Western Transportation Institute
University Transportation Center

2005 Annual Report
(For the period October 1, 2004 - September 30, 2005)

College of Engineering
Montana State University

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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 2005.

It has been a landmark year for WTI. In August, when President George Bush signed the federal highway funding bill, he once again designated WTI as a University Transportation Center.

WTI was first named as a UTC in 1998. As one of only 35 UTC's in the country, this designation has helped WTI achieve a national reputation for our specialized research in the field of rural transportation. To be named a national UTC a second time is especially gratifying, because it means that we are developing effective solutions to the real transportation challenges facing rural America.

The reaffirmation of our University Transportation Center status will allow WTI to build on our research in each of our focus areas. Many of the research topics in which we have developed extensive expertise are reflected in the themes of the federal highway bill, an indication that WTI is at the leading edge of research on issues of national priority. This year, WTI completed 15 UTC projects on important topics such as:

- Driver distraction during cell phone use
- Effectiveness of Wildlife Crossing Systems
- Providing communications and power to transportation technologies in remote locations
- Accuracy of Road Weather Information System sensors
- Testing geosynthetic materials for use in highway construction

In addition, the funding provided by the UTC program allows WTI to take the lead in initiating research collaborations among a variety of public and private partners. This federal funding often provides the seed money that gets new research off the ground. In a similar fashion, UTC funding allows WTI to create innovative laboratory facilities that makes new research simpler, safer or more cost-effective. With our Materials Corrosion Laboratory and Driving Simulation Laboratory successfully in place, WTI will soon be developing and expanding additional specialized research facilities for systems engineering, materials testing, and transportation software applications.

As a well-established University Transportation Center, WTI has also had the opportunity to develop a comprehensive education program. Through the years we have offered unique learning opportunities to students from elementary school through graduate school. Just this year, we added a Summer Transportation Institute for high school students. With our renewed UTC status, we can expand on our efforts to provide hands-on educational opportunities in order to recruit and prepare the transportation professionals of tomorrow. To strengthen the skills of today's transportation practitioners, we will be expanding our professional development course offerings in emerging issues, such as wildlife interactions on our highway system.

WTI would not have achieved any of these accomplishments without the support and assistance of 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. Working together, we have established a University Transportation Center that provides a full spectrum of top notch research and education programs. We look forward to our ongoing collaboration and future achievements together.

Steve Albert
Director

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 elevenyears. 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, business, biology and economics. Our professional staff alone has more than 150 years of 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 oversight members with clear, concise and accurate reports of WTI's activities so that they may adequately guide the long-term development of WTI;
- utilize MSU resources (research and training facilities, human resources, physical facilities and institutional support capabilities) to maximize efficiency; and
- establish 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.

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Administrative Success Story

Professional Development Opportunities
WTI Expands Management Opportunities for Professional Staff

Through a recent Strategic Planning process, WTI developed a number of goals and objectives related to developing career track opportunities for staff. Last year, WTI began conducting annual personnel assessments to identify in-house skill sets. This process confirmed that WTI's professional staff members possess extensive management and leadership skills, in addition to their technical expertise.

To capitalize on these valuable internal resources, WTI created several key promotional opportunities in 2005. For research staff, WTI added program manager positions for each of the research focus areas to increase oversight of rapidly growing research programs. The program managers are responsible for supervising all of the Principal Investigators conducting research in that area; providing high quality deliverables; and assuring that projects are well planned, properly budgeted and completed on time. Three current WTI researchers have already been promoted to the position of Program Manager for the Transportation Wildlife Interaction Focus Area, the Weather and Winter Mobility Focus Area, and the Systems Engineering Development and Integration Focus Area. More Program Managers may be added as the focus areas continue to grow and develop.

For administrative staff, WTI created the positions of Assistant Director for Administration and Assistant Director for Communications and Information Systems. These two posts will share the responsibilities formerly carried out by the Deputy Director, which include strategic planning, human resources, internal and external relations, financial administration, information technology, and technology transfer. Both positions have been filled by existing administrative professionals.

Increasing opportunities to promote from within has benefits for both the organization and the individual staff members. WTI benefits from drawing on the in-house skills and institutional knowledge of existing personnel, as well as creating incentives to retain highly qualified staff. Staff members are able to develop and apply their management skills, which further improve their ability to conduct successful projects and enhance future research and career opportunities.

Administrative Initiatives for 2006

Developing a Significant and Relevant Research Agenda

To stay at the forefront of the field, WTI constantly strives to analyze the future of transportation research in order to identify stakeholders, potential partners, emerging issues, and research opportunities. WTI also carefully tracks federal transportation trends, to ensure that research reflects issues of a national priority.

In 2005, the passage of the surface transportation reauthorization bill (known as SAFETEA) provided a national forum for discussing the future of transportation. Many of WTI's research priorities are reflected in the themes of the federal highway bill, an indication that WTI has been successful in selecting important research topics.

In 2006, WTI will conduct an extensive analysis of SAFETEA to identify research opportunities within the provisions of the bill. This process will help WTI to:

- Select research projects that not only match WTI's strengths, but also serve the most pressing national issues
- Identify strategic hires that will strengthen technical expertise in nationally-relevant issue areas
- Identify funding resources so that research dollars can be leveraged and used to their greatest potential
- Identify new collaborations to coordinate similar research efforts and strengthen technical expertise

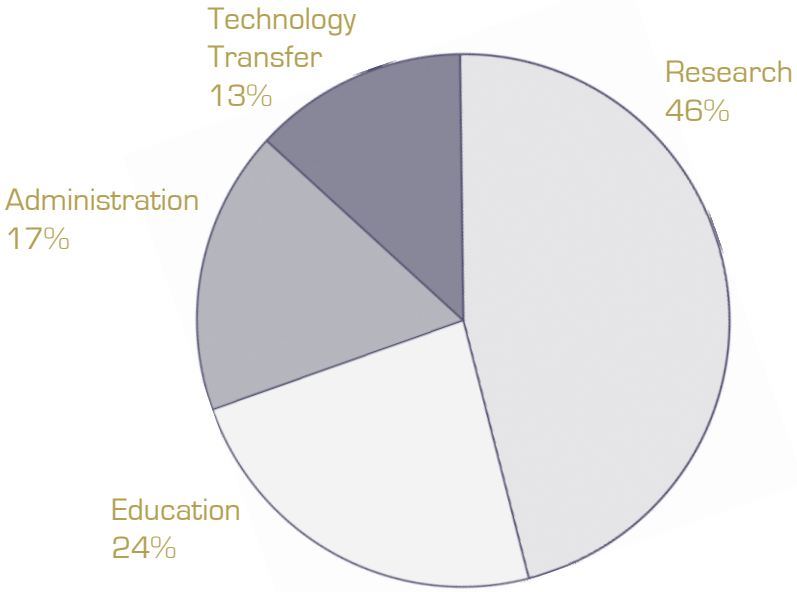
Financial Statement

The following pie charts illustrate allocations and funding sources for the Western Transportation Institute's UTC programs during year 7. Figure 1 shows the breakdown of expenditures and allocations of the Federal portion ($1,904,000) of the UTC program for Year 7. Approximately $451,000 was allocated for the Education Program, and $878,000 has been committed for research funding. The remaining $575,000 supports the administrative and technology transfer function of WTI.

