% w/o service*<br>• *Traffic Management - limited monitoring capabilities and need for coordination* | • *Mobility and Public Transportation* |
| *Global Connectivity* | • *Travel and Tourism - economic viability, high visitation, limited services*<br>• *Freight – heavy truck traffic, inter-modal connections* | • *Logistics and Freight Management*<br>• *Transportation Planning and Economics* |
| *Environmental Stewardship* | • *Surface Transportation and Weather - dynamic condition, life threatening*<br>• *Ecological Impacts – maintenance practices, growth, habitat, wildlife* | • *Winter Maintenance and Effects*<br>• *Road Ecology* |
| *Security* | • *Border crossing, institution relations and inter-operability*<br>• *Man-made and natural disasters* | • *Systems Engineering Development and Integration* |

diverse and often complex. Such challenges can only be met by transportation professionals and researchers working closely in a multidisciplinary team environment to produce comprehensive, fully integrated solutions that meet diverse stakeholder needs. Through the years, WTI has grown and developed its research program to offer such an integrated research capability and perspective. The breadth and depth of our research capabilities are well augmented by MSU faculty from such diverse disciplines as engineering, economics, political science and statistics. As a professor from the Civil Engineering Department myself, I hope to further strengthen the relationship between WTI and the University, as well as the link between research and academic programs.

I am confident that with our outstanding professional staff and faculty affiliates, coupled with our close association with various transportation practitioners and agencies, we can continue to offer usable solutions to real world rural transportation challenges.

*Jerry Stephens*
WTI Research Director

## WTI's Integrated Approach

# New Research Projects

| Project Name | Principal Investigator |
|---|---|
| Investigating Innovative Research Opportunities Related to the Application of Electrochemistry in Transportation | Xianming Shi |
| Animal Vehicle Crash Mitigation Using Advanced Technology – Phase II | Marcel Huijser |
| Static Warning Signs for Occasional Hazards: A Synthesis of Research and Practice | Ahmed Al-Kaisy |
| Habitat Connectivity and Rural Context Sensitive Design Within the Northern Rockies | Pat McGowen |
| A Cohesive Multi-Partner Road Ecology Program | Rob Ament |
| A High Fidelity Driving Simulator as a Tool for Design and Evaluation | Michael Kelly |
| An Integrated PDA/GPS System to Collect Standardized Road-kill Data | Doug Galarus<br>Amanda Hardy |
| California and Oregon Multi-Agency Partnership for Advanced Rural Transportation Systems (COMPARTS) | Christopher Strong |

## Investigating Innovative Research Opportunities Related to the Application of Electrochemistry in Transportation

*Xianming Shi*
*406-994-6486*
*xianming_s@coe.montana.edu*

Many emerging maintenance problems in the transportation industry, by nature, are electrochemical. The solutions to them lie in research related to the application of electrochemistry in transportation. For instance, corrosion of prestressed and normally reinforced concrete structures is a major and increasing worldwide problem, often leading to the premature failure of structures. Corrosion costs transportation and infrastructure sectors nearly $52 billion a year, much of which could be saved by using optimum corrosion management practices.

*This project will identify additional transportation issues that can be successfully explored and advanced in the WTI Materials Corrosion Laboratory.*

In response to this situation, WTI has established a Materials Corrosion Laboratory and initiated an active corrosion research program. Existing research ranges from the evaluation of corrosion-inhibited de-icers to the effect of concrete mixes and surface treatments on the chloride-induced corrosion of steel reinforcement in concrete. The research structure and expertise that WTI built to study corrosion can also be used to research other fields of electrochemistry such as electroactive polymers, electrochemical sensors, fuel cells, and rechargeable batteries for motor vehicles. This project will look at innovative research opportunities related to the application of electrochemistry in transportation and how to use and expand the research infrastructure and expertise at the WTI Materials Corrosion Laboratory. Specifically, researchers plan to identify funding resources that could be applied to program development, select one or two new research topics that could be explored in the laboratory, and conduct preliminary experiments for evaluation purposes.

## Animal Vehicle Crash Mitigation Using Advanced Technology – Phase II

*Marcel Huijser*
*406-543-2377*
*mhuijser@coe.montana.edu*

Since 1999, the Oregon Department of Transportation (ODOT) has worked with 14 other Departments of Transportation, the Federal Highway Administration, and WTI to examine the current state of knowledge on the reliability and effectiveness of animal detection systems that use Intelligent Transportation Systems and other advanced technology solutions. Phase I of this project resulted in the development and installation of a prototype animal detection system along US 191 in Yellowstone National Park, Montana. This prototype detection system was found to reliably detect large animals that approach the road. (see page 37 for a description of Phase I).

*This project will provide an opportunity to further refine and evaluate a leading-edge animal detection system in a location of national conservation significance.*

In Phase II of this project the blind spots of the system will be addressed and certain components of the system will be repaired or replaced. Once these modifications and repairs have been completed, the effectiveness of the system in reducing vehicle speed and reducing animal-vehicle collisions will be evaluated.

## Static Warning Signs for Occasional Hazards: A Synthesis of Research & Practice

*Ahmed Al-Kaisy*
*406-994-6116*
*aalkaisy@coe.montana.edu*

Warning drivers of non-permanent hazards such as animal crossings, ice formation, and falling rocks is a challenge to most highway agencies, due to the unpredictable nature of those hazards. Conventional static warning signs used for those hazards may lose their effectiveness as no real hazard is perceived by drivers most of the time, and therefore drivers may become desensitized over time to the warning provided by these signs.

*The information provided in this synthesis is valuable to highway agency planners who need access to research on the effectiveness of static warning signs and other alternative advanced measures in planning their safety programs.*

This project synthesized the current research and practice concerning the effectiveness of static warning signs for occasional hazards. An extensive literature review and a national survey of State Departments of Transportation were conducted to gather information for the synthesis.

Study results indicate that while 57% of responding agencies use some sort of unconventional warning signs or devices, most agencies are uncertain, or lack assurance about, the effectiveness of static warning signs for occasional hazards. Results also suggest that previous research assessing the effectiveness of static warning signs for occasional hazards is limited and that further research is needed to provide reliable information on their safety benefits. Further, this study demonstrates the need for additional guidance on the use and evaluation of warning signs and devices that are intended for occasional hazards.

## Habitat Connectivity & Rural Context Sensitive Design within the Northern Rockies

*Patrick McGowen*
*406-994-6529*
*patm@coe.montana.edu*

Rural areas in the American West are experiencing a period of rapid population growth. Many local agencies in small, rural towns have limited resources to deal with the challenges of effective land use planning, even though they depend on the scenic and ecological integrity of the surrounding countryside for their continued economic health. Improvements to the transportation infrastructure need to reflect local values, preserve the rural character of the area, and protect wildlife habitats and migration corridors.

*The results of the synthesis report can be used by MDT as a resource when planning and designing highways in rural areas.*

Although many transportation studies have been conducted to determine context sensitive solutions and help mitigate interactions between vehicles and wildlife, little work has been done to synthesize this information in a concise and meaningful way that is applicable to Montana. This project will synthesize context sensitive design information that can guide planning in Montana, with a focus on:

- Land use planning techniques for rural areas;
- Roadside design elements that preserve rural character; and
- Preserving habitat connectivity for wildlife.

In addition to a comprehensive literature review, WTI will use surveys and phone interviews to gather information from transportation departments, local agencies and national experts with context sensitive design experience. Researchers will solicit information regarding lessons learned, effective practices, currently used techniques, and emerging technologies.

## A Cohesive Multi-Partner Road Ecology Program

*Rob Ament*
*406-994-6423*
*rament@coe.montana.edu*

With the many challenges that exist in the emerging field of road ecology, WTI is positioned to lead a national effort in understanding and mitigating the impact of surface transportation systems on the environment. An overarching goal for the road ecology focus area is to develop a coherent integrated program that has a clear focus and successfully builds on its strengths. A major challenge will be deciding which new opportunities are developed so that growth and diversification is conducted strategically and staffing and funding is balanced.

*This project will expand WTI's ability to conduct road ecology research that advances the state-of-the-practice across North America.*

Through this project, the Road Ecology Program Manager will promote, integrate, and cultivate research, education, outreach, and technical transfer opportunities for the Road Ecology Program to assure its growth and development is aligned with WTI's strategic plan. This effort will include broadening partnerships and funding opportunities with a wide array of road ecology interests to support the growing network of professionals, students, and volunteers engaged in the field of road ecology.

## A High Fidelity Driving Simulator As A Tool for Design and Evaluation of Highway Infrastructure Improvements

*Michael Kelly*
*406-994-7377*
*mkelly@coe.montana.edu*

High fidelity driving simulators provide an opportunity to simulate and test drivers' responses to improvements in infrastructure, information and warning messages, and other deployments. The planned deployments on U.S. 191 in the vicinity of Big Sky, Montana are an excellent opportunity to use a simulator for rapid prototyping. For many of the scheduled deployments of curve, ice, and excessive speed warnings, driving simulation provides a potential tool to refine the plan for location, visibility, and message sets.

*The lessons learned from this project will help the driver simulator community design simulations that meet the needs of transportation agencies and could be used by MDT on a regular basis to safely and cost-effectively test proposed roadway improvements.*

Through this project, WTI will create and test a simulation capability in its Driving Simulator Laboratory to quickly and inexpensively evaluate these proposed deployments. WTI will use a rapid prototyping approach, with custom tiles representing sections of U.S. 191 to help MDT develop and refine safety countermeasures for that roadway.

A sample of drivers representing a mix of genders and ages will be recruited to drive a series of tests involving potential safety enhancements to the highway. Researchers will compare driver performance data collected in the simulator with available data from the selected roadway to validate results of the prototyping studies.


## An Integrated PDA/GPS System to Collect Standardized Road Kill Data

*Rob Ament*
*406-994-6423*
*rament@coe.montana.edu*

The researchers at WTI are developing the "Road-kill Observation Collection System" (ROCS), integrating customized software with a field-rugged instrument for the collection, integration, and analysis of animal-vehicle collision data. The goal of this effort is to demonstrate how a Personal Data Assistant (PDA) in combination with a Global Positioning System (GPS) and customized animal-vehicle collision software can be an efficient, cost-effective tool to collect spatially accurate and standardized data.

*The ROCS device may help transportation agencies easily pinpoint locations where animal-vehicle collisions are a serious motorist safety and environmental challenge.*

In the first phase of this project (see page 31), WTI researchers developed prototype data collection software for this device. In this second phase of the project, they will upgrade the software and conduct a pilot study of field-rugged PDA/GPS units in four locations. Researchers will conduct on-site training and modify the software to meet local needs. From the field study, WTI will evaluate the hardware and software, including its potential for expanded use across broad geographies.

## California & Oregon Multi-Agency Partnership for Advanced Rural Transportation Systems (COMPARTS) – COATS Phase 3

*Christopher Strong*
*406-994-7351*
*chriss@coe.montana.edu*

From 1998 until 2001 the California and Oregon Departments of Transportation, with the support of the Western Transportation Institute at Montana State University, led the Rural California/Oregon Advanced Transportation Systems (COATS) project. The purpose of the COATS effort was to encourage regional, public and private sector cooperation between California and Oregon organizations to better facilitate the planning and implementation of intelligent transportation systems (ITS) in a rural bi-state area extending between Eugene, Oregon and Redding, California.

*Through this project, WTI can support and facilitate the ongoing efforts of California and Oregon to expand ITS deployment in rural regions.*

COATS Showcase, built on the foundation of COATS, allowed WTI to engage in a number of research and evaluation activities that sought to provide information to improve the performance of existing ITS elements and provide data to justify, support, or direct future deployment of ITS in the COATS study area.

This project represents the third phase of COATS. It will help California and Oregon achieve the COATS vision by fostering bi-state cooperation and communication. Specifically, WTI researchers will promote technology transfer, assist in ITS planning and architecture development efforts, evaluate ITS projects and systems, and provide assistance to mainstream deployment of field-tested technologies. For example, WTI and Caltrans hosted a Western States Rural Transportation Technology Implementers Forum in June, in which transportation practitioners had the opportunity to exchange detailed, technical information about how recently deployed ITS projects were designed, engineered, integrated and implemented.

# On-Going Research Projects

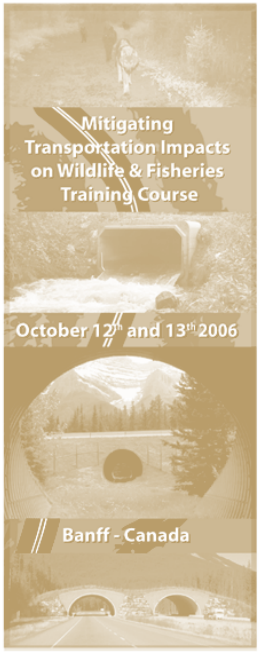
| Project Name | Principal Investigator |
|---|---|
| Technology Transfer of Guiding Principles of Wildlife Crossing Systems | Tony Clevenger |
| National Center for Integration and Systems Engineering of Transportation Technology Feasibility Study | Doug Galarus |
| ITS Applications in Golden Gate National Recreation Area, Phase I, Muir Woods | Christopher Strong |
| COATS SHOWCASE: Video Surveillance Trailer Equipment | Christopher Strong |
| Bozeman Transportation Research, Applications, and Instrumentation Laboratory (TRAIL) | Suzanne Lassacher |
| Feasibility of Using a Gyratory Compactor to Determine Compaction Characteristics of Base Course Aggregates | Eli Cuelho |
| Long-Term Monitoring and DNA-Based Approaches for Restoring Landscape Connectivity Across Transportation Corridors | Tony Clevenger |
| Evaluation of the UDOT Weather Operations/RWIS Program: Phase 1 | Xianming Shi |
| Corrosion Inhibition Mechanisms at the Steel/Concrete Interface | Xianming Shi |
| California – Oregon Advanced Transportation System (COATS) Program Showcase | Christopher Strong |

## Technology Transfer of Guiding Principles of Wildlife Crossing Systems

Effective wildlife fencing and crossings can significantly reduce many harmful impacts of roads on wildlife populations and increase motorist safety. A recent WTI research project compiled and critically analyzed information on ecological criteria and design attributes of wildlife crossing structure planning and performance. The objective of this project is to develop and implement a short-course to teach transportation professionals guidelines for planning and designing functional wildlife fencing and crossing structures.

*Tony Clevenger*
*403-609-2127*
*Tony.Clevenger@pc.gc.ca*






> *This course will provide transportation practitioners with up-to-date tools and resources for wildlife mitigation planning.*

The research team is reviewing and synthesizing information from "Guidelines for Designing and Evaluating North American Wildlife Crossing Systems" in order to develop the curriculum for an eight-hour course. The short-course initially will be offered to transportation practitioners and biologists for state and provincial Departments of Transportation.

## National Center for Integration and Systems Engineering of Transportation Technology Feasibility Study

*Doug Galarus*
*406-994-5268*
*dgalarus@coe.montana.edu*

Development and deployment of advanced transportation technologies is, of necessity, a multidisciplinary process requiring the application of advanced skills in civil engineering, computer science, electrical and computer engineering, industrial engineering, mechanical engineering, human factors engineering, and sciences such as ecology, chemistry, and economics. Currently, the transportation industry has a severe shortage of personnel who have the knowledge and experience to bring these disciplines together into effective teams and solutions, particularly in rural and small urban settings. There is also a lack of knowledge about best management practices for integrating the products of these disciplines.

*This center will be dedicated to developing and promoting a systems engineering approach to the integration, deployment and evaluation of complex transportation technologies.*

Development and deployment of advanced transportation technology is a process of seven interdependent steps: (1) identify the need for a technological solution to a problem, (2) research the underlying technical questions about the operational principles of the technology, (3) engineer to convert the underlying principles of the technology into practice, (4) deploy the technology into the transportation infrastructure, (5) operate and maintain the technology, (6) evaluate the technology, and (7) decommission the technology when its useful life is completed. Systems engineering and integration link these steps together as a structured engineering process. This process is often neglected due to lack of resources such as funding, time, manpower, and expertise necessary to bring together an effective, multidisciplinary team.

To address this problem, WTI proposes to leverage its existing status and expertise to form a Systems Engineering and Integration of Transportation Technology Program (SEITTP). This program will bring together a multidisciplinary team of engineers, scientists and students from a broad range of university departments to address the education, research, and application issues of systems engineering and integration in relation to advanced transportation technology.

Through this project, WTI and the MSU College of Engineering will refine the concept for a Systems Integration (SI) Program, and determine the feasibility of creating such a center, by analyzing the competition, potential customer base, stakeholders, potential sources of revenue, and other critical factors.

WTI, through the SEITTP and in conjunction with the Montana State University College of Engineering, will provide education, research and application support for systems engineering and integration to client organizations by:

- Providing workforce development and continuing education opportunities in systems engineering and integration for transportation professionals. It will promote systems engineering and integration training as part of the undergraduate and graduate engineering curriculum, and will provide students with the opportunity to apply what they've learned in the classroom to "real-world" problems.
- Providing multidisciplinary transportation-related research and development opportunities for engineering and science faculty, staff and students, and will use and promote WTI, COE and other MSU labs and facilities for systems integration efforts. It will use technology transfer and the publishing of research results to promote the application of transportation-related research in systems engineering and integration.
- Supporting the development of emerging transportation technologies, and assisting to evaluate and implement state-of-the-art technology, evaluating existing conceptual design products under actual use conditions, and developing and providing best management practices for integration of these technologies.

## ITS Applications in Golden Gate National Recreation Area

*Christopher Strong*
*406-994-7351*
*chriss@coe.montana.edu*

As visitation to national parks increases, the transportation system in the parks and surrounding communities may suffer from congestion, lack of parking, deteriorating infrastructure, poor traveler information, and other factors that may affect the public's enjoyment of these unique resources. The challenge for the National Park Service (NPS) is to find a way to execute its dual mission of preserving the historic, cultural and national resources under its control while promoting the enjoyment of these resources by the American public.

*This project is testing whether advanced technologies can help manage the impacts of increased visitation at our National Parks.*

This project seeks to overcome this problem at Golden Gate National Recreation Area (GGNRA), a national park which attracts more than 14 million visitors from local communities as well as other states and countries to enjoy the many unique cultural, historic, and natural features in the area near San Francisco Bay. The park has significant traffic challenges related to providing adequate pre-trip traveler information, relieving traffic congestion, having sufficient parking, and promoting alternative access modes. This park represents a unique location where intelligent transportation systems (ITS) applications have the potential to help the NPS address their challenges, and produce findings that may be useful and applicable to many other parks and recreational lands across the country.


This project is an extension of the ITS Applications in California National Parks project funded by Caltrans Division of Research and Innovation. In Phase I of that project, the transportation challenges in and around GGNRA were identified and ITS solutions were recommended. In Phase II, an early winner project was selected and deployed for GGNRA. The early winner project involved purchasing and deploying two portable changeable message signs (PCMS) on US Route 101. These signs provide information to the public on traffic congestion and parking status for Stinson Beach and Muir Woods National Monument.

Through this project, the PCMS are being evaluated on their impacts on visitor experience, visitor travel patterns, and their operations and maintenance experience.

## COATS SHOWCASE: Video Surveillance Trailer Equipment

WTI conducts transportation research throughout the western United States. The variety of project locations and relative distance to WTI's base in Montana can make data collection difficult. For this reason, WTI purchased three custom-designed video surveillance trailers to use in COATS Showcase evaluation activities. These trailers were custom-built for long-term surveillance activities with a minimum of maintenance. Features of the equipment include:

- Autonomous power, through an integrated solar panel and battery system, to allow for up to 30 days of continuous operation;
- Trailer-mounted, to allow for ease of mobility;
- Microwave sensor input, so that video recording is only activated when vehicles are approaching the camera location;
- Mast-mounted closed-circuit television camera, which can record real-time black-and-white video images from up to 25 feet above ground; and
- Video recording capabilities, ranging from real-time to time-lapse.

*These trailers will expand WTI's technical resources and capabilities, by facilitating long-term monitoring projects, regardless of where they are located.*

WTI developed initial requirements for these trailers and has used them in several research projects. Through this COATS Showcase project, WTI has sought to expand the capabilities and usefulness of these trailers. This year, WTI upgraded the trailers' recording capabilities to use digital technology. WTI is continuing to pursue ways to enhance the trailers to make them suitable for a broader range of research applications.

*Christopher Strong*
*406-994-7351*
*chriss@coe.montana.edu*

The trailers were first used for the evaluation of an icy curve warning system in northern California. They were deployed to measure vehicle speeds in a non-intrusive way during a variety of weather and lighting conditions. Since then, the trailers have been used to record queue lengths and to assist in measurements of vehicle width and length for other research projects. They have also been used in counting bicycle traffic.

## Transportation Research, Applications and Instrumentation Laboratory (TRAIL)

*Suzanne Lassacher*
*406-994-6010*
*suzannel@coe.montana.edu*

The Transportation Research, Applications, and Instrumentation Laboratory (TRAIL) will demonstrate and evaluate various data acquisition, control systems, information delivery, and management systems in small urban and rural environments. The laboratory will provide a test bed for the various types of research currently being conducted by WTI, including weather and winter mobility, highway infrastructure design and maintenance, wildlife and ecology, commercial vehicle operations, emergency medical services, special events traffic management, and public transportation.

*The TRAIL laboratory will serve as a test bed for a variety of new human factors, weather, pavement, animal detection and traffic technologies.*

TRAIL is being developed and deployed in multiple phases, with the initial phases being deployed locally at Montana State University – Bozeman. Preliminary work involved developing the requirements and determining the potential partnerships for a local component of the transportation laboratory, including instrumentation, communication, and a data processing and management center. The goal of the first phase is to establish a "smart travel corridor" for 19th Street in Bozeman, Montana, a primary traffic corridor in the city that is experiencing a high rate of development and a rapid increase in traffic volumes and congestion. Deployment of sensors that collect traffic and road condition data has allowed WTI to obtain real-time and summary data on travel conditions, which is communicated to the TRAIL data management center for processing and archiving. Currently, traffic cameras are being evaluated and tested for incremental deployment at two key intersections on the 19th Street corridor for traffic monitoring purposes.

Future phases will seek to implement new systems and technologies, in collaboration with national and international research partners. The long-term goal of the project is to open a facility where a wide range of new technologies research can be conducted, students can have hands-on learning opportunities, and technology transfer can be expedited through facilitated data collection and sharing.

## Feasibility of Using a Gyratory Compactor to Determine Compaction Characteristics of Soils

*Eli Cuelho*
*406-994-7886*
*elic@coe.montana.edu*

The most commonly used laboratory method to determine the maximum dry density and optimum moisture content of soils used in civil structures is the Standard and Modified Proctor tests. Although compaction methods in the field have changed dramatically, the Proctor test has remained relatively unchanged for decades. One shortcoming of this test is that it uses impact loads to compact the soils, which do not accurately reflect field compaction. Soil density in the field comes from a combination of kneading, vibration, and increased normal pressures.

*This project explored the feasibility of using a gyratory compactor to accurately predict optimum dry unit weights and moisture contents for field compaction of various soil types.*

Consequently, a more appropriate method of compacting soils in the laboratory is needed. As part of the Strategic Highway Research Program, a device called a gyratory compactor was created in the early 1990s to more accurately predict in-place asphalt densities. Gyratory compactors simultaneously use static compression and a shearing action to compact asphalt mixtures. Because gyratory compactors more accurately predict in-place asphalt densities, this project will look at using this method to obtain the maximum dry density and optimum moisture content of construction soils.

A suite of four soils were selected to use throughout this gyratory compaction study. These soils were selected to represent a broad range of soils encountered during highway construction. The selected soils are classified by AASHTO as A-1-a (stone fragments, gravel, and sand), A-3 (sand), A-4 (silt), and A-7-6 (clay). Geotechnical index testing as well as Standard and Modified Proctor compaction tests were performed on each of the four soil types to determine the soil properties. The maximum dry unit weights achieved through Proctor compaction were used as a standard to compare gyratory compaction.

A matrix of gyratory compaction tests was performed to evaluate how soil type and variable gyratory parameters affect soil compaction. The two main gyratory parameters consist of the confinement pressure applied to the soil sample and the number of gyrations used to compact the sample. These parameters were evaluated to determine how they affect the dry unit weight of the sample during compaction. Results indicated that the degree of soil compaction was primarily influenced by the number of gyrations. Increasing confinement pressures generally increased the dry unit weights, although to a lesser degree.

The results of these gyratory tests were also compared to Proctor test results to evaluate the degree of soil compaction achieved by the gyratory compactor. Initially, it was hypothesized that the dry unit weights achieved using the gyratory compactor would surpass those of Standard and Modified Proctor tests. This hypothesis was proved true for three of the four soils (A-1-a, A-3 and A-7-6). Gyratory compaction of the A-4 soil only reached 96.9% of the maximum Modified Proctor dry unit weight.

Gyratory compaction has been found to be a feasible method of soil compaction. Issues that arose during this study which need to be addressed in future gyratory studies include: finding a viable method of controlling soil moisture loss during compaction and determining an accurate testing protocol that can relate gyratory compaction to other standardized compaction methods. If these issues can be accurately addressed, gyratory compaction may be a viable method of modernizing laboratory soil compaction.

## Long-Term Monitoring & DNA-Based Approaches for Restoring Landscape Connectivity Across Transportation Corridors

*Tony Clevenger*
*403-760-1371*
*tony.clevenger@pc.gc.ca*

Within the Yellowstone to Yukon biooregion, habitat fragmentation and physical barriers undermine the integrity of the vast ecological network. Major transportation corridors and road networks are of greatest concern and perhaps the most acute obstruction to conserving animal populations in the entire area. The anticipated growth in population and projected highway improvement plans in the Rocky Mountain region, coupled with the resounding concern for maintaining large-scale, landscape connectivity will continue to generate interest in conservation tools and applications for addressing the diverse issues linking transport, ecology and local communities. Research to date has produced key results in establishing benchmark mitigation plans for the design of 17 new wildlife crossings scheduled for the Trans-Canada Highway (TCH) west of Banff, Alberta.

*This project will continue research, monitoring, and transfer of science-based information resulting in a range of applications useful to transportation planning, practice, and policy in areas where road networks and landscape conservation concerns collide.*

This project seeks to establish an ongoing partnership between Parks Canada, WTI, the Woodcock and Wilburforce Foundations, and other agencies to continue current research and monitoring efforts. The research team will:

- Determine the efficacy of a DNA-based hair sampling technique for assessing the conservation value of individual wildlife using the highway crossing structures;
- Develop science-based guidelines for transportation departments, land management agencies, and the conservation community; and
- Expand technology transfer efforts to disseminate research findings in journals and international conferences

## Evaluation of the UDOT Weather Operations/RWIS Program: Phase 1

*Xianming Shi*
*406-994-6486*
*xianming_s@coe.montana.edu*

The Utah Department of Transportation operates a Traffic Management Division that consists of two main components: the Weather Operations function and the Intelligent Transportation Systems (ITS) component. Weather Operations has four staff meteorologists stationed in the Traffic Operations Center (TOC) providing year-round weather information for winter maintenance, construction and rehab projects, planning, the highway avalanche safety program, TOC operations, risk management, and training. The ITS component manages 48 RWIS stations and expert systems such as bridge spray systems, high wind alerts, and fog warnings.

*This evaluation will help UDOT plan for future improvements to and investment in their Weather Operations/RWIS program.*

WTI will examine the UDOT Weather Operations/Road-Weather Information System (RWIS) and preliminarily assess the effectiveness and benefits of it. The research team will take a phased approach to evaluation. This project will involve Phase I of the evaluation, focusing on the forecasting services provided by the program to UDOT Winter Maintenance and Construction staff. The evaluation will quantify the direct benefits of the program to winter maintenance operations, by examining maintenance locations with varying utilization levels of UDOT weather service. The research team has conducted a survey to document the use of customized weather service by DOTs across North America; documented and analyzed current practices at UDOT though site vists, interviews, and questionnaires; and evaluated the cost-effectiveness of the UDOT Weather Operations/RWIS program.

## Corrosion Inhibition Mechanisms at the Steel/Concrete Interface

*Xianming Shi*
*406-994-6486*
*xianming_s@coe.montana.edu*

Concrete normally provides both chemical and physical protection for the steel reinforcement embedded in it. Cement hydration leads to a highly alkaline (pH ≈ 13 – 14) pore solution in concrete, which promotes the formation of an oxide/hydroxide film at the steel surface that is about 10 nanometers thick. For bridge structures exposed to deicer applications or marine environments, chloride ingress into concrete is of primary concern in terms of steel corrosion and subsequent concrete durability. Therefore, the focus of this research is upon this cause of corrosion alone. Extensive research has been conducted to investigate the mechanisms of steel corrosion in concrete in the presence of aggressive chloride ion ($Cl^-$), and the ability of numerous corrosion inhibitors to mitigate this corrosion. However, the corrosion inhibition mechanisms at the steel/concrete interface still elude direct explanation and require further study.

*The testing in this research is expected to reveal the mechanisms of corrosion and corrosion inhibition of steel in concrete.*

With the combined use of electrochemical and physical techniques, it is possible to further the understanding of the localized corrosion of carbon steel in concrete and to unravel the corrosion inhibition mechanisms of various types of corrosion inhibitors. Such knowledge will contribute greatly to identifying and researching effective measures to mitigate steel corrosion in concrete and protect concrete structures in a chloride-containing environment.