The second figure depicts the Year 7 funding sources for the WTI UTC program. The match for the USDOT portion is provided by the Montana Local Technical Assistance Program, the MSU Civil Engineering Department, pooled research and demonstration projects, individual state Departments of Transportation and Foundation support.

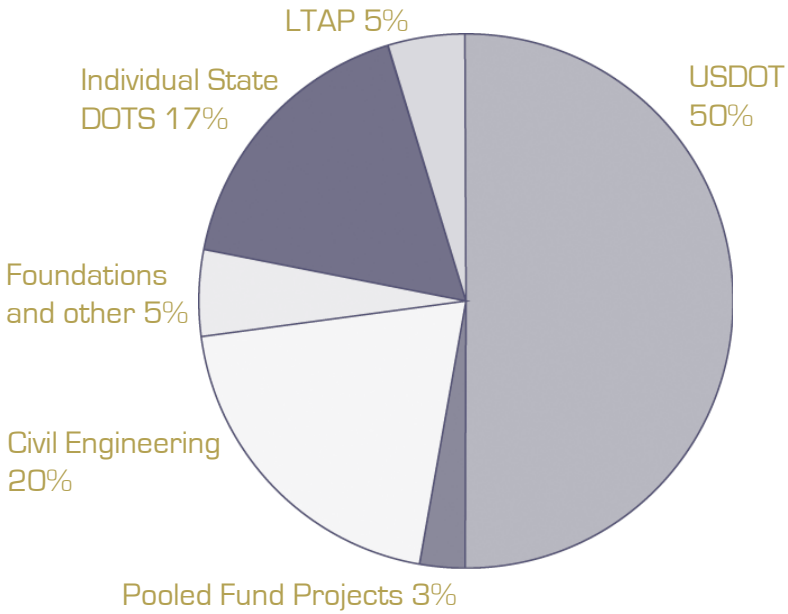
Allocations for Year 7:

October 1, 2004 - September 30, 2005



Funding Sources for Year 7:

October 1, 2004 - September 30, 2005



Research Staff

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Suzy Lassacher
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Patrick McGowen
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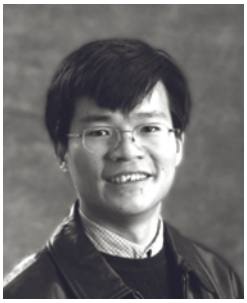
Steve Perkins
Associate Professor,
Civil Engineering

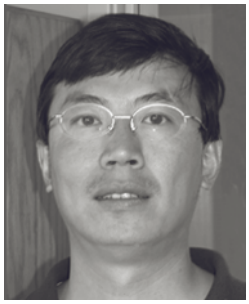


Xianming Shi
Research Scientist

Laura Stanley
Research Associate

Jerry Stephens
Associate Professor,
Civil Engineering

Christopher Strong
Research Engineer



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Doug Galarus - Program Manager,
Systems Engineering Development and Integration

Tony Clevenger - Program Manager,
Transportation System Wildlife Interactions

Xianming Shi - Program Manager,
Weather and Winter Mobility

Research

"To create an ongoing program of basic and applied research, the products of which are judged by peers or other experts in the field to advance the body of knowledge in transportation"

Research Program

In 2005, WTI had several significant accomplishments in our research program. WTI researchers completed a record fifteen UTC projects in one year; installed and conducted research in two new research laboratories and developed plans for the expansion or addition of three more, and formed new research funding partnerships with private environmental foundations. All of these advancements strengthen the research experience and capabilities we offer as an organization. The following section provides details on all of WTI's new, ongoing and completed UTC research projects.

Transportation System Wildlife Ecology Interactions

Integrating research, education and training to provide world-class surface transportation and environmental solutions for mitigating animal vehicle collisions and habitat connectivity.

Highway Infrastructure Design and Maintenance

Using progressive research to improve the design and maintenance of rural highway infrastructure…

Weather and Winter Mobility

Improving traveler safety and operating agency effectiveness to address weather and winter mobility challenges.

Rural Applications of Advanced Technology

Evolving the state of the practice in advanced technology to meet rural transportation challenges and constraints.

Public Transportation and Mobility

Improving people's lives by addressing rural public transportation challenges

New Research Projects

Project Name	Principal Investigator
Development of a Road Ecology Curriculum	Tony Clevenger
Technology Transfer of Guiding Principles of Wildlife Crossing Systems	Tony Clevenger
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
Corrosion Inhibition Mechanisms at the Steel/Concrete Interface	Xianming Shi
Evaluation of the UDOT Weather Operations/RWIS Program	Xianming Shi
Haptic and Auditory Interfaces as a Collision Avoidance Technique During Run-Off Road and Head-On Collisions and Driver Perception of Modalities	Laura Stanley

Development of a Road Ecology Curriculum

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The book, "Road Ecology: Science and Solutions" has generated significant interest in road ecology among the transportation community and general public. The objective of this project is 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 will look 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 knowledge. 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.

Technology Transfer of Guiding Principles of Wildlife Crossing Systems

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Effective wildlife fencing and crossings can significantly reduce many harmful impacts of roads on wildlife populations. 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 professional development short-course to teach guidelines for planning and designing functional wildlife fencing and crossing structures.

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

The research team will review and synthesize 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 Departments of Transportation.

Feasibility Of Using A Gyratory Compactor To Determine Compaction Characteristics Of Base Course Aggregates

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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 will explore the effectiveness of using a gyratory compactor to accurately predict optimum in-place soil densities.

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.

Initially, researchers will conduct basic geotechnical index tests to describe the various properties of each of the soils. A suite of impact compaction tests (Proctor tests) will also be conducted to determine standard moisture/density relationships.

Subsequently, the team will conduct compaction tests on a full suite of soil samples. Using the standard impact compaction equipment, various energies will be imparted into the soils to determine the effect on soil density. Results will be compared to those obtained when a Gyratory compactor is used to compact the soils.

Results from testing have been encouraging and generally seem to correlate with other research conducted using this equipment. So far, five soil types have been tested in a dry state.

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

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Within the Yellowstone to Yukon Ecoregion, 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.

To 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 wildlife crossings
- Develop science-based guidelines for transportation departments, land management agencies, and conservation community.
- Expand technology transfer efforts to disseminate research findings in journals and international conferences.

Corrosion Inhibition Mechanisms at the Steel/Comcrete Interface

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Concrete normally provides both chemical and physical protection for the steel reinforcement embedded in concrete. Cement hydration leads to the highly alkaline (pH ~ 13 - 14) pore solution of concrete, which promotes the formation of an oxide/hydroxide film at the steel surface, a passive film of 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 concrete durability. Therefore, the focus of this research is placed 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 numerous corrosion inhibitors to mitigate the corrosion of steel in concrete have been studied. 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 would contribute greatly to the effort of searching for effective measures to mitigate steel corrosion in concrete and protect concrete structures in a chloride-containing environment.

Initially, researchers will document the state-of-the-practice information related to this project. Then, experiments will be designed to investigate the corrosion at the steel/concrete interface as a result of chloride attack, in the absence and presence of various corrosion inhibitors. 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.

Evaluation of the UDOT Weather Operation/RWIS Program: Phase 1

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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 program.