Initially, researchers are documenting the state-of-the-practice related to this project. Preliminary research has identified three non-proprietary, commercially available chemicals as promising candidate corrosion inhibitors for this project. For select corrosion inhibitors with proper concentration, their corrosion inhibition behavior will be investigated using the facilities at the Image and Chemical Analysis Laboratory (ICAL) at Montana State University. The corrosion at the steel/concrete interface as a result of chloride attack will be investigated in the absence and presence of various corrosion inhibitors.

## California/Oregon Advanced Transportation Systems (COATS) Showcase

*Christopher Strong*
*406-994-7351*
*chriss@coe.montana.edu*

The California/Oregon Advanced Transportation Systems (COATS) project began in 1998 as a bi-state partnership to improve rural transportation through the demonstration and evaluation of intelligent transportation systems (ITS). The first phase resulted in the successful completion of an ITS Strategic Deployment Plan in 2001. The California Department of Transportation (Caltrans) and the Oregon Department of Transportation (ODOT) decided to continue their partnership, enabling the project to continue in the form of COATS Showcase.

*By providing more credible and detailed information about ITS benefits, COATS Showcase can help create broader awareness and acceptance of the potential of ITS.*

COATS Showcase consists of a set of evaluations that seek to clarify the benefits associated with ITS investment, and to identify lessons learned from demonstration projects that may help to improve future deployment. Evaluations are developed to cover the broad geographic area of the COATS study region – an 80,000 square mile area encompassing the southern half of Oregon and the northern third of California – and the comprehensive, multimodal nature of the COATS project's goals and objectives.

Evaluation activities occurring during this last year included the following projects:

- Operational Impacts of Weather on Rural Highways;
- Case Studies of ITS Maintenance on Rural Field Devices;
- Evaluation of ITS in Rural Work Zones;
- Narrows Oversize Vehicle Identification System;
- Evaluation of the Fredonyer Summit Icy Curve Warning System; and
- Comparative Evaluation of Automated Wind Warning Systems.

# Completed Research Projects

| Project Name | Principal Investigator |
|---|---|
| Materials Corrosion Laboratory: Evaluating Common Corrosion-Inhibited Deicers | Xianming Shi |
| Development of a Prototype Integrated PDA/GPS System to Collect Roadkill Data | Marcel Huijser |
| COATS SHOWCASE: Impacts of Weather on Rural Highway Operations | Manju Kumar |
| Case Studies of Maintaining ITS Devices in Rural Areas | Manju Kumar |
| Saco Bridge Field Evaluation | Eli Cuelho |
| COATS SHOWCASE: Comparative Evaluation of Wind Warning Systems | Manju Kumar |
| Transportation Toolkit for Federal Lands Managers | David Kack |
| Development of a Road Ecology Curriculum | Tony Clevenger |
| Haptic and Auditory Interfaces as a Collision Avoidance Technique During Run-Off Road and Head-On Collisions and Driver Perception of Modalities | Laura Stanley |
| Animal – Vehicle Crash Mitigation | Marcel Huijser |
| Investigating Innovative Research Opportunities Related to Highway Infrastructure Design & Maintenance | Eli Cuelho |

## Materials Corrosion Laboratory: Evaluating Common Corrosion-Inhibited Deicers

*Xianming Shi*
*406-994-6486*
*xianming_s@coe.montana.edu*

To minimize the adverse impacts that highway winter maintenance activities may have on vehicles and transportation infrastructures, it is a popular practice to add corrosion inhibitors into deicers. Working with the Pacific Northwest Snowfighters (PNS) association, WTI has created a Materials Corrosion Laboratory to build the corrosion research capabilities at WTI and to establish protocols for evaluating the corrosion rate of materials and the associated performance of corrosion inhibitors. In December 2004, WTI organized a PNS corrosion forum and the peer-to-peer discussion has led to improvements in the existing NACE/PNS corrosion test protocol addressing some of the reliability and reproducibility issues.

*The electrochemical technique was able to rapidly evaluate the corrosivity of deicer products in the presence and absence of corrosion inhibitors, and with some improvements, it is expected to supplement the existing gravimetric corrosion test.*

In addition, researchers established a novel electrochemical technique to rapidly evaluate the corrosivity of chloride-based deicers for winter highway maintenance. Potentiodynamic polarization curves were measured in the ranges of Ecorr±150 mV. Corrosion parameters were calculated on the basis of potential (E) versus current density (i) characteristics in the range of Ecorr±70 mV (weak polarization). The Tafel slopes were approximated by fitting the anodic and cathodic curves to two polynomials and then taking their derivative at Ecorr ±60 mV, respectively. First, the experiments were conducted in salt solutions with chloride concentration of 0.5M, representative of five deicer categories, i.e., NaCl, MgCl2, CaCl2, NaCl+10wt.% MgCl2, and NaCl+20wt.% MgCl2. Then, the inhibiting efficiency of three different chemicals on steel corrosion in NaCl+10wt.% MgCl2 was investigated. The experiments were performed at room temperature with carbon steel coupons, for both potentiodynamic polarization and gravimetric measurements. For the solutions investigated, the corrosion potential (Ecorr) and corrosion current density (icorr) were found useful to predict the results of gravimetric tests at reasonable accuracies.

## Development of a Prototype Integrated PDA/GPS System to Collect Roadkill Data

*Marcel Huijser*
*406-543-2377*
*mhuijser@coe.montana.edu*

There are approximately 725,000-1,500,000 crashes between vehicles and ungulates (large hoofed animals) in the U.S. annually. These collisions are estimated to cause more than 200 human fatalities and over one billion dollars in property damage a year. In order to avoid or reduce animal-vehicle collisions, basic data need to be recorded and analyzed. However, not all state Departments of Transportation record animal-vehicle collision data. Furthermore, the DOT's that do record such data often use different methods. A national standard for the recording of animal-vehicle collisions may encourage DOT's and other organizations to collect these data and allow for more effective analyses and application of the data.

*This project developed a tool for collecting standardized animal road kill data with a system that is spatially accurate, easy to use, and has a data format that is easy to integrate and analyze.*

The main purpose of this project was to develop a standard for the collection of animal-vehicle collision data and to show how Personal Data Assistants (PDA's) in combination with a Global Positioning System (GPS) can help researchers to collect accurate and standardized data. The system will help collect, analyze and interpret data on animal road kill locations. These data will help pinpoint high-risk locations and will allow for the prioritization of mitigation measures. Ultimately, the work may contribute to reducing the number of animal-vehicle collisions while continuing to allow animals to move across the landscape.

Through this project, WTI developed software that allows for easy, standardized and spatially precise collection of animal-vehicle collision data. The software runs on a pocket PC that is linked to a GPS (Global Positioning System). WTI tested the prototype in the field, customized the software, modified the software based on feedback, and developed procedures that allow for easy data management and analyses and integration with other spatial data. In a second phase project (see page 20), WTI researchers will further upgrade the software and pilot test field rugged units in four different locations.

## COATS SHOWCASE: Impacts of Weather on Rural Highway Operations

*Manju Kumar*
*406-994-7909*
*mkumar@coe.montana.edu*

Weather poses a significant challenge to rural highway operations. In many cases, the operation of the transportation system under severe weather can be improved through the strategic use of advanced operational strategies, including the use of intelligent transportation systems (ITS). To estimate the benefit of ITS or other solutions requires accurate estimates of the pre-deployment, baseline conditions for roadway operations. However, very little baseline data exists for highway capacity and speeds in rural environments during weather events such as snow, heavy rain, and fog.

*This project has provided baseline data that will help evaluate the effectiveness of future road safety technologies and improvements.*

The objective of this project was to develop a method for estimating the road capacity reduction effects of weather on rural highways, through the correlation of data collected from automatic traffic recorders with information about weather conditions. This project has provided valuable information that may be used to assess the benefits of a variety of transportation system improvement projects, including the use of intelligent transportation systems (ITS) during severe weather conditions.

Several data collection sites were selected within the COATS study area and Montana. These sites have road weather information systems (RWIS) and detection systems located near one another, which provide traffic volume and speed information. This facilitated the analysis of traffic volumes and speeds under various severe weather conditions. The entire set of locations includes sites subject to a variety of weather conditions. Traffic and weather data were collected for a period of three years, in order to capture a variety of weather events. Statistical comparisons between periods of free flow traffic and periods of adverse weather conditions were conducted to isolate the effects of various weather events on roadway volume demand and speed. A series of models were then developed to help assess the baseline capacity and speed conditions under various weather conditions.

## COATS SHOWCASE: Case Studies of Maintaining ITS Devices in Rural Areas

*Manju Kumar*
*406-994-7909*
*mkumar@coe.montana.edu*

Proper maintenance of intelligent transportation systems (ITS) elements is crucial because it can extend the useful life of the ITS infrastructure, help increase reliability, reduce long-term costs, and build public confidence in ITS deployments. ITS maintenance in rural environments has unique challenges compared to urban areas, due to the reduced availability or greater expense of maintenance through contracting, long distances separating field devices from trained maintenance staff, specialized training needs for ITS maintenance, and limited system redundancy.

As more ITS technologies are employed in the COATS study area, a rich repository of information on actual maintenance becomes available, offering the opportunity to collect pertinent cost data and develop best practices.

*This evaluation should provide several tangible benefits to local and national stakeholders, including improved design and procurement processes that account for maintenance concerns, better budgeting by gathering more accurate information on maintenance costs, improved scheduling of maintenance staff, and more realistic estimation of reliability and life time of field devices.*

The objective of this project, therefore, was to document case studies of ITS maintenance to guide future ITS deployments in the COATS study area, improve maintainability of field devices in the design and procurement stages, and generate more accurate information on maintenance costs.

A literature review was conducted to help assess the maintenance needs of ITS elements. Based on input from local stakeholders, several ITS technologies and deployment locations were identified for case studies. Locations were selected based on the availability of adequate experience and record keeping, in order to document maintenance history and develop lessons learned. Data have been collected from maintenance staff for each device to gain an overall understanding of the systems/devices, their perceived usage and maintenance history. A detailed review of maintenance records has also been conducted to identify primary maintenance concerns from technical and institutional perspectives. The results of this effort have been compiled as a final report, summarizing major findings and providing recommendations for improved maintenance procedures.

## Saco Bridge Field Evaluation

*Eli Cuelho*
*406-994-7886*
*elic@coe.montana.edu*

It is generally acknowledged across the country that the service life of bridge decks designed by traditional procedures is often shorter than desired. The construction of three new bridges near Saco, Montana on State Route 243 provides a unique opportunity for bridge engineers at the Montana Department of Transportation (MDT) to study various techniques for extending the service life of reinforced concrete bridge decks.

*This project allowed MDT to conduct a nearly "side-by-side" field comparison of three different types of concrete bridge deck construction.*

WTI conducted a comparative study of the performance of three bridge decks in Saco, Montana to assess their expected long term durability. To accomplish the research objectives, an array of strain and temperature instrumentation was embedded in each of the bridge decks prior to placing the deck concrete. Basic structural behavior of the decks is being characterized by subjecting the decks to controlled live load tests in which vehicles with known characteristics and weights are driven across the bridges while simultaneously monitoring the strain response. During the live load tests conducted in July 2003 and July 2005, two heavily loaded three-axle dump trucks (~285 kN or ~64 kip) were used to load each of the bridge structures along nine longitudinal paths.

The live load test data was used to develop a fundamental understanding of how each bridge deck responds to vehicle loads. Simple observations in this regard were then used to compare the relative performance of the three decks. Comparisons between the reported data and expected responses derived from basic strength of materials concepts were also used in this analysis. This analysis focused more upon the transverse rather than the longitudinal deck response, as it was believed to be more significantly affected by the differences in construction of each deck, as well as to be less confounded by any incidental differences in the restraint to longitudinal movement offered by the abutment and bent supports of each bridge. Further, relative to transverse behavior, a typical deck panel defined by the end and middle transverse diaphragms in any span of each bridge was expected to represent the general behaviors across the entire bridge.

Long term monitoring consisted of measuring internal deck strains and temperatures, assessing corrosion potential, conducting visual distress surveys, and detecting global movement of the bridge structures through periodic topographic surveys of the bridge decks. The data acquisition system was programmed to collect strain and temperature information from all of the embedded sensors on an hourly basis. All other effects were monitored through periodic visits. The data available from the long term monitoring was studied to correlate changes in deck performance with the vehicle and environmental loads they experienced, and then to further evaluate the relative performance of the three types of decks. The primary "environmental" behaviors experienced by the decks are related to the dimensional changes they experienced due to changes in relative humidity (shrinkage of the concrete) and temperature (shrinkage and expansion of both the concrete and the reinforcing steel). The analysis of long term data utilized strain and temperature data from vibrating wire sensors, as well as associated deformations of the decks in response to temperature changes.

Based on all of the information obtained to-date, the HPC deck potentially will offer the most cost effective performance of the three deck configurations, followed closely by the Conventional deck, and more distantly by the Empirical deck. This conclusion is primarily based on the relative visual distresses observed in the decks and on the relative stability of their behavior over time, as inferred from the live load strain data. In making this statement, it is important to recognize that: a) the differences in performance between the decks were small; b) the various pieces of evidence related to their relative performance sometimes tell a conflicting story; and c) subtle differences in their current performance could become significant in the future. Thus, this conclusion must be considered as "preliminary" in nature, until it can be confirmed (or refuted) based on additional study of the decks' performance over time.

This analysis serves as a baseline assessment of the relative condition of the three bridges before prolonged demands from traffic and the environment. Should a follow-on project be initiated, data obtained from continued long-term monitoring and live load testing will likely provide a more complete body of evidence from which to determine which deck design offers superior performance over time.

## COATS SHOWCASE: Comparative Evaluation of Wind Warning Systems

*Christopher Strong*
*406-994-7351*
*chriss@coe.montana.edu*

High crosswinds can cause high-profile vehicles - such as commercial vehicles and recreational vehicles - to overturn and lower-profile vehicles to leave their lanes. These conditions pose a serious threat to traveler safety. The Oregon and California Departments of Transportation have used ITS installations to continually measure wind speed and direction and automatically warn motorists when hazardous windy conditions are present. Three such systems have been deployed:

*This project evaluated automated wind warning systems to facilitate deployment of similar systems. This project also provided a benefit-cost analysis of the automated wind warning systems and documented the effectiveness of two different types of wind warning systems.*

- US Route 101 between Port Orford and Gold Beach, Oregon;
- Yaquina Bay Bridge (US Route 101) in Newport, Oregon; and
- Interstate 5 between Yreka and Weed, California.

While the two systems in Oregon are fully automated and operational, the system in California is not yet fully automated. So, this evaluation focused on just the two systems in Oregon. The objective of this evaluation was to assess the safety benefits, motorist satisfaction and operational benefits associated with automated wind warning systems installed in the COATS region, and contrast the relative merits of each system type. This evaluation assessed whether these different systems have resulted in a reduction in the frequency and severity of crashes involving high profile vehicles, and also identified other benefits.