For this project, 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 Central Maintenance, Maintenance, and Construction. The evaluation will determine the direct benefits of the program to construction management/contractors, winter maintenance operation, etc., by looking at issues such as the accuracy of the information provided, whether customers are satisfied and whether the information is changing their behaviors. Researchers will conduct a survey of practices in other states, document current practices at UDOT, and evaluate the cost-effectiveness of programs and investments.

Haptic and Auditory Interfaces as A Collision Avoidance Technique During Run-Off-Road And Head-On Collisions and Driver Perception of Modalties

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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:

This study will provide valuable data for the development of effective in-vehicle lane departure warning systems

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

The primary goal of this project is 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 will drive a simulated road segment, during which time they will each receive three alerting sensory modalities: haptic (seat vibration), auditory ("rumble strip" sound), and combined auditory and haptic sensory warnings.

From this study, researchers will:

- determine appropriate and comparable intensities for the auditory and haptic signal
- compare driver responses to variations in haptic (seat vibration), auditory ("rumble strip" sound), and combined modalities of auditory and haptic
- determine driver perception and acceptance of the presented modalities as a collision avoidance warning technique on rural two-way two-lane roads.

On-Going Research Projects

Project Name	Principal Investigator
Materials Corrosion Laboratory: Evaluating Common Corrosion-Inhibited Deicers	Xianming Shi
Investigating Innovative Research Opportunities Related to Highway Infrastructure Design & Maintenance	Eli Cuelho
ITS Applications in Golden Gate National Recreation Area, Phase I, Muir Woods	Christopher Strong
UTC National Center for Integration and Systems Engineering of Transportation Technology Feasibility Study	Doug Galarus
UTC Development of a Prototype Integrated PDA/GPS System to Collect Roadkill Data	Marcel Huijser
California - Oregon Advanced Transportation System (COATS) Program Showcase	Christopher Strong
Impacts of Weather on Rural Highway Operations	Manju Kumar
Case Studies of Maintaining ITS Devices in Rural Areas	Manju Kumar
Comparative Evaluation of Wind Warning Systems	Manju Kumar
Video Surveillance Trailer Equipment	Christopher Strong
Saco Bridge Field Evaluation	Eli Cuelho
Transportation Toolkit for Federal Lands Managers	David Kack
Bozeman Transportation Research, Applications, and Instrumentation Laboratory (TRAIL)	Suzanne Lassacher
Animal - Vehicle Crash Mitigation	Marcel Huijser

Materials Corrosion Laboratory: Evaluating Common Corrosion-Inhibited Deicers

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To minimize the adverse impacts that highway winter maintenance activities pose on vehicles and transportation infrastructures, it is a popular practice to add corrosion inhibitors into the deicers. The Pacific Northwest Snowfighters (PNS), an association of transportation agency technical experts from British Columbia, Idaho, Montana, Oregon, and Washington, has implemented testing protocols and guidelines for new deicer product qualification. A central feature of these requirements is the presence of corrosion inhibitor in all deicers, and the qualification of all deicers by a NACE/PNS corrosion test before such chemicals can be approved for sale in PNS states.

The Laboratory will have the capabilities to conduct a wide-range of future research, including quality control of deicer products, evaluation of corrosion-inhibiting admixtures for concrete, application of electrochemical protection for highway structures, and development of alternative deicers.

In conjunction with the Montana Department of Transportation (MDT), WTI has created a Materials Corrosion Laboratory to establish the corrosion research capabilities at WTI and to establish protocols for evaluating the corrosion rate of materials and performance of corrosion inhibitors. In light of the NACE/PNS protocol, researchers will establish an improved chemical protocol for evaluating the corrosivity of chemical deicers. WTI will also establish electrochemical protocols for evaluating the corrosion rate of materials and performance of corrosion inhibitors. It may supplement the Chemical Analysis Protocol and will be faster and more reliable. Once the protocols are established, various corrosion-inhibited deicers will be evaluated in the laboratory. Some of the initial research will be conducted in partnership with Nanyang Technological University, Singapore.

Investigating Innovative Research Opportunities Related to Highway Infrastructure Design and Maintenance

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This project aims at proactively addressing the nation's failing infrastructure through innovative and practical research. Many Departments of Transportation are looking for new methods and technologies to better build and maintain highway infrastructure. Creative ideas must be employed 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 is necessary to develop partnerships and relationships with multiple DOTs, research institutes and academic institutions.

This project will enhance the Highway Infrastructure Design and Maintenance program area at the Western Transportation Institute by generating new partners and strengthening partnerships that currently exist.

The primary task for this project is to promote research opportunities that identify highway infrastructure field instrumentation related to design and maintenance, create partnerships with saeveral state departments of transportation to foster state-of-the-art research related to geosynthetic pavement design, and initiate new research that utilizes technological solutions and high performance materials in design. To accomplish this work, WTI will diligently pursue funding and partnerships from a variety of sources, including the reauthorization of TEA-21, state-supported pooled fund studies, the Strategic Highway Research Program (SHRP), the National Cooperative Highway Research Program (NCHRP), state departments of transportation or FHWA. Associate Professor Steve Perkins was recently hired as a joint appointment between the Civil Engineering Department and the Western Transportation Institute to help cultivate additional research within this focus area. Several proposals were written to follow up with geosynthetic work conducted through the UTC. WTI anticipates growth in this area as a result of these efforts.

ITS Applications in Golden Gate National Recreation Area

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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 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 seeks to overcome this problem at one particular location, the Golden Gate National Recreation Area (GGNRA). Each year, GGNRA 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 resulting traffic challenges the National Park Service (NPS) in 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 will test whether advanced technologies can help manage the impacts of increased visitation at our National Parks and will serve as data to decide whether this pilot project should be continued.

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.

The goal of this project is to evaluate the early winner project. This will be accomplished through traffic volume counts, shuttle counts, visitation counts, stakeholder surveys, and public surveys.

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

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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.

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.

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

To address this problem, the Western Transportation Institute at Montana State University-Bozeman 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, would 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.

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

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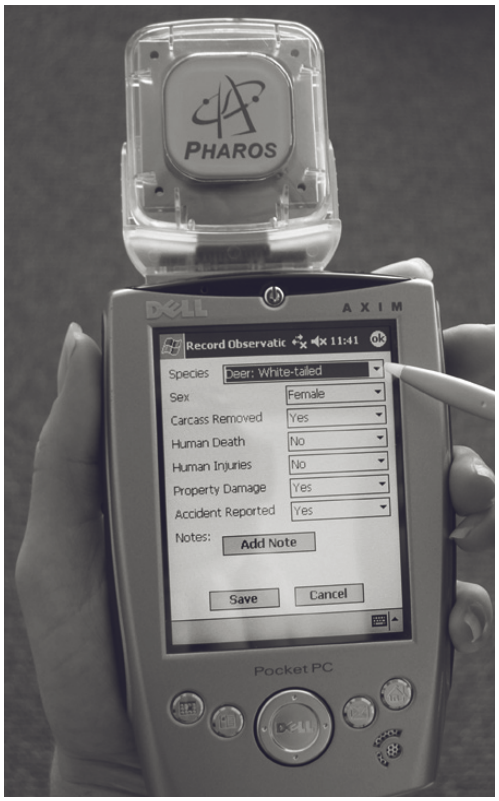
There are approximately 725,000-1,500,000 crashes between vehicles and ungulates (large hoofed animals) in the U.S. annually. These collisions are estimated to cause more than 200 human fatalities and over one billion dollars in property damage a year. In order to avoid or reduce animal-vehicle collisions, 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 will help develop 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 is 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. If successful 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 has 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 will test the prototype in the field, customize the software, modify software based on feedback, and develop procedures that allow for easy data management and analyses and integration with other spatial data.

California/Oregon Advanced Transportation Systems (COATS) Showcase

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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 to create broader awareness and acceptance of the potential of ITS.

COATS Showcase is comprised 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. Once designed and selected, the evaluations become independent projects.

COATS SHOWCASE:
Impacts of Weather on Rural Highway Operations

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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 will provide foundational data that will help evaluate the effectiveness of future road safety technologies and improvements.

The objective of this project is to develop a method for estimating the road capacity reduction effects of weather on rural highway, through the correlation of data collected from automatic traffic recorders with information about weather conditions and other factors such as road grades. This project will provide 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 have been selected within the COATS study area and Montana. These sites have both road weather information systems (RWIS) and detection systems to measure vehicle volume and speed under various severe weather conditions. The entire set of locations includes sites subject to a variety of weather conditions, and sites with a variety of grades and geometric characteristics. Traffic and weather data have been collected for the past two years, in order to capture a variety of weather events. Statistical comparisons between periods of free flow traffic and periods of adverse weather conditions are conducted to isolate the effects of various weather events on roadway volume demand and speed. A series of models is 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

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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. The objective of this project, therefore, is 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.

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.

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 is being conducted to identify primary maintenance concerns from technical and institutional perspectives. The results of this effort will be compiled, summarizing major findings and providing recommendations for improved maintenance procedures.

COATS SHOWCASE:
Comparative Evaluation of Wind Warning Systems

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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:

- 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.

This project will evaluate automated wind warning systems to facilitate deployment of similar systems. This project also provides a unique opportunity to compare the relative effectiveness of three different types of wind warning systems.

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 is 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 will assess whether these different systems have resulted in a reduction in the frequency and severity of crashes involving high profile vehicles, and will also identify other benefits.

The evaluation includes 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 assesses the relative merits of different types of system concepts, and make recommendations that may guide future design and implementation of wind warning and other automated systems.

COATS SHOWCASE:
Video Surveillance Trailer Equipment

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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. The equipment includes the following characteristics:

- 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 and adjustment;
- microwave sensor input, to activate video recording only when vehicles are approaching the camera location;
- a mast-mounted closed-circuit television camera, which can record real-time black-and-white video images from up to 25 feet above ground; and
- a time-lapse video recorder, which can record at variable speeds up to real-time (30 frames per second).

These trailers will expand WTI's technical resources and capabilities, by facilitating long-term evaluations of its research 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, the mast system was extended on each of the trailers to permit a greater height from which to view traffic. On one trailer, WTI doubled the size of the solar panel to increase the recharge rate of the trailer. A weather system was also purchased to provide additional data regarding current field conditions. WTI is continuing to pursue ways to enhance the trailers to make them suitable for a broader range of research applications.

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. A paper presented at the 2003 Transportation Research Board annual meeting, based in part on that evaluation, showed that the trailers proved to be effective in accurately and precisely measuring vehicle speed. 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.

Saco Bridge Field Evaluation

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One major area of concern regarding concrete bridge deck performance is durability. 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 Montana Route State 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.

The Western Transportation Institute at Montana State University was contracted to conduct a comparative study of the performance of three bridge decks in Saco, Montana and assess their 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, 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.

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

The analysis of live load data concentrated on transverse deck response, since it was believed to be most significantly affected by the design configuration of each bridge deck. Because the bridges are relatively young, only subtle behavioral differences have emerged to date from the data collected and analyzed from the live load tests. Nevertheless, throughout the preceding analyses of live load test data, it was determined that all three decks exhibit similar global behaviors in the longitudinal direction, and that these behaviors agree with expected behaviors. Overall, for the parameters analyzed in this research, no difference in performance (i.e., occurrence of cracking, non-linear behavior, or possible indication of accumulating damage) was observed between the three bridge decks. The second set of live load tests conducted this past summer (2005) are currently being analyzed to determine whether there are any behavioral differences between the decks. Recent tests were conducted using the same vehicles and protocol.

In addition, approximately 28 months of long-term data has been collected from embedded sensors in each of the bridge decks. Baseline corrosion tests, topographic surveys, and crack and delamination surveys have been conducted on each of the bridge decks. As expected, obvious differences between the different deck designs have not been observed in the results of these activities, although, recent crack formations may be showing preliminary behaviors unique to each of the designs. Data collected to-date serves as a baseline to establish the condition of the three bridges before further exposure to traffic and the environment. The analysis of data obtained from long term monitoring and the second live load test will help substantiate any conclusions made thus far, and will hopefully provide a more comprehensive body of evidence by which to judge deck design superiority.

Transportation Toolkit for Federal Land Managers

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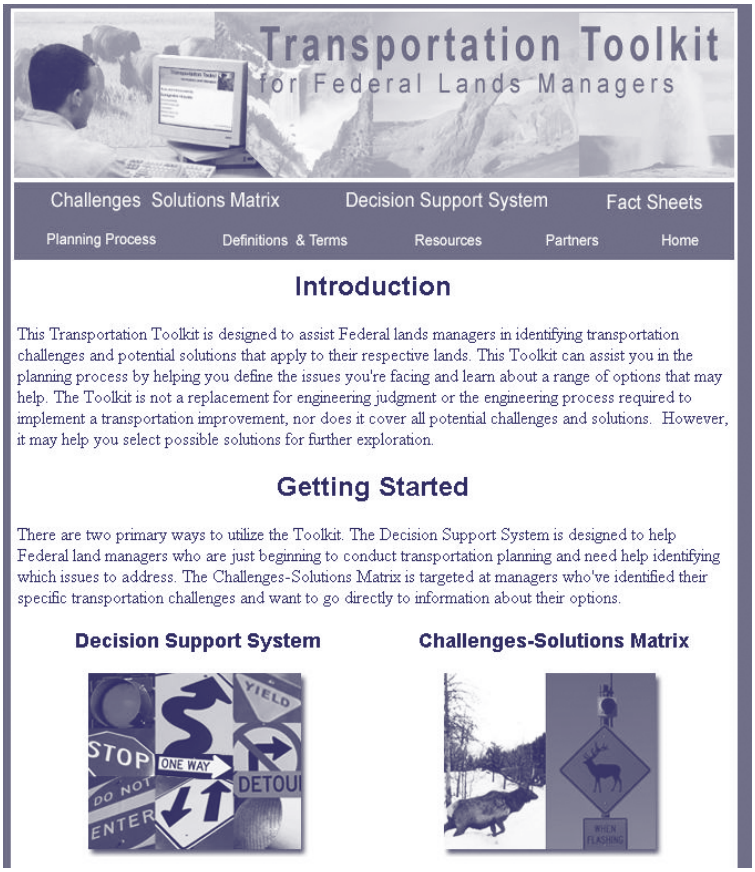
The Federal government manages significant portions of rural land, much of which serves as destinations for tourism and recreation. Unlike many tourist destinations, Federal lands are mandated to preserve and protect unique natural, cultural and historical resources. Maintaining the balance between the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



Transportation Research, Applications and Instrumentation Laboratory

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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 would 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 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 will be developed and deployed in multiple phases, with the initial phases being deployed locally at Montana State University - Bozeman. The first phase of this project will be to develop the requirements and determine 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 second 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 traffic, weather, and road condition sensors will allow WTI to obtain real-time and summary data on travel conditions, which can be communicated to the TRAIL data management center for processing and archiving.