The evaluation included a nationwide survey to identify comparable systems; an analysis of crash data; developing and testing hypotheses for the types of crashes which could most likely be avoided through use of these systems; a motorist survey to determine public perception of these systems; an assessment of the operational benefits related to these systems; and an assessment of their technological performance. Because these systems have unique aspects – including project justification and the "best" measures of effectiveness, method of motorist information, and integration with other types of traveler information – this project assessed the relative merits of different types of system concepts, and made recommendations that may guide future design and implementation of wind warning and other automated systems.

## Transportation Toolkit for Federal Land Managers

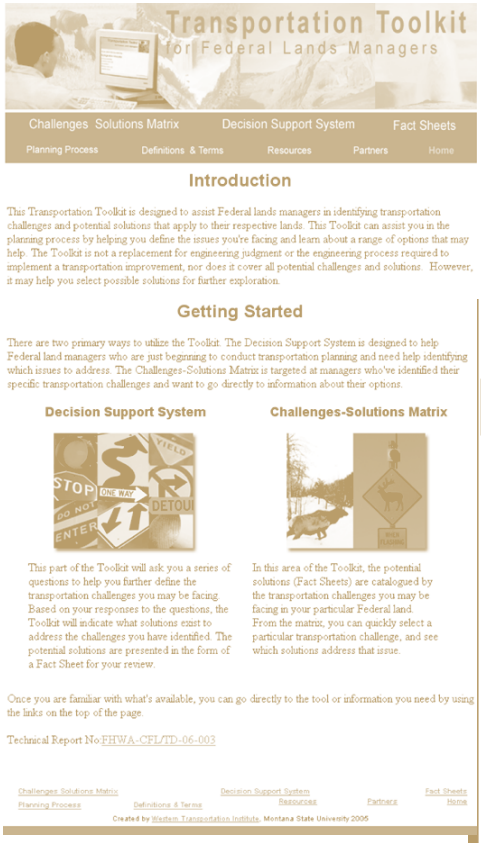
*David Kack*
*406-994-7526*
*dkack@coe.montana.edu*

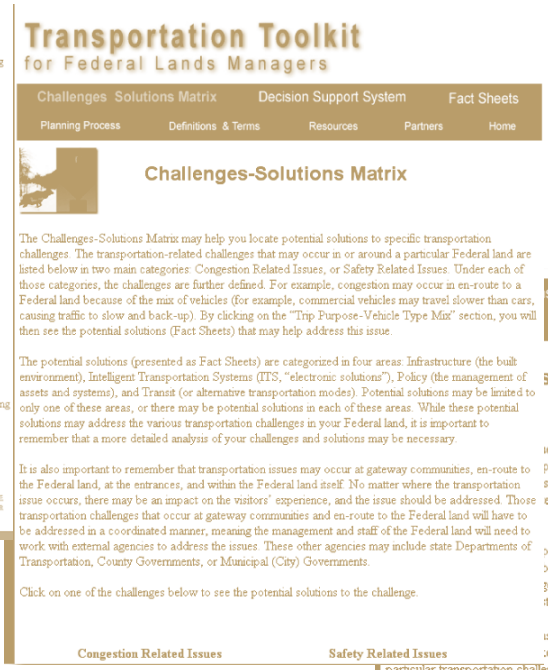
The Federal government manages significant portions of rural land, much of which serves as destinations for tourism and recreation. Unlike many tourist destinations, Federal lands are mandated to preserve and protect unique natural, cultural and historical resources. Maintaining the balance between the demand for increased visitation and the need to preserve resources can be challenging.

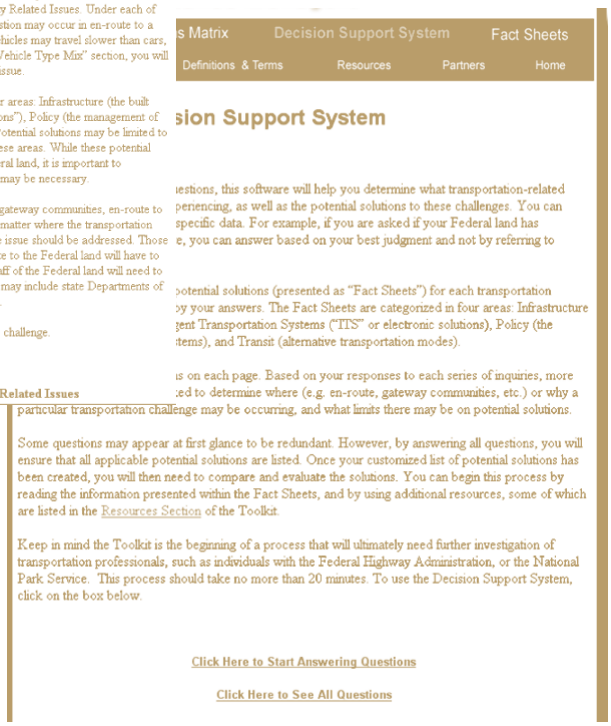
One area in which this balancing act has important consequences is the transportation system. Within a Federal land, there may be significant constraints on the transportation infrastructure, including gate capacity, air and noise pollution, right-of-way limits, lack of ability to expand parking and similar issues. Unless these problems are addressed, they may result in potential resource damage and a degraded visitor experience. If Federal land managers lack a background in transportation, they may not consider various transportation solutions – both "traditional" traffic engineering measures as well as advanced technology or intelligent transportation systems (ITS) system improvements – that may allow for both increased visitation and resource preservation.

*This project will help federal land managers match their transportation challenges with appropriate and innovative solutions.*

The purpose of this project is to provide Federal land managers with greater awareness of the tools available to solve transportation challenges in their jurisdiction, and to understand the next steps needed to pursue implementation of these solutions. The project seeks to develop a system that will help managers identify possible transportation system improvements based on user input related to characteristics of their specific land. WTI is leading this effort to prioritize the key types of transportation challenges facing Federal lands, identifying and classifying appropriate solutions, and programming the software system. In 2004, an initial prototype of the system was completed. By the end of 2006, Version 1.0 of the Toolkit will be available on the Internet.



## Development of a Road Ecology Curriculum

*Tony Clevenger*
*403-609-2127*
*tony.clevenger@pc.gc.ca*

The book, "Road Ecology: Science and Solutions", Island Press 2003, has generated significant interest in road ecology among the transportation community, academia, and the general public. The objective of this project was to develop and implement a university-based road ecology curriculum and short-course at Montana State University. The course and curriculum developed in this project will give transportation professionals an opportunity to learn more on this increasingly popular topic. The course looks at the many ways that roads impact the environment and the techniques being used to mitigate these impacts to wildlife, land, water, and plant ecosystems.

*This project will disseminate the latest road ecology research to both transportation professionals and university students.*

As part of the curriculum development, the research team also conducted a thorough literature review of additional road ecology information. The first two-day, 8-hour course was held at Montana State University on March 4-5, 2005, during the Spring Engineering Festival. WTI will publicize the course offering on transportation Web sites and list serves, and determine additional venues.

## Haptic and Auditory Interfaces as a Collision Avoidance Technique During Run-Off-Road and Head-On Collisions and Driver Perception of Modalities

*Laura Stanley*
*406-994-6114*
*wti@coe.montana.edu*

Roadway departure fatalities, which include run-off-road and head-on collisions, accounted for 55 percent of all roadway fatalities in the United States in 2003. In an effort to reduce the number of roadway departures, many transportation agencies have introduced static rumble strips in shoulder and/or centerline sections of the roadway. Recently, more advanced technology has been developed in the form of in-vehicle advanced lane departure warning systems. These systems are currently showing their value in some commercial trucks in Europe, and are soon to become available in U.S. passenger cars. Two critical factors will govern their ultimate success:

- Their ability to warn the driver in an effective and timely manner to make the correct action; and
- Their success in gaining the driver's trust and acceptance.

*This study provides valuable data for the development of effective in-vehicle lane departure warning systems.*

The primary goal of this project was to better understand basic human factors principles to haptic (touch) and auditory (sound) interfaces as a collision avoidance technique during run-off-road and head-on collisions, as well as how drivers perceive each type of interface. Using the WTI Driving Simulation Laboratory, fifteen subjects drove a simulated road segment, during which time they received three alerting sensory modalities: haptic (seat vibration), auditory ("rumble strip" sound), and combined auditory and haptic sensory warnings.

Based on the findings of this study, haptic (seat vibration) warnings demonstrate promise as an alerting strategy over auditory and combination modalities in reducing roadway departures. In these tests, drivers who received haptic warnings demonstrated a decrease in reaction time and less erratic steering responses; as a result, haptic warnings have the potential to assist drivers in returning to the lane more quickly and safely

## Animal-vehicle Crash Mitigation Using Advanced Technologies Pooled Fund Study

*Marcel Huijser*
*406-543-2377*
*mhuijser@coe.montana.edu*

Three methods have typically been used to reduce animal-vehicle collisions: (1) warn the driver of the hazard through warning signs or public education; (2) improve the driver's ability to react through reduced speed zones, vegetation clearances or improved lighting; or (3) limit animal presence on the roadway using fences, sometimes in combination with over- and underpasses, reflectors, scent and sound-based repellents, or reduced herd size.

With the advent of Intelligent Transportation Systems and an increased focus on technological solutions, many feel that alternative solutions to animal-vehicle crashes should be examined. The "Animal-vehicle Crash Mitigation Using Advanced Technologies Pooled Fund Study" was initiated to investigate the most promising roadway animal detection/driver warning systems. This study was funded by the Departments of Transportation of 15 states and the Federal Highway Administration. The Oregon Department of Transportation (ODOT), in cooperation with WTI, was the lead state for this research and demonstration project, which aimed to install prototype animal detection and driver warning systems and evaluate their effectiveness in reducing animal-vehicle crashes. The sites selected for demonstration were:

*This project evaluates whether new technologies are indeed a valuable addition to the existing spectrum of mitigation measures.*

• Site #1 Montana, US 191, about 50 miles south of Bozeman, Montana, where the predominate challenge is elk-vehicle collisions in the winter months. The system at this site was designed by Sensor Technology Systems.

• Site #2, Pennsylvania, US 322, about 35 miles northwest of Harrisburg, at a location with a known concentration of deer-vehicle collisions. The system at this site was designed by Oh Deer, Inc.

Important lessons have already been learned and documented regarding the design of animal detection systems, the partnership with vendors of experimental technologies, and the installation of these systems. Furthermore, a broad overview of experiences with operation and maintenance and other issues has been obtained from other sites throughout Europe and North America.

The final report for this project was completed in August 2006. Key results for this phase include:

- The completion of a world wide overview of animal detection system technologies, their reliability, effectiveness, and experience with operation and maintenance; and
- The development of two experimental animal detection systems. One of these systems resulted in a technology that detects large animals reliably.

Refinement and evaluation of the Montana system will continue in a second phase project (see page 17).

## Investigating Innovative Research Opportunities Related To Highway Infrastructure Design and Maintenance

*Eli Cuelho*
*406-994-7886*
*elic@coe.montana.edu*

This project was aimed at proactively addressing the nation's failing infrastructure through innovative and practical research. Many Departments of Transportation have been looking for new methods and technologies to better build and maintain highway infrastructure. Creative ideas are necessary to ensure that 1) new designs are adequate to meet the heavy demands and 2) longevity of new infrastructure is assured. Due to the depth and breadth of this work, it has been necessary to develop partnerships and relationships with multiple DOTs, research institutes and academic institutions.

*This project has enhanced the Infrastructure Maintenance and Materials program area at WTI by fostering new partners, strengthening partnerships that currently exist and becoming involved in service activities that strategically position WTI as a resource for future infrastructure-related research.*

The primary tasks for this project focused on promoting research opportunities that identify highway infrastructure field instrumentation related to design and maintenance, creating partnerships with several state departments of transportation to foster state-of-the-art research related to geosynthetic pavement design, and initiating new research that utilizes technological solutions and high performance materials in design.

To accomplish this work, WTI has diligently pursued funding and partnerships from a variety of sources, including: National Science Foundation (three proposals related to geosynthetic material properties pertinent to pavement reinforcement); a multi-state supported pooled fund study to investigate geosynthetic material properties for highway design involving MT, WY, WA, CA, TX, MO and NY; private industry (Tensar Technologies Inc., Ryan R. Berg & Associates, Inc., Christopher Consultants); universities (University of Illinois – Champaign-Urbana, University of Maryland); and FHWA (proposal through Federal Business Opportunities – FBO). Representatives from this program area also initiated and orchestrated several meetings with the Montana Department of Transportation to determine and address specific research needs. Multiple projects have resulted from these meetings. Conference attendance and paper submissions were also expanded to disseminate research findings and to potentially foster research partnerships. Finally, researchers were also involved in several service activities to learn the direction of transportation-related materials research and to promote WTI as a resource for doing this type of research.

Significant effort was also made to formally develop these ideas into a distinct and strong program area within the Western Transportation Institute. A joint appointment between the Civil Engineering Department and the Western Transportation Institute will help cultivate additional research related to geosynthetic reinforced pavement design. During this effort, a 1000 square-foot laboratory dedicated to materials-related research was also planned and constructed. This laboratory is currently being furnished with several pieces of equipment dedicated to conduct geosynthetic and other materials-related experiments. WTI anticipates significant growth in this area as a result of these efforts.