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, where students can have hands-on learning opportunities, and where technology transfer can be expedited through facilitated data collection and sharing.

Animal-vehicle Crash Mitigation Using Advanced Technologies Pooled Fund Study

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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.

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

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 is funded by the Departments of Transportation of 15 states and the Federal Highway Administration. The Oregon Department of Transportation (ODOT), in cooperation with WTI, is the lead state for this research and demonstration project, which will result in the installation of prototype animal detection and driver warning systems and an evaluation of their effectiveness in reducing animal-vehicle crashes. The sites selected for demonstration are:

Site #1 Montana, US 191, about 50 miles south of Bozeman/Belgrade, MT 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.

Completed Research Projects

Project Name	Principal Investigator
Implementation of a Driving Simulation Laboratory	Mike Kelly
ODOT ITS Performance and Benefit Plan	Christopher Strong
Evaluation of Driver Distraction During Mobile Phone Interaction with the 511 Information System	Mike Kelly
Evaluation of Montana Department of Transportation's Technical Assistance Program	Jaime Eidswick
Communications and Power Improvements for Rural ITS Field Devices	Christopher Strong
Geosynthetic Pullout Behavior under Small Displacements	Eli Cuelho
Development of a Roadway Weather Severity Index	Christopher Strong
Evaluating the Accuracy of RWIS Sensors	Christopher Strong
Tribal Automated Accident Reporting System	Doug Galarus
Compressibility and Heave Characteristics of Subgrade Soils Exposed to Freeze/Thaw Conditions	Robert Mokwa
Evaluation of Reinforcement Strain Growth During Traffic Loading	Steve Perkins
Mitigating Wildlife Mortality and Habitat Fragmentation	Tony Clevenger
Development of Test Protocols for Characterization of Soil/ Geosynthetic Interaction and Intrinsic Geosynthetic Material Properties	Eli Cuelho
Mobile Laboratory	Robb Larson
Demonstration and Evaluation of ITS on the Rural Highway Environment (Frontier)	Steve Albert

Implementation of a Driving Simulation Laboratory

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A high-fidelity driving simulation laboratory allows testing of driver performance and behavior in the safety and controlled environment of the laboratory. Collection of data related to driving hazards and unsafe conditions is dangerous and time consuming if done on actual highways or test tracks. Because of the changing nature of environmental conditions and traffic, it is impossible to maintain the full control and repeatability of driving scenarios necessary for experimental precision. This can be accomplished safely and easily in a simulation laboratory designed to collect detailed measures of driver performance during high fidelity, realistic driving scenarios.

The simulation laboratory, the only one of its kind in the Pacific Northwest, will be available to support data collection for a large number of multi-disciplinary projects.

Through this project, WTI created and implemented a high-fidelity simulation laboratory that can be used to investigate issues in driver performance related to distraction, aging, training, and infrastructure design. A research simulator will allow testing and development of prototype systems before they can be fielded. The laboratory will economically support research in safety, control theory, psychology, driver fatigue, alcohol and OTC drugs effects, and other topics that are difficult to study in low fidelity laboratory simulations or on the real roadways.

Initial research in the simulator addressed issues of driver performance and safety related to distraction caused by in-vehicle communications devices, driver response to animal warning signs and animals in the roadway, and aging driver visual performance and safety. Studies in these areas have been submitted and presented at several major conferences.

Oregon ITS Performance and Benefit Plan

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The Oregon Department of Transportation (ODOT) has implemented many intelligent transportation system (ITS) projects and services throughout the state, including an Advanced Transportation Management System (ATMS), Advanced Travel Information Systems (TripCheck), Highway Travel Condition Reporting System (HTCRS), Road and Weather Information Systems (RWIS), Variable Message Signs (VMS), and others.

In order to ensure support for ongoing ITS investment, ODOT is working to evaluate the performance of ITS, document the benefits, and educate the public about how ITS enhances transportation safety, mobility and efficiency. Through this project, WTI is conducting a series of individual research tasks that will assist ODOT with this effort.

By documenting and showcasing the benefits of current ITS systems, ODOT can sustain public and institutional support for future ITS expansion.

One of the principal accomplishments has been the development of a web page that documents some of the primary benefits of ODOT's ITS deployments. The web page contains a comprehensive list of projects in Oregon, grouped by purpose of the project, such as Traveler Information, Safety, and Public Transportation. The introductory page also has links to detailed information on specific systems, including documented benefits with supporting numbers and performance data. The intent of the web page is to make information on the benefits of Oregon ITS systems readily available to the public. The page has been incorporated into the ODOT website at www.odot.state.or.us/its.

WTI also evaluated an infrared camera that could be used for detecting ice on roadways. The evaluation used MSU's cold weather chamber to generate a variety of weather conditions, in order to examine how quickly and accurately the camera detected phase change. The results of this evaluation will help ODOT to more accurately detect when roadways require winter maintenance.

Most recently, WTI developed a set of quantifiable criteria to assist ODOT in making decisions on where ITS field elements should be placed statewide. Criteria were developed for closed-circuit television (CCTV) cameras and dynamic message signs (DMS), two ITS elements in widespread use within Oregon. The criteria were developed and analyzed in a GIS environment using a variety of data, such as traffic volumes, crash rates, weather, and roadway geometrics. Using a GIS format allowed WTI to better capture the spatial relationship between ITS elements while taking advantage of rich sources of data.

Evaluation of Driver Distraction During Mobile Phone Interaction with the 511 Information System

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A significant body of research has indicated that the use of hand-held cellular phones in moving vehicles can create a dangerous distraction to drivers in urban areas. Cellular phones with headphone interfaces may create a lesser, but still significant distraction. No research had yet explored the use of these phones by drivers on less congested rural roads where the driver's workload is lower. Likewise, no research had specifically addressed the use of cellular phones by drivers accessing the "511" highway information system.

The first study in WTI's new Driving Simulation Laboratory, this research provides early data on a high-visibility topic.

This project used the WTI Driving Simulation Laboratory to collect data addressing driver distraction while using two common mobile phone interfaces in rural and urban traffic, and to collect data addressing the usability of the 511 information system while being accessed by mobile telephone from a moving vehicle.

The thirty-six test subjects ("drivers") were assigned to three equal groups: a hand-held telephone group, a handsfree telephone group, and a control group. They were tested driving through a series of scenarios during which they obtained specific information about road conditions from the 511 information system. Researchers measured performance on tasks such as headway/following distance, lane maintenance, and responses to obstacles, then evaluated results based on the accuracy of information reported by the user; the amount of time required to obtain the information; and survey/interview information concerning problems, comments, and suggestions about the interface design.