# Cumulative List of Completed Research Projects (10/1/1991 - 9/30/2006)

| | |
|---|---|
| Statewide Demand-Response Software | David Kack |
| ODOT ITS Performance and Benefit Plan | Christopher Strong |
| Implementation of a Driving Simulation Laboratory | Mike Kelly |
| Materials Corrosion Laboratory: Evaluating Common Corrosion-Inhibited Deicers | Xianming Shi |
| Evaluation of Driver Distraction During Mobile Phone Interaction with the 511 Information System | Mike Kelly |
| Development of a Prototype Integrated PDA/GPS System to Collect Roadkill Data | Marcel Huijser |
| Evaluation of Montana Department of Transportation's Technical Assistance Program | Jaime Eidswick |
| Evaluation of Reinforcement Strain Growth During Traffic Loading | Steve Perkins |
| Winter Surface Condition Forecasting | Ed Adams |
| Geosynthetic Pullout Behavior under Small Displacements | Eli Cuelho |
| Evaluating the Accuracy of RWIS Sensors | Christopher Strong |
| Impacts of Weather on Rural Highway Operations | Manju Kumar |
| Communications and Power Improvements for Rural ITS Field Devices | Christopher Strong |
| Case Studies of Maintaining ITS Devices in Rural Areas | Manju Kumar |
| Galavan Service Improvement Plan | Lisa Ballard |
| Tribal Automated Accident Reporting System | Doug Galarus |
| Canamex Smart Tourist Corridor | John Taylor |
| Personal Digital Assistants for Emergency Medical Services Providers | Steve Albert |
| Saco Bridge Field Evaluation | Eli Cuelho |
| National Park Service Sustainable Transportation | Mike Kelly |
| Paratransit Systems Operation Model | Ed Mooney |
| Montana Department of Transportation Maintenance Process Improvements | Steve Albert |
| Public Safety & Communications State of the Practice | Greg Cross |
| Compressibility and Heave Characteristics of Subgrade Soils Exposed to Freeze/Thaw Conditions | Robert Mokwa |
| Comparative Evaluation of Wind Warning Systems | Manju Kumar |
| Development of a Roadway Weather Severity Index | Christopher Strong |
| Mitigating Wildlife Mortality and Habitat Fragmentation | Tony Clevenger |
| Paratransit Operations Review | David Kack |
| Artemis Clearinghouse | Amanda Hardy |
| Mobile Laboratory | Robb Larson |
| Tribal Transportation and Safety Needs Survey | Christopher Strong |
| Demonstration and Evaluation of ITS on the Rural Highway Environment (Frontier) | Steve Albert |
| Numerical Modeling and Design Development of Geosynthetic Reinforced Flexible Pavements | Steve Perkins |
| Safe Passage: Development and Demonstration of a Rural Weather Prediction Model and Motorist Communication System for Safe and Efficient Traffic Management/Infrastructure Maintenance | John Mounce |
| Application of CT Scanning Technology to Highway Icing | Ed Adams |
| Development of Test Protocols for Characterization of Soil/Geosynthetic Interaction and Intrinsic Geosynthetic Material Properties | Eli Cuelho |
| Field Study to Evaluate Intrusion Detection Technology: Intersection Crash Avoidance | Kate Hunter-Zaworski |
| Transportation Toolkit for Federal Lands Managers | David Kack |

## Cumulative List of Completed Research Projects *(continued...)*

| | |
|---|---|
| Animal – Vehicle Crash Mitigation | Marcel Huijser |
| Development of a Surface Transportation and Weather Decision Support Tool and Strategic Plan for Improved Highway Operations in Montana | Lisa Ballard |
| A Rating System for Rural Culvert Crossing Repair and Maintenance | Joel Cahoon |
| Characterizing Commercial Vehicle Safety in Rural Montana | Jodi Carson |
| Development of a Road Ecology Curriculum | Tony Clevenger |
| Haptic and Auditory Interfaces as a Collision Avoidance Technique During Run-Off Road and Head-On Collisions and Driver Perception of Modalities | Laura Stanley |
| Investigating Innovative Research Opportunities Related to Highway Infrastructure Design & Maintenance | Eli Cuelho |

Summaries of these completed projects are included in this or previous editions of the WTI - UTC annual report.

## Laboratory Resources

In the past, WTI focused on defining areas of research expertise, and building a staff of professional researchers with strengths in those fields. Having established a successful research record and a talented core staff, WTI is now working to improve its facilities and equipment to further increase its research capabilities. In the past year, WTI has made tremendous progress in the creation and expansion of several specialized laboratories. These facilities are significant because they increase WTI's ability to research transportation problems of national significance and to develop and evaluate prototype solutions. The laboratories augment the research resources of America's universities, where many innovations and advancements occur. The labs are also a valuable training ground for the next generation of transportation researchers, planners, and engineers. In December 2005, WTI moved into a newly renovated building with more than 16,000 square feet of space for research and administrative staff. The building includes 6,000 square feet of dedicated space for research laboratories. Five laboratories are now equipped, operational, and ready to focus on rural transportation needs.

**Driving Simulation Laboratory**

The high-fidelity driving simulation facility provides an ideal setting to collect data on driver performance and behavior in a variety of customized scenarios.

The DriveSafety DS500C Vection driving simulator features five visual channels providing approximately 140-degrees of perspective, rear-view and side mirrors, and speakers that provide a realistic sound environment. Using the HyperDrive software system, driving scenarios are custom-designed to meet the needs of specific research projects. The operator station, situated next to the simulator, allows the researcher to develop and control research scenarios and to collect a broad range of data on driver performance. A separate control room is used for participant reception, test monitoring, and graduate student research.

Carefully constructed research and laboratory facilities such as this one allow researchers and engineers to test and evaluate road designs and vehicle innovations before they are actually deployed. Potentially, millions of road construction dollars can be saved and many lives spared through a proactive approach to safety.

The simulator has been used on projects to:

- Compare the most effective type of animal warning signs;
- Evaluate the effectiveness of safety innovations;
- Test the use of cellular phones and their impact on driver behavior ; and
- Examine highway improvements in the lab before construction.

**Corrosion and Electrochemistry Laboratory**

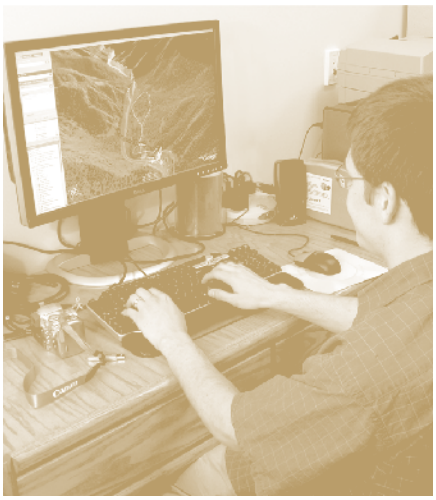
This laboratory has the facilities and equipment to research corrosion and other issues related to winter operations of the nation's transportation system.

The newly constructed laboratory has been equipped with an environmental chamber, ventilation hoods, a corrosion testing machine, potentiostats, advanced electrochemical systems, and modeling software. The lab is utilized by a multi-disciplinary team of researchers with a diverse combination of expertise including corrosion science and engineering, electrochemistry, polymer chemistry, environmental science, and civil engineering.

This laboratory has been used on projects to:

- Conduct accelerated chloride ingress tests, gravimetric and electrochemical corrosion tests, and electrochemical engineering experiments;
- Study environmentally friendly concretes and cement-based composites;
- Analyze the behavior and effectiveness of corrosion mitigation measures for highway bridges, earth-retention systems, and pipelines in cold regions; and
- Research and develop polymers to mitigate winter effects on concretes, asphalt binders, biodiesel, and fuel cells.

**Systems Engineering, Development, and Integration (SEDI) Laboratory**



This laboratory has the equipment necessary to facilitate the application of systems engineering best practices to the development and integration of intelligent transportation systems, information technologies, and communications systems.

This laboratory consists of sophisticated, state-of-the-art equipment that enables the Systems Group staff to test and develop hardware and software. The lab has sufficient space to assemble and test prototype systems, as well as to demonstrate prototype technologies and to conduct training for small groups. A flexible cabling system facilitates the testing and demonstration of various wired and wireless communication technologies. Servers and workstations are equipped with "virtualization" and development software that allows staff to rapidly configure, develop, and test programs using multiple operating systems. GIS and mathematical analysis software are used by staff to model, analyze, and visualize systems and their charac-

teristics. Digital cameras, camcorders, and a projection system assist staff in the development of demonstrations and training tools.

This laboratory has been used on projects to:

- Integrate satellite and cellular communication equipment with mobile computing devices;
- Aggregate and disseminate sensor readings into a database to indicate weather changes;
- Test systems and algorithms for triggering warnings to drivers in workzones via variable message signs;
- Visualize and compare the coverage of communication systems in rugged terrain; and
- Process input from hand-held field devices regarding animal-vehicle collisions, rock slides, and other incidents that impact travelers and roadways.

**Geosynthetic Materials Laboratory**

This laboratory is equipped to test the properties of geosynthetic materials in relationship to the surrounding pavement structure.

There is a growing need for geosynthetic material tests to define mechanical properties pertinent to working load conditions within pavement structures. This information is essential for the reliable use of reinforcement products in construction and repair of the transportation infrastructure. The research performed in this laboratory will help fulfill this critical need by providing testing equipment and associated test protocols that can be used to determine material properties needed in pavement design and analysis.

The geosynthetic lab is in the process of acquiring a servo-hydraulic system to enhance its existing pullout device and a servo-hydraulic uniaxial tension device. This new equipment will make it possible to conduct research and evaluate the benefit of geosynthetics in new and rehabilitated highway structures.

This laboratory will be used on projects to:

- Develop test methods to determine material properties for mechanistic-empirical reinforced pavement design;
- Investigate the properties of new and unique geosynthetic products; and
- Support projects involving the modeling and design of reinforced pavements

**Transportation, Research, Applications, and Integration Laboratory (TRAIL)**

The purpose of this laboratory is to simulate a small urban and rural Traffic Management Center (TMC) and thus serve as a test bed to comprehensively research TMC operations and supporting Intelligent Transportation Systems (ITS) technologies.

Currently, the lab is deploying ITS technologies such as sensors and video surveillance cameras in heavily traveled corridors to gather data with the intention of enhancing safety. The lab provides an environment for ITS evaluation and workforce development, as well as a setting for local and state government agencies and transportation departments to observe the benefits of a Traffic Management Center (TMC).

The lab is equipped with two fifty inch high-definition plasma monitors that display various types of data currently collected by sensors and video cameras. This laboratory assists communities with future growth plans by collecting and sharing data that can be used by various agencies to determine community needs and provide solutions to ongoing problems.

This laboratory will be used on projects to:

- Identify problematic winter road conditions;
- Collect and analyze data pertaining to vehicle speeds, counts, classifications, and pavement conditions;
- Evaluate ITS technologies and communications schemes; and
- Enhance workforce development.

# Laboratories Under Development

**Cold Region and Rural Transportation Research, Maintenance and Operations Test-bed**

The Cold Region and Rural Transportation Research, Maintenance and Operations Test-bed in Lewistown, Montana will allow WTI to perform high quality research and testing on surface transportation issues facing rural and cold regions, such as winter maintenance, winter driving and training, pavement design, work zone safety, driver safety, and animal-vehicle collision avoidance. Research will be conducted on closed runways, taxiways, and other underutilized assets at Lewistown Airport. A high-speed test track with two large paved pads, skid pad, choice reaction lanes, and office and classroom buildings are used for driver training and driver testing as well as occasional sports car competitions.

WTI and the Montana Department of Transportation are working together to expand and integrate the research capabilities of the testbed. WTI is leading outreach efforts to attract the participation of a wide range of national, state, and local partners. Recently, a four-year, $4 million federal earmark was received to develop the facility.

In two research projects currently underway, the Test-bed is being used to:

- Evaluate several road-animal detection systems from different vendors to determine if they reliably detect whether animals are on or near a roadway, and how the performance of the systems compares; and
- Provide a group of newly licensed drivers with an advanced defensive vehicle handling course, and evaluate the effectiveness of the training on their driving records.

**Subzero Science and Engineering Facility**

WTI is excited about the construction of a new $1.8 million, state-of-the-art cold laboratory facility in the College of Engineering. This lab will be used in subzero research on natural systems in Montana and elsewhere. When completed, this facility will create an outstanding science and engineering research laboratory at Montana State University that can address the unique cold climate transportation challenges in northern states. It will also further enhance the established position of Montana State University as a leading research center focusing on cold natural environments.

# Research Success Story

## Investment in Systems Engineering Laboratory Attracts New Research Funding

In December 2005, WTI moved into a new location with significantly more space. This move helped WTI to realize one of its research initiatives for this year, namely, to expand its in-house research and testing capabilities. All five of WTI's planned laboratories were operational in its new location by early summer, and now conduct active research projects (see page 41 for laboratory descriptions). The primary goal of creating these laboratories was to improve our ability to perform specialized testing in-house to support our research activities. Concomitantly, these facilities are expected to create and attract new research opportunities and bring additional outside collaboration and funding into the center. Some early successes were realized immediately following this strategy, as specifically described below for the case of the Systems Engineering, Development, and Integration (SEDI) Laboratory.

The SEDI Laboratory is designed to facilitate the development of intelligent transportation systems, information technology, and communications systems. It consists of sophisticated, state-of-the-art equipment that enables the Systems Group researchers to test and develop hardware and software. With virtualization software and multi-media equipment, the staff can conduct realistic prototype demonstrations and training sessions. WTI installed the SEDI Laboratory in January at a cost of approximately $93,000, using UTC funding. Since then, WTI has secured two major, external research projects that will take advantage of the laboratory's capabilities. The combined value of these projects is $647,000, which represents a return on investment after only nine months of more than six-to-one.

The UTC program provided the seed money to develop this laboratory, which quickly attracted these projects. These funding sources, in turn, help support the ongoing operation of the laboratory.

In addition to successfully leveraging UTC funds, WTI meets other center goals through the establishment of these laboratories. Ongoing access to these facilities allows our staff to conduct state-of-the-art research, which increases their expertise in their fields of specialization. The laboratory also facilitates partnerships with various departments on the Montana State University campus, increasing our ability to conduct multi-disciplinary research.

# Research Initiatives for 2007

As WTI enters the first year of the new UTC funding cycle, it is an appropriate time to re-evaluate our research process, from project selection, to performance, to delivery of the final product. Considerable thought was recently given to each of these activities in preparing our UTC strategic plan that will direct our efforts over the next four years. Guided by WTI's long standing policies and past experience with project selection processes, project management tools, and quality assurance programs, procedures have been developed and detailed in the strategic plan to accomplish each of these activities. These procedures are essential to systematically ensuring that WTI:

- Engages in research on relevant subjects consistent with its areas of expertise (i.e., research of national significance, on subjects related to rural transportation, within WTI's program areas);
- Uses its research resources in an efficient and effective manner; and
- Produces high quality research products.

Briefly summarizing our research process by major activity:

**Project Selection:**
Project opportunities and ideas will be selected for support based on established criteria that reflect the mission of the center. These criteria will reflect, among other things, the short and long term research focus of the organization set annually by the Research Advisory Committee. All proposals will be peer reviewed, with the specific nature of the review determined by the scope of the project.

**Project Management:**
Project progress and expenditures will be monitored through periodic reports (typically quarterly) to ensure that any issues with schedule, budget, or technical activities are identified and resolved as early as possible.

**Project Deliverables:**
Peer review will be the primary mechanism to ensure the quality of WTI's work product. Both internal and external peer review will be performed. These reviews will address both the technical content and presentation quality of the deliverables.

In the year ahead, effort will be focused on 1) work ing out the details of these procedures and fully implementing them, and 2) revising them as necessary to improve their efficiency and effectiveness.

# Education

*"To develop a multidisciplinary program of coursework and experiential learning that reinforces the transportation theme of the center."*

## Education Program

The Western Transportation Institute's Education Program engages in activites designed to a) attract students to the transportation field, b) provide a quality and diverse transportation curriculum, c) promote experiential learning through student research involvement, and d) place graduates in transportation careers. A comprehensive K-12 outreach program encourages youth from elementary school through high school to consider careers in the transportation field. Joint faculty/research appointments ensure a well-rounded transportation academic program. Extensive involvement of both undergraduate and graduate students in innovative transportation research at WTI is intended to increase the number, diversity, and quality of students entering careers in the transportation field. Support for students to travel to professional conferences and to network with transportation professionals helps to bridge their transition from school to career.

# Student Research Involvement

WTI provides students with a variety of hands-on opportunities to gain exposure to the transportation field. In 2005-2006, twelve undergraduates and seventeen graduate students, representing eleven different academic disciplines, participated as paid research assistants at WTI. In all, students contributed research support on twenty-eight different transportation projects. Student research contributions on various funded projects are outlined in the table on the next page (note: one student working on two projects counts as two students).

Given the success of the program over the past few years, WTI has continued to offer the unique UTC-funded Undergraduate Research Experience Program. The program supports up to four undergraduate researchers for a full academic year. Over the course of the program, students work under the mentorship of an experienced staff researcher, develop their own research work plan, produce a final research technical report, and present their findings to staff and peers. Participants in the 2005-2006 program presented their research findings during the Undergraduate Scholars Program Conference, an all-day event held annually on the MSU campus. One participant went on to present her paper titled "Investigation of Coarse Aggregate Durability Using the Micro-Deval Abrasion Testing" at the 40th Annual Symposium on Engineering Geology & Geotechnical Engineering held in May at the Utah State University campus in Logan, Utah. A second program participant co-wrote two reports "Evaluation of Alaska's 511 Phone System and Website: User Surveys" and "Alaska 511 Database Evaluation" for the Alaska Department of Transportation.

In addition to its undergraduate program, UTC Education funding supports WTI's graduate transportation fellowship program. The fellowship provides students with a tuition and fee waiver as well as a monthly stipend. WTI Graduate Fellows consistently distinguish themselves within the transportation field following graduation. Graduate Fellow Sean Graham accepted a Research Associate position at the Western Transportation Institute after completing his Masters in Computer Science in December 2005. Sean now works on a number of research projects within the Systems Engineering Development and Integration focus area. Casey Durbin, a WTI Graduate Fellow who completed his Masters in Civil Engineering in June 2006, has taken a transportation consulting position with GC Wallace in Las Vegas, Nevada. Casey's thesis research resulted in a co-written paper with Dr. Ahmed Al-Kaisy, which has been accepted for presentation at the 2007 Transportation Research Board meeting. Laura Stanley, a WTI Graduate Fellow, completed her doctoral degree in Industrial Engineering in 2006 with a focus on transportation human factors. She now pursues human factors research full-time as a research staff member at the Virginia Tech Transportation Institute.

# Student Research Involvement

| Project | Undergraduate | Graduate |
|---|---|---|
| Advanced CMS | | 1 |
| Alaska 511 | 1 | |
| Axial Capacity of Piles | | 1 |
| Bozeman Pass Wildlife Channelization | 1 | |
| Comparative Analysis of Course Surfacing Aggregate Using Micro-Deval | 1 | |
| Corrosion Inhibition Mechanisms at the Steel/Concrete Interface | 1 | |
| Effect of Chloride-Based Deicers on Reinforced Concrete Structures | 2 | |
| Enhancement of Statewide Operations (TMC) | | 1 |
| Evaluation of Golden Gate National Recreation Area's Portable Changeable Message Signs | 1 | |
| Experimental Assessment of Aggregates | | 2 |
| Fredonyer Summit Evaluation (COATS Showcase) | 1 | |
| Geosynthetic Pullout Behavior | 2 | |
| Gyratory Compactor Feasibility Study | | 1 |
| Haptic and Auditory Interfaces as a Collision Avoidance Technique During Run-off and Head-on Collisions and Driver Perception | | 1 |
| Long-term monitoring and DNA approaches for Restoring Landscape | | 1 |
| MSU Building Adjacent Parking Study | | 1 |
| NCHRP Synthesis of Vehicle-Based Winter Maintenance Technologies | | 2 |
| Performance Measures for Two-Lane Highways | | 1 |
| Redding Incident Management Responder | | 1 |
| Reinforced Native Grass Sod | | 1 |
| Saco Bridge Evaluation | 1 | |
| Synthesis of Information on Anti-Icing/Pre-Wetting | | 1 |
| TMC-TMS Communications | | 1 |
| Traveler Information Database Requirements Analysis | | 1 |
| US 93 Animal Crossing Evaluation | | 1 |
| Validating the Durability of Corrosion Resistant Mineral Admixture Concrete | 1 | 1 |
| Video Surveillance Trailers (COATS Showcase) | 1 | |
| Work Zones (COATS Showcase) | | 1 |

# Student Professional Development Activities

## Professional Speakers

A number of professional speakers shared their transportation expertise with students on the Montana State University campus over the past year.

On December 1, 2005, Chris Saunders from the City of Bozeman Planning Department discussed past, current, and upcoming transportation projects in the Bozeman area. He spoke about many of the obstacles faced by each project and the solutions that the City of Bozeman developed to keep the projects going. Chris also discussed the specific challenges facing a governmental agency when trying to meet the needs and requests of developers, citizens, and local businesses. After Chris finished, David Kack from the Western Transportation Institute spoke about the new bus transit system to be implemented in Bozeman within the year.

On March 3, 2006, Michael Sanderson, Principal of Engineering, Inc. from Billings, Montana spoke with MSU students about a recent project to implement five roundabouts along a transportation corridor in a booming area in Billings. He outlined the process of designing the corridor using roundabouts instead of signalized intersections and the obstacles of convincing local residents and government staff about the advantages of using a roundabout design. Kirk Spalding, a senior transportation engineer with Engineering, Inc., also participated in the presentation.

On March 23, 2006, Doug Enderson, a former MSU graduate and MSU-ITE chapter member, presented a variety of new ITS technologies that Kimley-Horn is implementing on their projects. Doug also presented a number of case studies of recent projects, the engineering obstacles involved, and the creative solutions Kimley-Horn created.

# Student Professional Development Activities *continued*

## Conferences and Technical Tours

In 2005-2006, twenty-six undergraduate and graduate students had the opportunity to participate in professional development and career awareness activities sponsored by WTI, including participation in professional conferences and technical tours. Participation in professional conferences provides students with important networking opportunities and exposes them to current research efforts in the transportation field. These opportunities are very valuable in bolstering students' confidence and professional skills, and are especially important to students preparing to enter careers or graduate programs in transportation. Of the seventeen students who participated in professional conferences in 2006 with WTI support, eight students attended as paper presenters. Student participation in professional development activities is detailed in the table below: Nine students from the MSU Institute of Transportation Engineers (ITE) Student Chapter traveled to San Francisco and Oakland, California in April to observe state-of-the-art transportation facilities and interact with professional transportation engineers in their work environment. While onboard a commuter train, students were given a presentation on future goals for San Francisco's transit system with professionals from Fehr & Peers. They learned about opportunities in the transportation workforce during a presentation at Kimley-Horn. They visited both the Oakland and the City of San Francisco traffic management centers, went on a tour of intersection sensors and cameras with city staff, and received a demonstration of the area's 511 system. The students were also treated to a once-in-a-lifetime opportunity to tour the Bay Bridge re-construction project.

| Date | Conference/Meeting | Student Attendance |
|---|---|---|
| January 21-25, 2006 | Transportation Research Board Annual Meeting; Washington, DC | 5 |
| April 6-9, 2006 | ITE Technical Tour/Field Trip to San Francisco, CA | 9 |
| May 18-20, 2006 | ITE Intermountain Section Meeting; Jackson, WY | 4 |
| May 24-26, 2006 | 40th Annual Symposium on Engineering Geology & Geotechnical Engineering; Logan, UT | 4 |
| August 2006 | ITE International Meeting; Milwaukee, WI | 3 |
| September 13-16, 2006 | "Tools of the Trade" TRB Conference on Transportation Planning for Small Communities; Nashville, TN | 1 |

# Outreach

Building interest in transportation careers is critical to meeting future transportation workforce needs. WTI's active K-12 outreach program aims to excite youngsters about transportation careers during critical points in their schooling.

**Bridges and Dams Outreach**

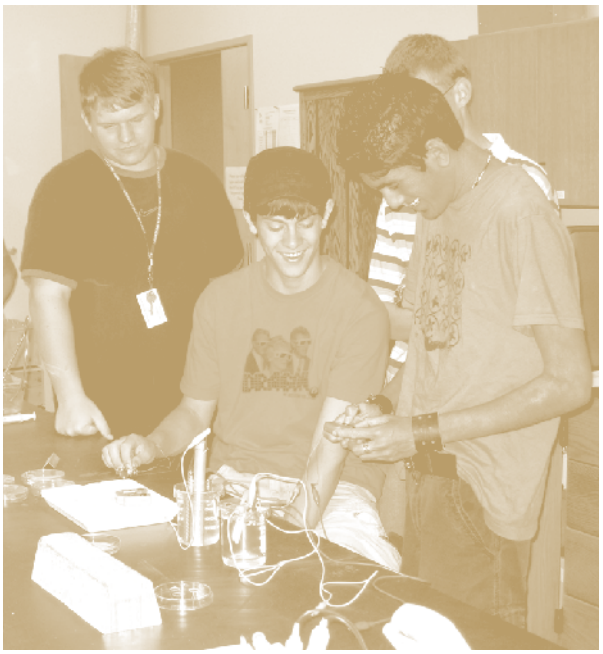
The Western Transportation Institute continues to partner with MSU student chapter organizations to fulfill its outreach mission to elementary school-aged children, while simultaneously assisting student organizations to achieve their community service goals. Interested student chapter members were trained to facilitate two-hour workshops in second and third grade classrooms. The workshops demonstrated the engineering principles of constructing bridges and dams through hands-on exploration. Over the past year, sixty-four second graders participated in the workshops together with nineteen MSU student facilitators.

**National Engineering Week- Girl Scout Badge Day**

For the second year in a row, WTI sponsored "Girl Scout Badge Day/Introduce a Girl to Engineering Day," as part of National Engineers Week. The event has already grown in popularity, with over ninety area Girl Scouts traveling to the MSU campus to learn about the various fields of engineering.

**Expanding Your Horizons (EYH)**

Each year, seventh and eighth grade girls visit Montana State University to learn about careers in math and science during Expanding Your Horizons. In 2006, WTI introduced the girls to the problem of corrosion in transportation infrastructure. The participants had an opportunity to create their own primitive batteries with metal, sand, and lemon juice and to learn more about the relationship between chemistry, electricity, and corrosion.



**Summer Transportation Institute (STI)**

WTI hosted its second annual Summer Transportation Institute, a four-week on-campus program for high school students in grades ten through twelve. Participation grew from nine students the first year to fifteen students in 2006. STI participants learn about the field of transportation through field trips, guest speakers and hands-on activities. Students in the program were exposed to a

wide array of different transportation careers and modes. Participants had the unique opportunity to learn about aviation while taking a "discovery flight" on a Cessna with trainers from Summit Aviation. They also learned about challenges with fish passage through culverts and wildlife-vehicle interactions while on an overnight field trip to Yellowstone National Park. Students also tested their own engineering design skills through a number of team projects, including construction of a motorized vehicle using complex gear trains, a crash attenuator test, and a balsa wood bridge competition. Beyond transportation, STI participants gained life skills about succeeding in college, career development, and leadership.

# Student of the Year Award

Each year at the Transportation Research Board annual meeting in Washington, DC, the U.S. Department of Transportation Research and Innovative Technologies Administration honors the most outstanding student from each University Transportation Center (UTC). The UTC Students of the Year are selected based on their accomplishments in research, academics, professionalism, and leadership. The Western Transportation Institute selected Laura Stanley as its 2005 Outstanding Student.

Laura Stanley is from Abingdon, Virginia and earned her Ph.D. in Industrial Engineering at Montana State University studying Human Factors, Transportation Engineering, and Applied Statistics. Laura earned a B.S. in Industrial & Systems Engineering from Virginia Tech and a M.S. in Industrial & Management Engineering from Montana State University. She is also a recipient of the Western Transportation Institute's Professional Fellowship Award. At WTI, her focus has been on designing and conducting research in the high fidelity driving simulation laboratory. Ms. Stanley provided key support in the installation and testing of the Simulation Laboratory, as well as in the administration of the first study. Laura's academic interests also include web development applications.

Her recent conference papers include Driver Responses to Enhanced Wildlife Advisories in a Simulated Environment presented at the 2006 Transportation Research Board Annual Meeting; Driver Performance While Interacting with the 511 Travel Information System in Urban and Rural Traffic, presented at the Third International Driving Symposium on Human Factors in Driver Assessment Training; Vehicle Design held in June 2005 in Rockport, Maine; Development of a Web-Based Household Travel Survey, presented at the 2005 Institute of Transportation Engineers District 6 Meeting; and Assessing Opinions, Experiences; and Perspectives of Female Engineers Nationwide Via a Web-Based Questionnaire, presented at the Women in Engineering Programs & Advocates Networks (WEPAN) 2004 Conference.

Laura Stanley is an active member of the Institute of Transportation Engineers (ITE) student chapter at MSU, a young member of the TRB Vehicle User Characteristics Committee, and she was selected as an Eno Fellow in 2005. Laura's past work experience includes working as a cost engineer/manager at IBM in Raleigh, NC and as a research assistant at the Virginia Tech Transportation Institute in Blacksburg, VA.

## Student Success Stories

Over the past year, WTI student researchers were successful in producing a large number of papers accepted for publication or presentation at professional conferences. Student co-authors are marked in bold in the list below.