Performance on the primary tasks of driving (e.g., lane and speed maintenance) was found to be unaffected by interacting with the cell phone. Yet the tasks that require more prompt response times (e.g., avoiding collisions during unexpected conflicts) were degraded by the use of a cell phone, regardless of the type of instrument used. Findings also indicate that drivers were less aware of their surroundings when interacting with the 511 traveler information system while using a cellular phone and driving.

Results from this study were strikingly similar to findings from other studies of cell phone conversations while driving. Interaction with the 511 travel information system appears to have the same performance effects and risks as a free-form cell phone conversation.

Evaluation of Montana Department Of Transportation's Transportation Awareness Program

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The Montana Department of Transportation (MDT) has a Transportation Awareness Program (TAP) that promotes MDT and its programs to the public. The TAP staff conducts outreach at schools, driver education classes, and large public events, and provides information about topics such as fuel tax, the 511 traveler information system, noxious weeds, snowplow safety, and workzone safety. Through these outreach efforts, MDT seeks to improve public safety, reduce liability claims, and improve community relations.

The survey data will be used to identify and prioritize program improvements.

WTI conducted an evaluation of TAP for MDT to determine how many Montanans know about the program, to identify its benefits, and to measure its effectiveness. WTI developed both a phone and mail survey to administer to Montana residents. Researchers completed 1000 phone interviews and distributed 3000 surveys.

Findings indicate that Montanans are aware of the TAP program. Ten percent of phone respondents knew the program by name, 39 percent of phone respondents had spoken to an MDT employee at a public event, 46 percent of mail survey respondents had previous knowledge of TAP, and 11 percent of mail survey respondents had participated in other TAP programs such as safety courses. Both surveys indicated that fairs and driver education classes are the most effective marketing tools for the program.

The majority of comments regarding the program were overwhelmingly positive, and most suggestions for future changes recommended expanding current outreach efforts. The survey data was analyzed and summarized in a final report that was made available to MDT.

COATS SHOWCASE: Communications and Power Improvements for Field Devices

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Intelligent transportation systems use advanced computer, electronics and communications technologies to improve the operation of the surface transportation system. However, many rural areas lack an integrated communications or power infrastructure that can support the deployment of ITS, so agencies are typically forced to improvise a solution.

This project provides an important informational resource to rural areas trying to address transportation challenges with a limited communications or power infrastructure.

The purpose of this project is to document case studies of innovative solutions for addressing the communications and power needs of ITS field devices deployed in a rural environment. By documenting and building upon the lessons learned from past deployments, the reliability and effectiveness of future ITS deployments may be significantly improved.

A web-based survey was conducted among the 50 state Departments of Transportation to inquire about their experiences in the deployment of video and non-video applications and alternative power sources in rural areas. Upon receiving and reviewing the responses, the promising alternative power sources were identified. A second survey was distributed via email among states that indicated employing alternative power sources to obtain additional information on the functionality, application, cost, and lessons learned of their systems. Wind generators and propane fuel cells are two alternative power sources that some states are currently using or experimenting with to complement or replace the solar energy. Wind generators are known for their efficiencies and low maintainability. Although propane fuel cells are still at their experimental stage, they are being considered as another promising source of energy for rural areas.

No case studies were selected among the communication technologies as none were found to be new applications. Upon reviewing the survey report, the Project Evaluation Team suggested that the reported video (high bandwidth) and non-video (low bandwidth) communications applications are generally standard approaches. Coordinated efforts on national and/or state levels appear to enhance the coverage and technology of the wireless communications means.

COATS SHOWCASE: Roadway Weather Severity Index

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Weather can have a significant impact on rural highway operations and safety. However, it is difficult to quantitatively account for the effects of weather when identifying the advantages and disadvantages of operational and safety improvements. A weather index for roadways could help in such situations. Severe weather indices have been developed for other fields, such as wildlife management, household utilities and inland maritime icebreaking operations. While similar indices have been developed for surface transportation, very few have explored the direct relationship between weather parameters and highway safety.

A weather severity index will help transportation officials to isolate the effects of weather on roadway safety and winter maintenance costs.

This study developed a set of winter weather severity indices which could be used for surface transportation. These indices were developed using linear regression models which estimated crash rates as a function of various weather parameters. Researchers benefited from using a wide variety of data from Oregon, Montana and State Route 299 in California, including archived road weather information systems (RWIS) and National Weather Service data for weather observations, and crash data, including data from the Federal Highway Administration's Highway Safety Information System, over a several year period.

Indices were developed on zonal (e.g. mountain, valley and plain) and statewide bases for Oregon, Montana and State Route 299 in California. Different variables and parameters were derived in an effort to identify those parameters which had the strongest influence on safety. The research presented ways that these models, and the index values derived from them, could be used to provide enhanced information for travelers driving through wintry areas. Because different models were derived for different areas, additional research is recommended to better understand the underlying factors that may best explain how winter weather affects motorist safety.

Geosynthetic Pullout Behavior Under Small Displacements

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The national movement to develop a mechanistic-empirical design guide for pavements requires that the fundamental material properties for all components of the design be quantified. When geosynthetics are used to reinforce the base course layers of flexible pavements, one of the two main design parameters is the interaction between the geosynthetic and the surrounding aggregates. Interaction at this interface can be quantified in terms of a stiffness parameter, Gi, the resilient interface shear modulus. The most relevant interaction tests use cyclic loads like those experienced in transportation applications. Currently, however, there is no standard test to quantify soil/geosynthetic interaction using cyclic loads. This research effort modified the standard pullout test protocol to resemble the resilient modulus tests for unbound aggregates which utilizes cyclic loads at various levels of normal confinement. The resilient modulus for unbound aggregates (MR) closely resembles Gi, since they are both simultaneously dependent on shear load and confinement. Overall, the results from the cyclic pullout tests conducted on six geosynthetics showed that cyclic pullout testing has great potential for describing a stress dependent interface shear modulus. A three-parameter, log-log equation developed in the NCHRP Project 1-28a was used to predict Gi. Correlations between predicted and measured values were somewhat erratic. Additional research is planned to improve the test equipment and establish specific test protocols.

By studying the interaction between geosynthetic materials and the surrounding soil using cyclic loads, this project will provide valuable data that can be applied to future pavement design standards.

COATS SHOWCASE: Evaluating the Accuracy of RWIS Sensors

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Many transportation agencies use Road Weather Information Systems (RWIS) to make critical decisions regarding road maintenance and use, especially during severe weather conditions. RWIS include an assortment of integrated sensors that measure air temperature, precipitation, visibility, wind speed, pavement temperature, and other parameters of interest.

Most RWIS sensors have been used in non-road applications with high levels of accuracy. However, there is concern about the accuracy of pavement sensors in detecting whether the roadway is icy, snow-covered, wet or dry. Sensors mounted in the pavement also require re-installation when a road is resurfaced or rehabilitated. Infrared (IR) camera technology, which does not require intrusion into the pavement, has been increasingly used to detect the presence of ice or snow on the road. Lab testing in Montana State University's Cold Regions Laboratory indicated that the IR camera would accurately predict surface conditions and temperature phase changes. However, as a newer technology, there has been limited field testing of IR cameras for measuring pavement condition. For RWIS to provide quality and accurate data for maintenance personnel and the traveling public, it is important that transportation agencies know which sensing methods will provide reliable data on a consistent basis.