- Hardy, A., **Lee, S**., and Al-Kaisy, A. (2006). "Effectiveness of Animal Advisory Messages on Dynamic Message Signs as a Speed Reduction Tool: A case study in rural Montana". In Transportation Research Records, the Journal of the Transportation Research Board, in press.
- Mokwa, R. L., Peebles, C. S., and **Trimble, N. R**. (2006) Evaluation of the Engineering Characteristics of RAP/Aggregate Blends, Presented at the Transportation Research Board Meeting, January 22-26.
- Shi, X. and **O'Keefe, K**. (2006) Anti-icing and Prewetting: Improved Methods for Winter Maintenance in North America. Presented at the Transportation Research Board Meeting, January 22-26.
- Cuelho, E., Stephens, J., **Smolenski, P.**, and **Johnson, J.** (2006) Evaluating Concrete Bridge Deck Performance Using Active Instrumentation. Presented at the Transportation Research Board Meeting, January 22-26.
- **Stanley, L.** (2006) Driver Responses to Enhanced Wildlife Advisory Messages in a Simulated Environment. Presented at the Transportation Research Board Meeting, January 22-26.
- **Browne, M**., Mokwa, R.L., and Cuelho, E. (2006) Feasibility of Using a Gyratory Compactor to Determine Compaction Characteristics of Soil. Presented at the 40th Annual Geosymposium Conference, Logan, UT, May 23.
- **Obert, K**., Cuelho, E., and Mokwa R.L., (2006) Investigation of Coarse Aggregate Durability Using the Micro-Deval Abrasion Testing. Presented at the 40th Annual Geosymposium Conference, Logan, UT, May 23.
- **Trimble, N.,** and Mokwa, R.L. (2006) Permeability Investigation of a Silty Clay Alluvium/Chromium Contamination Transport. Presented at the 40th Annual Geosymposium Conference, Logan, UT, May 23.
- **Durham, W.** and Gallagher, S. (2006) Bozeman Bicycle Network Plan. Presented at TRB Committee ADA 30 Tools of the Trade Conference on Transportation Planning in Small and Medium Sized Communities, Nashville, TN, September 13-15.
- **O'Keefe, K.** (2006) Evaluation of the UDOT Weather Operations/RWIS Program. Presented at the 2006 National Rural ITS Conference, Big Sky, MT, August 14 -16.
- Mokwa, R. L., and **Trimble, N.** (2006) Permeability Characteristics of RAP/Aggregate Blends for use in Highway Construction. Presented at the 40th Annual Geosymposium Conference, Logan, UT, May 23.
- William Durham, a former Research Experience for Undergraduates participant, also received the Best Student Paper Award at the 2006 Tools of the Trade Conference on transportation planning
- Mike Brown, MSU graduate fellowship student, received the Second Place Student Paper Award at the Utah Symposium on Engineering Geology and Geotechnical Engineering.

## Education Initiatives for 2007

WTI's Road Ecology research focus area continues to develop and conduct professional development courses in the field of road ecology. In Spring 2007, Montana State University will offer the first graduate course in Road Ecology. To meet additional training needs, WTI will create an on-line course in Road Ecology. The course will be designed for current and future transportation professionals who desire to learn guiding principles for planning, designing, evaluating and implementing strategies to mitigate the impact of highways on the environment. The primary goal of the proposed course will be to increase available information about the emerging science of road ecology to engineering students, educators, and practicing transportation professionals in order to meet workforce development needs in this field.

# Technology Transfer

*"To increase the availability of research results to potential users in a form that can be directly implemented, utilized or otherwise applied."*

## Technology Transfer Program

The technology transfer program at the Center is designed to support the USDOT in their mission of "efficient use and conservation of resources" by sharing research results quickly and to the widest possible audience. Cutting edge research as well as outstanding educational opportunities and programs lose their effectiveness if appropriate and timely transfer of information does not take place. In short, effective information exchange accelerates the advancement of transportation knowledge and minimizes redundancy of research efforts. While the specific goal of the technology transfer program is the dissemination of research results, the Center also envisions this activity in a broader sense, as a means of increasing the scope and effectiveness of its other program areas.

# Conferences and Workshops

The center participated in a variety of conferences and workshops over the past year in various capacities, ranging from coordinating and hosting a national conference to providing refreshment breaks at a statewide meeting of county officials.

**National Rural ITS comes to Big Sky, Montana**

The 2006 National Rural ITS (NRITS) Conference was held in Big Sky, Montana, from August 13-16, attracting more than 250 rural transportation and emergency services professionals with three days of workshops, technical sessions, and continuing education programs.

Hosted by the Montana Department of Transportation, Rocky Mountain ITS Chapter, Western Transportation Institute, Federal Highway Administration, Critical Illness and Trauma Foundation, and ITS America, the 2006 NRITS provided the opportunity for attendees to obtain information on current rural transportation issues, and exchange valuable ideas and information regarding the challenges faced in rural transportation. Session topics included Advanced Traveler Information Systems and 511, Road Weather Systems and Modeling, Coordinated Public Mobility, Data Collection and Sharing, Solutions for Rural Transit and Congestion, Commercial Vehicle Safety, ITS Resources and Multi-State Initiatives, Public Safety, Communications, Animal Detection Systems, Operations and Maintenance, and more.


The format of this year's conference was expanded to include more training opportunities, including workshops, professional continuing education units (CEUs), and interdisciplinary sessions. For example, this year's program included a National Highway Institute ITS Procurement Course and an invitation-only United We Ride/Mobility Services for All Americans Workshop for Rural Areas. In addition, the ITS America Rural SIG developed a full day of interdisciplinary sessions to highlight the important connection between rural emergency medical service transportation and need for rural ITS. These sessions were designed to complement the Rural Emergency Medical Services Summit, which immediately followed NRITS and provided an additional training opportunity for participants. Presentations from the conference sessions are available at http://www.coe.montana.edu/wti/tech_transfer/NRITS/NRITS.html

**Technology Forum Promotes Peer-to-Peer Information Exchange**

In June 2006, WTI and the California Department of Transportation (Caltrans) sponsored the Western States Rural Transportation Technology Implementers Forum in Mount Shasta, California. The goal of the one-day meeting was to allow rural ITS technology practitioners to exchange detailed technical information about how solutions are designed, engineered, integrated and implemented. WTI researchers have been actively involved in ITS deployment and evaluation in this region for many years through the California-Oregon Advanced Transportation Systems (COATS) project and the follow-up effort, COATS Showcase.

The event was attended by state and local transportation professionals, including field engineers, maintenance staff, systems engineers, and communications technicians. To promote a high level of technical content, each presentation focused on a specific solution or application that had actually been deployed in the field. Topics included:

- Fiber Optic Network/Topology Design on State Highways;
- Microwave Communications for Rural ITS Applications;
- The Redding Responder Project: Mobile Data Communication Challenges and Solutions in Remote Rural Areas;
- Caltrans District 9 Mountain Pass Signs; and
- Web-Based ITS Field Element Control.

Each presentation was followed by an extensive discussion period, to encourage detailed technical descriptions and candid recommendations. "Engineers want to hear about the successes as well as the failures, so they know what doesn't work and why," said WTI Research Engineer and Forum organizer, Chris Strong.

For WTI, the event also represented an opportunity to cost-effectively disseminate research results from COATS ITS projects. The forum was funded through the third phase of the COATS project, sponsored by California and Oregon to mainstream deployment of field tested technologies.

Sponsors were pleased with attendee participation and response, and are considering a similar forum for next year. "I think this event was well-received by the participants and is a good kickoff for future forums of this nature," said Sean Campbell, Senior Transportation Electrical Engineer and Specialist from the Caltrans Division of Research and Innovation.

**WTI Conducts Tour for Montana Association of Counties (MACo)**

WTI was one of the sponsors of the Montana Association of Counties (MACo) conference, which was held in Bozeman, Montana this year. As part of the sponsorship, WTI provided break refreshments and a tour of WTI's research facilities.

The tour included a welcome and overview of WTI by Steve Albert, WTI's director. The overview highlighted research projects conducted by WTI for Gallatin County, and projects that could benefit other counties in the state.

Tour participants visited the various labs at the facility, and had a chance to drive the automobile simulator housed at WTI. The tour helped local government officials understand advancements that can improve their ability to aid their counties with transportation related issues.

# Peer Reviewed Publications

**Tony Clevenger**

"Maintaining and Restoring Connectivity in Landscapes Fragmented by Roads". Clevenger, A.P. & Wierzchowski, J., 2006. In Maintaining Connections for Nature (Eds. K. Crooks, M. Sanjayan) by Cambridge University Press

"Habitat and Corridor Function of Rights-of-ways". Huijser, M.P. & A.P. Clevenger, 2006. In The Ecology of Transportation: Managing Mobility for the Environment (J. Davenport & J.L. Davenport, editors) by Springer

"Assessing and Managing the Ecological Impacts of Paved Roads". NRC (National Research Council), 2005. The National Academies Press, Washington, DC. (authors: Gunderson, L, Clevenger, A, Cooper, A, Dale, V, Evans, L, Evink, G, Fahrig, L, Haynes, K, Kober, W, Lester, S, Redford, K, Strand, M, Wagner, P, Yowell, J.)

"The Influence of Disturbance and Habitat on the Frequency of Non-native Plant Species Along Transportation Corridors". Hansen, M. & A.P. Clevenger, 2005. Biological Conservation 125:249-259.

**Eli Cuelho**

"Evaluating Concrete Bridge Deck Performance Using Active Instrumentation". Cuelho, E., Stephens, J., Smolenski, P., and Johnson, J., 2006. Proceedings: 2006 Annual Meeting of the Transportation Research Board

**Katie O'Keefe**

"Anti-icing and Pre-wetting: Improved Methods for Winter Highway Maintenance in North America". O'Keefe K., and Shi X, 2006. Proceedings: 2006 Annual Meeting of the Transportation Research Board.

**Xianming Shi**

"A Regional Pilot Weather Information System for Surface Transportation and Incident Management". Shi X., Wang S., Turnbull I., Chu M., and Albert S., 2006. Proceedings: 2006 Annual Meeting of the Transportation Research Board

**Chris Strong**

"Development of a Roadway Weather Severity Index". C. Strong, 2006. Transportation Research Record: Journal of the Transportation Research Board, No. 1948, pp. 161-169.

# Presentations

**Steve Albert**
- "Transportation Management System in Montana: Operational Needs", Montana Joint Engineers Conference, Helena, MT, November 2005
- "Traveler Information Forum: 511 Perspectives for the Future", ITS America Annual Meeting, Philadelphia, PA, May 2006
- "Making Connections Between Transportation and Emergency Medical Services", National EMS Summit at the Summit, Big Sky, MT, August 2006

**Rob Ament**
- "Roadkill Observation Collection System: A New Tool for Mitigating Busy Highways", CERI Workshop, Gardiner, MT, October 2005
- "Roadkill Observation Collection System: A New Tool for Specialized Precise Data Sets", GIS & Conservation Modeling Conference, Gardiner, MT, September 2006

**Matt Blank**
- "Two and Three Dimensional Water Velocities in Culverts", Western Division Annual Meeting, Bozeman, MT, May 2006

**Mike Brown**
- "Feasibility of Using a Gyratory Compactor to Determine Compaction Character of Soil", 40th Annual Geo-Symposium Conference, Logan, UT, May 2006

**Wei Chu**
- "Protocol and Software Program for Cathodic Protection of Deep Water Marine Risers", NACE/Corrosion 2006, San Diego, CA, March 2006
- "Utility of Bulk Submerged Galvanic Anodes for Bridge Substructure Cathodic Protection", NACE/Corrosion 2006, San Diego, CA, March 2006
- "Software Program for Designing CP Retrofits for Marine Pipeline", NACE/Corrosion 2006, San Diego, CA, March 2006

**Anthony Clevenger**
- "Lessons from Long-term Monitoring", Transportation Research Board Annual Meeting, Washington, D. C., January 2006
- "Long-term Monitoring and DNA Based Approaches for Restoring Landscape Connectivity Across Transportation Corridors in the Canadian Rocky Mountains", Seminar on Linear Infrastructures and Biodiversity, Evora, Portugal, October 2005

**Eli Cuelho**
- "Lewistown Airport Cold Region Rural Transportation Research Facility", Pacific Northwest Snowfighters Annual Meeting, Spokane, WA, June 2006
- "Evaluating Concrete Bridge Deck Performance Using Active Instrumentation", Transportation Research Board Annual Meeting, Washington, D. C., January 2006
- "Lewistown Airport Cold Region Rural Transportation Research Facility", WASHTO Subcommittee Maintenance Annual Meeting, Midway, UT, March 2006

**William Durham**
- "Bozeman Bicycle Network", Tools of the Trade Conference on Transportation Planning, Nashville, TN, September 2006

**Jaime Eidswick**
- "Evaluation of Alaska's 511 System", 2006 National Rural ITS Conference, Big Sky, MT, August 2006
- "Comparative Analysis of State 511 Survey Results", National 511 Conference, San Diego, CA, July 2006

**Laura Fay**
- "Evaluation of Alternate Anti-icing and De-icing Compounds Using Sodium Chloride & Magnesium Chloride as Baseline Deicers", Alternate Deicers Research Study Panel, Denver, CO, July 2006

**Doug Galarus**
- "The Redding Responder Project: Computing and Communication in the Middle of Nowhere", 2006 National Rural ITS Conference, Big Sky, MT, August 2006
- "The Redding Responder Project: Mobile Data Communication Challenges in Remote Areas", 2006 National Rural ITS Conference, Big Sky, MT, August 2006
- "The WeatherShare Project: Aggregation and Dissemination of Weather Information for Public Safety", 2006 National Rural ITS Conference, Big Sky, MT, August 2006
- "The Application of Systems and Software Engineering Process Models for Developing Small to Medium Sized ITS Projects", 2006 National Rural ITS Conference, Big Sky, MT, August 2006
- "Redding Responder-Computing & Communication in the Middle of Nowhere", IEEE Montana Section Meeting, Bozeman, MT, February 2006

**Sean Graham**
- "An Intelligent Work Zone Information System", 2006 National Rural ITS Conference, Big Sky, MT, August 2006

**Amanda Hardy**
- "Roadkill Observation Collection System Training", Virginia DOT PDA/GPS Training Meeting, Lexington, VA, September 2006
- "Mitigating Animal-vehicle Collisions: What Works?", 57th Road Builders Conference, Coeur d' Alene, ID, March 2006
- "Mitigating Animal-vehicle Collisions--What Works?", Transportation Research Board Annual Meeting, Washington, D.C., January 2006
- "Effectiveness of Animal Advisory Messages on Dynamic Message Signs as a Speed Reduction Tool: A Case Study in Rural Montana", Transportation Research Board Annual Meeting, Washington, D.C., January 2006
- "Effectiveness of Animal Advisory Messages on Dynamic Message Signs", 2006 National Rural ITS Conference, Big Sky, MT, August 2006

**Marcel Huijser**
- "Reliability of Animal Detection System Along US Highway 191 in Yellowstone National Park", CERI Workshop, Gardiner, MT, October 2005
- "The Reliability of the Animal Detection System Along US Highway 191 in Yellowstone National Park", Transportation Research Board Annual Meeting, Washington, D. C., January 2006
- "Animal-vehicle Collisions Along Montana Highway 83 in the Seeley-Swan", CERI Workshop, Gardiner, MT, October 2005
- "Current Road Ecology Research at WTI-MSU", Deer-vehicle Crash Reduction National Meeting, Madison, WI, October 2005
- "The Reliability of the Animal Detection System Along Highway 191 in Yellowstone National Park", 2006 National Rural ITS Conference, Big Sky, MT, August 2006
- "The Reliability of the Animal Detection System Along Highway 191 in Yellowstone National Park", Northwest Transportation Conference, Corvallis, OR, February 2006

**David Kack**
- "Evaluation of the Transportation Component of the Real Choices System Change Grant in Montana", 2006 National Rural ITS Conference, Big Sky, MT, August 2006
- "Developing a Transportation Toolkit for Federal Land Managers", 2006 National Rural ITS Conference, Big Sky, MT, August 2006