This project will provide transportation agencies with independent research results regarding the accuracy of RWIS sensors.

For this evaluation, WTI installed the IR camera on a 30-foot mast overlooking Bozeman Pass, aiming it at an existing in-pavement sensor. Data collected during the winter 2004-05 from the camera and the in-pavement sensor were compared with each other and with field observations. It was found that the camera correctly identified winter weather and performed reasonably well in wet and dry conditions. However, the camera was unable to detect slush, and had problems with road grime on the lens and bad data when the infrared signal was reflected. The in-pavement sensor misidentified snow on the pavement, and tended to be more sensitive to moisture than the camera.

Overall, the camera was determined to be more accurate than the in-pavement sensor. Deployment was recommended to be considered for roadways with low to medium traffic volumes, provided that there was a high angle of installation, an extension on the camera housing to protect the lens from grime, and a plan for maintenance. There were cautions against immediate broader deployment, because of concerns over maintenance and transportation agencies not being sufficiently familiar with the technology.

Tribal Automated Accident Reporting System

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Accident data is a useful tool for transportation and emergency response planning. In Montana, the availability of quality data is limited due to several factors related to the current reporting system: the inaccuracy of data, the incompleteness of the data and the potential errors associated with transcribing and communicating the data.

The purpose of this project is to improve accident reporting in the State of Montana through the application of advanced technologies. The basis of the improvement is the use of mobile computing systems to collect the data at the accident scene and the use of Global Position System (GPS) units to identify the accident locations with greater precision.

Collecting accurate crash data is a fundamental component of research to develop and test transportation safety advancements, and viable technology exists to facilitate and enhance such collection efforts.

Researchers developed two prototype systems. The first included a mobile data collection application and a database interface. The initial target platform for the mobile product was a Pocket PC coupled with a GPS unit. However, limited screen space made it difficult to implement complex form elements on this platform. Thus, further development on the first prototype was conducted on a desktop PC, with the intent of compatibility with notebook or tablet systems. The mobile data collection application provided a user interface that mimics the current State of Montana paper reporting system to maximize user acceptance and minimize errors. The database interface was intended to demonstrate the ability to operate on current computing systems, to interoperate with current database mechanisms supported by local and State of Montana agencies for accident reporting, and to provide an opportunity to perform validity checking on the report data. The first prototype demonstrates the potential for creating an accident reporting system with a corresponding database; however further research is needed to address compatibility issues between the GPS systems and PC systems as well as limitations of the Pocket PC.

Tablet PCs offer greater flexibility for creating forms that mirror their paper counterparts than Pocket PCs or even standard notebook computers. WTI investigated the viability of a Tablet PC implementation by developing a second prototype specifically targeting the Tablet PC platform. This prototype focused on ease-of-use and increased accuracy. Pen input was incorporated into this prototype, which provided a functional grouping of form elements and auto-population of location fields, date and time fields. Text could be handwritten, typed or entered using an onscreen keyboard. Hand-drawn incident sketch capability was also implemented.

An added outreach component of this project has been a targeted effort to meet with Native American leaders in Montana, to identify the reasons for low accident reporting on reservations and investigate whether advanced technologies such as these can facilitate increased reporting. The outreach effort has identified important obstacles to increased data collection and reporting, such as a lack of clearly established policy on the traffic accident reporting process. In addition, there is not yet agreement among the tribes about which data should be reported to the state. Ongoing efforts to create new technology solutions will have to be flexible enough to be adapted to the needs of individual tribes.

Compressibility and Heave Characteristics of Subgrade Soils Exposed to Freeze/Thaw Conditions

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Frost action below road pavements and structures supported on shallow foundations results in significant long-term maintenance problems in most temperate zones in which seasonal soil freezing occurs. The problem is widespread, and is becoming increasingly important as wheel loadings, traffic frequency, and costs of pavement structures increase. A practical approach is needed for evaluating the frost susceptibility of soils and for predicting the magnitude of strength reduction, heave, and settlement of soils exposed to repeated freeze-thaw cycles. This study focused on the procedures necessary to obtain a numerical model capable of predicting the thermal response of frost susceptible soils.

This project provides fundamental information that could eventually lead to highway construction methods that decrease the number of long-term maintenance problems resulting from severe winter weather.

A field facility was designed and constructed with the purpose of measuring and comparing in-situ frost heave characteristics with laboratory-scale test results. The field facility is located in Bozeman, Montana, about 5 miles west of the Montana State University campus. A laboratory-testing device was also designed, constructed, and instrumented in order to measure the thermal response of various soil types in a controlled freezing environment. Geotechnical index testing was conducted on the soils used in the freezing experiments to fully characterize the material properties and to examine potential correlations between common soil index properties and frost action behavior.

The results of the first season of experimentation provided the framework for a testing protocol necessary for the development of a predictive numerical model. The data obtained from the laboratory tests was used to calculate a relatively new engineering parameter called the segregation potential (SP), which was used as an input into the numerical model that was developed as part of this study. The model was used to simulate freezing and thawing characteristics of the soil at the field facility using temperatures measured at the site over a one-year cycle. The calculated results were reasonable considering the simplifying assumptions used in developing the numerical model. It is recommended that an enhanced data base be created to further calibrate the model with a goal of developing empirical correlations between thermal and geotechnical index properties of frost susceptible soils.

An improved testing protocol is necessary to obtain more accurate and consistent results. Continued research in this area will allow for the advancement of a robust predictive numerical model that engineers could use to simulate and predict the freezing and thawing effects of frost susceptible soils in cold regions.

Evaluation of Reinforcement Strain Growth During Traffic Loading

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A recently completed project for FHWA has resulted in a proposed mechanistic-empirical design method for reinforced pavements that is compatible with the American Association of State Highway and Transportation Officials (AASHTO) 2002 Pavement Design Guide currently in development. A critical component of this design method is a relationship between the ratio of permanent to resilient strain and a normalized measure of traffic passes. This relationship was determined for several reinforcement products from previously constructed test sections and appeared to provide reasonable relationships that predicted acceptable levels of performance.

Researchers will have the opportunity to evaluate the feasibility of using this type of data in reinforced pavement design methods.

To more fully establish the feasibility of using data from test sections to describe this relationship, this project examined data from approximately 18 other reinforced test sections. The evaluation of this data was designed to determine if this relationship is unique for any aggregate type and pavement cross section geometry and whether the relationships for different geosynthetics are distinct and consistent with the reinforcement benefit seen from these test sections.

In general, the data presented in this report suggests that of the variables incorporated in the test sections (geosynthetic type, subgrade strength, aggregate type, aggregate thickness), only geosynthetic type influences the shape of the normalized curve. The shift value of the normalized curve appears to be dependent on the number of load cycles the pavement can carry before reaching 25 mm of permanent surface deformation, which in turn most likely accounts for variables such as subgrade strength, aggregate type and aggregate thickness. The differences in curve shape between the different geosynthetic types are not as distinct as expected and more work is needed to improve strain measuring techniques to improve this situation.

This project is considered a seed project that will lead to new proposals that fully establish these relationships for use in design.