**Manju Kumar**
- "A Smart Work Zone Delay Estimation System for Rural Highway Operations", 2006 National Rural ITS Conference, Big Sky, MT, August 2006
- "Maintenance of ITS Devices in Rural Areas: Case Studies", 2006 National Rural ITS Conference, Big Sky, MT, August 2006
- "Evaluation of Automated Wind Warning Systems", 2006 National Rural ITS Conference, Big Sky, MT, August 2006

**Suzanne Lassacher**
- "Method to Accelerate the Deployment of Rural TMCs and ITS Potential FHWA Pooled Fund Study", 2006 National Rural ITS Conference, Big Sky, MT, August 2006

**Pat McGowen**
- "Weather Responsive Signal Timing: Practical Guidelines", 2006 National Rural ITS Conference, Big Sky, MT, August 2006

**Keely Obert**
- "Investigation of Coarse Aggregate Durability Using the Micro-deval Abrasion Testing Apparatus", 40th Annual GeoSymposium Conference, Logan, UT, May 2006

**Katie O'Keefe**
- "Anti-icing and Pre-wetting: Improved Methods for Winter Highway Maintenance in North America", Transportation Research Board Annual Meeting, Washington, D. C., January 2006
- "Evaluation of the UDOT Weather Operations/RWIS Program", 2006 National Rural ITS Conference, Big Sky, MT, August 2006

**Steve Perkins**
- "COST 348: What Has It Done For the Industry", COST Action 348 Dissemination Symposium,Winsdor, UK, March 2006

**Xianming Shi**
- "Anti-icing and Pre-wetting: Improved Methods for Winter Highway Maintenance in North America", Pacific Northwest Snowfighters Annual Meeting, Spokane, WA, June 2006
- "Highway Runoff Best Management Practice and Winter Traction Materials Management: Cold Regions Perspective", Transportation Research Board Annual Meeting, Washington, D. C., January 2006
- "Weather Share: An Integrated, User-friendly Surface Transportation Weather System for Northern California", 12th World Congress on Intelligent Transportation, San Francisco, CA, November 2005
- "Integrating the Surface Transportation Weather Information: An ITS System for Northern California", 2006 National Rural ITS Conference, Big Sky, MT, August 2006
- "Synthesis of Vehicle Based Winter Maintenance Technologies", 2006 National Rural ITS Conference, Big Sky, MT, August 2006
- "Anti-icing & Pre-wetting: Improved Methods for Winter Highway Maintenance in North America", Transportation Research Board Annual Meeting, Washington, D. C., January 2006
- "A Regional Pilot Weather Info System for Surface Transportation and Incident Management", Transportation Research Board Annual Meeting, Washington, D. C., January 2006

**Yurii Shvetsov**

• "Develop of a Roadway Weather Severity Index", Transportation Research Board Annual Meeting, Washington, D.C., January 2006

**Laura Stanley**

• "Driver Responses to Enhanced Wildlife Advisory Messages in a Simulated Environment", Transportation Research Board Annual Meeting, Washington, D. C., January 2006

**Jerry Stephens**

"Uncommon Methods of Analyzing Strain & Temperature Data to Reveal the Presence of Distress in Bridge Decks", NDE Conference on Civil Engineering, St. Louis, MO, August 2006

**Chris Strong**

• "Pilot Application of AVL on Snow Plows", 2006 National Rural ITS Conference, Big Sky, MT, August 2006
• "AVL: A Tool for Rural Highway Maintenance and Operations", ITS America Annual Meeting, Philadelphia, May 2006
• "Rural ITS Applications",2006 National Rural Transportation Peer Learning Conference, Indianapolis, IN, September 2006
• "Rural ITS Applications", California Transportation Planning Conference, Monterey, CA, May 2006
• "Applicability of ITS in National Parks: California Case Studies", 12th World Congress on Intelligent Transportation, San Francisco, CA, November 2005
• "Golden Gate National Recreation Area ITS Pilot Project Evaluation", 2006 National Rural ITS Conference, Big Sky, MT, August 2006

**Nick Trimble**

• "Permeability Investigation of a Silty Clay Alluvium/Chromium Contamination Transport", 40th Annual Geo-Symposium Conference, Logan, UT, May 2006

## Conference Booths

The WTI booth was displayed at the 2006 National Rural ITS Conference, which was held in Big Sky, Montana on August 13-16. More details about the conference can be found in the Conference Section of this report on page 57.

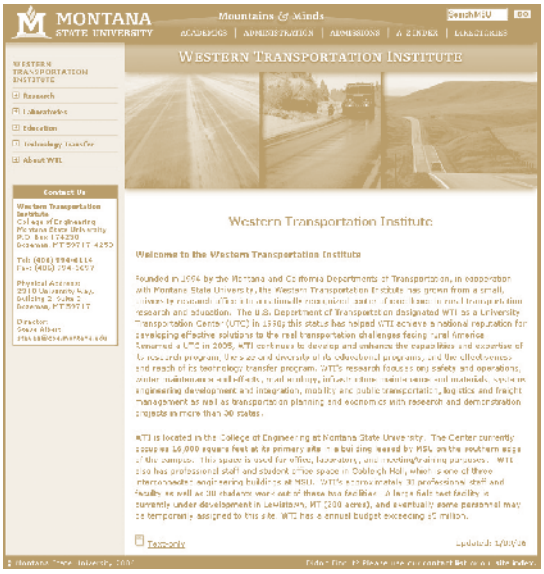
The main focus of the booth is to provide current and relevant research information to conference attendees. The booth has been completely redesigned to illustrate how the Center's revised focus areas address specific rural needs, as well as advance national transportation priorities. With an expanded size, the booth also has room to demonstrate the capabilities of the newly completed research laboratories. WTI research staff members were available at the booth throughout the conference to answer questions and discuss future research opportunities with conference attendees.

Demonstrations projects were also an important component of the booth redesign. At the NRITS conference, several WTI research projects were showcased. These demonstrations gave conference attendees a unique opportunity to view the technology in action. In the case of the Roadkill Observation Collection System (ROCS), potential project partners were able to view first hand how the GPS equipped PDA works. This allowed agencies to gather additional information before making their decision about joining the pooled fund research effort, which will further evaluate this method of standardizing the collection of road kill data. WTI researchers also demonstrated the Redding Responder project, which is a prototype incident collection system based on GPS equipped tablet PCs.

## Website

WTI completed a major "remodel" of its website during the past year. In response to new graphic identity standards set by Montana State University, technology transfer staff updated the overall website design. The site map and left hand navigation bar were reorganized to more closely match the Center's main functions of research, education and technology transfer. Each of these main functions now has a separate homepage which allows for easy access to the most current and relevant information in each area. For example, the research homepage displays a chart linking to the ongoing and completed projects for each of the focus areas, which allows for quick navigation to the projects that interest the web user.

In the research section of the site, home pages were created for each of the research focus areas and laboratories. These homepages allow each focus area to customize its area of the site to ensure it best serves the needs and interests of their web users. Several of the focus areas have created additional pages that link back to their home page, which allows for further customization. These pages contain information such as links, opportunities and news relevant to the particular focus area. It is envisioned these pages may become mini-clearinghouses of information and thus become a resource for other transportation professionals. The laboratory homepages create a method for the labs to clearly illustrate the facilities and equipment available for research, testing, and evaluation projects. And finally, both the research focus area and laboratory homepages demonstrate the depth of project experience, staff expertise, and facility capabilities available to potential research partners.



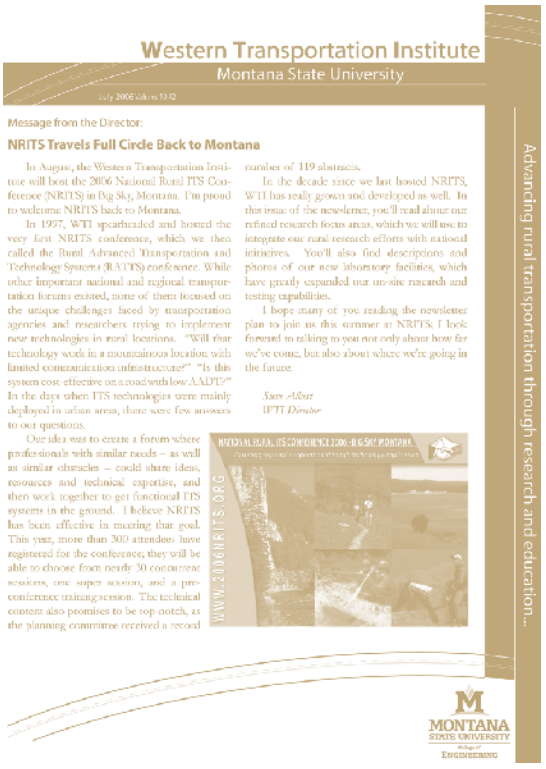

Only minor changes were made in the Education and Technology Transfer portions of the website. In the Education section, a slightly different webpage template was developed so that time critical documents such as scholarship applications are displayed in a right hand navigation bar on each education related page. This design change will hopefully address a common suggestion from students to make application materials easy to locate. In the Technology Transfer section, separate pages were created for publications, conferences and the newsletter archive. This division of information makes it easier for transportation practitioners to locate and review the documents they need from WTI's growing body of research and publications.

# Newsletters

The Center newsletter was published in March and July 2006 to inform readers about our latest research, education and technology transfer activities. Both editions of the newsletter can be downloaded as pdf files from http://www.coe.montana.edu/wti/tech_transfer/newsletter.html. The newsletter was sent to approximately 2190 readers. This surpasses our circulation goal by 130%

**The March 2006 WTI Newsletter included these articles:**

- "Location, Location, Location!"
- "For The Enjoyment of Future Generations" Innovative transportation planning helps National Parks to promote visitation while protecting resources
- Habitat Connectivity Project Focuses on Endangered San Joaquin Kit Fox
- Advanced Collision Avoidance Techniques to be Studied in WTI's Driving Simulation Laboratory
- Sensor Technology for Winter Maintenance: the State-of-the-Practice and the State-of-the-Art
- WTI Explores Electrochemistry Solutions to Transportation Issues
- Motor Carrier Safety Assurance Program will be Evaluated by WTI
- Long Term Benefits of Wildlife Crossings Studied in the Rocky Mountain Region
- Billings Transit Provider Uses Software to Simplify Scheduling, Create Efficient Routes
- Testing the Effects of Chloride-Based Deicers on Concrete Corrosion
- Do Traditional Warning Signs Improve Safety on Montana Roads?
- Study of Aggregates will Help Road Designers
- Packed Agenda for NRITS 2006 – Don't Miss It!!!
- Road Ecology Book Co-authored by WTI Researcher
- Laura Stanley selected as "Student of the Year"
- Second Annual Girl Scout Engineering Day a Huge Success
- WTI Alumni: Where are They Now?
- WTI Researcher Named IEEE Montana Section Chair
- WTI will Study Effectiveness of Animal Warning Systems


Western Transportation Institute
Montana State University
Message from the Director:
NRITS Travels Full Circle Back to Montana
Advancing rural transportation through research and education...
MONTANA STATE UNIVERSITY

**The July 2006 WTI Newsletter included these articles:**

- NRITS Travels Full Circle Back to Montana
- NOVIS Project Tests Vehicle Detection Technologies
- WTI Researcher Identifies High Animal-Vehicle Collision Zones on Montana Highway 83 in the Seeley-Swan Valley
- Field Test Underway for Caltrans Mobile Data Communication
- Effectiveness of Animal Detection System to be Evaluated
- WTI Examines Animal-Vehicle Collision Data Collection Practices
- WTI Conducts First Study on Ecological Impact of Median Barriers
- Technology Forum Promotes Peer-to-Peer Information Exchange
- COATS Project Enters Third Phase to Improve Rural ITS Planning
- New Laboratory Facilities Offer Expanded Research Opportunities
- WTI hosts Council of University Transportation Center Summer Meeting
- Summer Institute Introduces Teens to Transportation Career Opportunities
- WTI Integrates Research to Meet Rural Challenges and Advance National Priorities
- Driving Simulator to Replicate a Montana Highway and Test Planned Improvements
- WTI Researchers Co-author New Book on Transportation and Ecology
- WTI Researcher Helping to Restore Habitat Connectivity Across Transportation Corridors in Bulgaria
- Training Course Offered on Mitigating Transportation Impacts on Wildlife and Fisheries

## Technology Transfer Success Story

In August, the Western Transportation Institute hosted the 2006 National Rural ITS Conference (NRITS) in Big Sky, Montana. In 1997, WTI spearheaded and hosted an early NRITS conference, which was then called the Rural Advanced Transportation and Technology Systems (RATTS) conference. While other important national and regional transportation forums existed, none of them focused on the unique challenges faced by transportation agencies and researchers trying to implement new technologies in rural locations. WTI's idea was to create a forum where professionals with similar needs – as well as similar obstacles – could share ideas, resources and technical expertise, and then work together to get functional ITS systems in the ground. This year, more than 250 attendees participated in nearly 30 concurrent sessions, one super session, and a pre-conference training session. The technical content was top-notch, as the planning committee received a record number of 119 abstracts.

By hosting NRITS a second time, WTI was able to draw on all of its experience to maximize the value of the conference for participants. After nine years of collaborative research and successful deployments, WTI has working relationships with national and international transportation experts who were invited to serve as reviewers and presenters.

As described earlier, the format of this year's conference was expanded to include more training opportunities, including workshops, professional continuing education units (CEUs), and interdisciplinary sessions. According to Steve Albert, Chairman of the ITS America Rural Special Interest Group (SIG) and Director of the Western Transportation Institute, "The Rural SIG's goal is to transition the NRITS Conference from a predominately technology transfer event to one that is more focused on workforce development and training, which began with this year's NRITS Conference." These events that combine research dissemination with training help transportation practitioners get more benefits out of limited travel and training budgets.

## Initiatives For 2007

The technology transfer initiatives for 2007 will focus on two new efforts to get the word out about rural transportation research. As a service to researchers, and to the transportation community in general, the technology transfer program will maintain a clearinghouse for rural transportation information that is uniquely distinguished by a) its focus and customization to rural issues, b) the extent of the material it chronicles, and c) the timeliness with which materials are posted. The clearinghouse will serve as a "one-stop shop" and provide a tool to accelerate knowledge delivery by getting information into the hands of researchers and practitioners, at a local, state and national level. The clearinghouse will contain information from regional and national conference proceedings (including presentations), regional UTC Centers, and other similar sources of knowledge and experience. It will complement and not duplicate traditional information sources such as TRIS.

In a parallel venture, the program will also maintain a rural transportation blog to facilitate dialog among transportation professionals on rural issues. The Center will actively host the rural transportation blog and ensure its effectiveness through concise moderation. The blog will have several main subject areas, which will be moderated by transportation professionals knowledgeable in that area. Topic areas will include: technology applications, best practices, research findings, contact information, and future needs to meet the rural transportation challenges.