Mitigating Wildlife Mortality and Habitat Fragmentation due to Transportation Infrastructure

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The purpose of this collaborative project was to continue landmark wildlife mitigation research in Banff National Park begun by Dr. Anthony Clevenger. In 1996, Dr. Clevenger initiated an intensive five-year research program in Banff. The study focused on wildlife crossing structures and fencing on the Trans-Canada Highway, in order to address permeability for wildlife, animal-vehicle mortalities, wildlife movements, and habitat connectivity in the Bow River Valley. The research team evaluated means of mitigating road effects on wildlife and made recommendations for future transportation planning efforts in the mountain parks.

This partnership has expanded WTI's wildlife research focus area, and facilitated national and international research collaborations.

The Banff-Bow Valley provides an unrivalled environment for research on the efficacy of wildlife crossing structures and reducing wildlife-vehicle collisions. There are numerous types of wildlife crossing structure designs built during two time periods as well as many park-supported wildlife research studies. Banff mitigation research has the world's longest, year-round monitoring program and largest dataset on passage use by wildlife.

This partnership between WTI and Dr. Clevenger began in 2002 has resulted in several positive developments, including:

- A continuation of the research in Banff beyond the original five-year program
- An integration of Banff research with the US 93 reconstruction project in Montana
- The development of a unique international partnership between public and private institutions, which has expanded WTI research into new areas, such as DNA-based techniques for evaluating ecological performance of highway mitigation measures
- An expansion of WTI's technology transfer efforts in the field of wildlife transportation interactions, including new professional development courses and extensive media coverage

Development of Test Protocols for Determining Intrinsic Geosynthetic Material Properties

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When designing any civil structure, it is necessary to determine the properties of the various material components under conditions pertinent to their eventual use. Geosynthetic reinforced earthen structures are no different. Standard tension tests currently exist to determine basic material properties of geosynthetics used to construct reinforced walls, slopes, embankments and other static structures. However, because these material tests apply slow monotonic loads at room temperature, they may not properly represent conditions pertinent to geosynthetic reinforced pavements. A number of research projects have been conducted in the past to investigate possible differences in material properties using various temperatures, confinements, load types, and strain rates.

These test protocols will allow researchers to more accurately characterize geosynthetic materials used as reinforcement in flexible pavements.

This research effort conducted an extensive literature review to study the effects of these four parameters on geosynthetic material properties. Additionally, material tests were conducted to determine how cyclic loading affects geosynthetic material properties. Modifications were made to the existing wide-width test protocols (ASTM D4595 for geotextiles, and ASTM D6637 for geogrids) to incorporate cyclic loads. These dynamic wide-width strain-controlled tension tests demonstrated great promise for providing values of elastic material properties. The results from these tests showed that the modulus of the geotextile materials changed at various levels of initial permanent strain, while the modulus of the geogrids remained relatively constant. Future testing will be conducted to further examine similar effects due to temperature, strain rate, load type and confinement.

Mobile Laboratory

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WTI has created a mobile laboratory to support transportation-related research projects, in compliance with WTI's mission to make rural transportation and travel safer, more efficient, and more convenient. The Mobile Laboratory supports research, evaluation and development of new products and technologies for transportation, evaluation of prototype devices and systems, and testing of commercially available systems. It is an ideal tool for outreach and for undergraduate research opportunities.

The Mobile Laboratory is not only a valuable research facility; it also provides unique learning opportunities to many students at the university.

The Lab supports three usage modes:

1. Fixed Site mode: Usage includes measurement and recording of site-specific data such as traffic counts & classification, weather conditions, and animal-vehicle interactions. The lab features dual mast-mounted traffic cameras with video recording and data logging equipment. The deployable pneumatic mast can alternatively be topped with a weather station for climate condition data acquisition.

2. Roving Mode: Location-dependent roadway data can also be gathered real-time using a variety of on-board sensors. Sub-meter accurate GPS coordinate and time stamping of acquired data is supported. Examples of this operational mode include thermal mapping of road surface temperatures, road surface roughness or reflectivity studies and logging of highway surface or roadside features.

3. Mixed Mode: Mixed-mode studies such as inter-vehicle fleet communication and roadside-to-vehicle communications research, development and testing projects are possible.

The vehicle can serve as a portable environmental shelter and field laboratory with most of the tools and facilities found in a conventional laboratory. The 1-ton, four-wheel-drive "cube van" lab houses a large selection of equipment, including two laptop computers with docking stations, a high-speed multi-channel data acquisition system with dedicated computer, and 120-volt A/C power supplied by a deep-cycle storage battery bank feeding a 3000 watt DC-to-AC power inverter, and a 4 KW RV-style generator. Web-enabled cell phone service and a 2-way radio provide communication support.

The mobile laboratory became operational in the summer of 2002, and is available to MSU faculty and student researchers from many disciplines across campus. Several WTI projects have utilized the van for research and support, and researchers from MSU's Center for Biofilm Engineering, the Thermal Biology Institute, and the department of Mechanical and Industrial Engineering are among the growing list of users. The lab should continue to support these and similar projects throughout its predicted operational life of 10 years.

FRONTIER

Research and demonstration projects involving Intelligent Transportation Systems (ITS) technologies have primarily focused on applications of this technology in metropolitan environments to address problems such as congestion, mobility and incident management. The nation's rural highway system (two-lane highways) -- which comprises over 80 percent of road mileage in the U.S. and accounts for approximately 40 percent of all vehicle miles traveled each year - has largely been ignored with respect to ITS. An unproven assumption has been made that urban ITS applications are directly transferable to the rural highway environment to meet rural traveler needs.

The FRONTIER project has helped to identify key factors that must exist to ensure successful deployment of ITS technologies in a rural environment.

The primary objective of this research effort was to prove that advanced technologies can be successfully transferred to rural environments. The project's approach was to deploy, on a small scale, appropriate ITS technologies in rural areas and document the resulting benefits, in order to encourage rural agencies to embrace the potential of ITS solutions.

In Phase I, researchers conducted a national and state specific review of efforts to quantify rural ITS benefits, and identified candidate demonstration projects. In Phase II, the eight participating DOT's that comprised the Technical Advisory Committee selected two demonstration projects for deployment: a Rural Travel Time Estimation project in Oregon and a High Water Level Sensor project in Texas.

In Phase III, researchers evaluated the results of the deployment:

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• The Rural Travel Time Estimation Project (Oregon) tested the use of Automatic License Plate Readers to determine travel time information on rural travel corridors. The system was capable of detecting and matching vehicles, measuring travel time statistics, measuring travel time data, and documenting travel delays. However, the potential capabilities of the system were overshadowed by operational and maintenance concerns.

• The High Water Level Sensor Project (Texas) was designed to notify maintenance personnel of impending flooding. During the deployment period, the system accurately detected both a flood event and ice on the road. Surveys and interviews conducted with maintenance personnel indicated that they are interested in installing additional systems at other locations.

During the evaluation, researchers also documented key lessons learned regarding rural conditions and challenges that must be addressed prior to a successful ITS deployment, such as technological infrastructure, available staffing resources and expertise, and available fiscal resources to support testing and deployment delays.

Cumulative List of Completed Research Projects (10/1/1991 - 9/30/2005

Statewide Demand-Response Software	David Kack
ODOT ITS Performance and Benefit Plan	Christopher Strong
Implementation of a Driving Simulation Laboratory	Mike Kelly
Evaluation of Driver Distraction During Mobile Phone Interaction with the 511 Information System	Mike Kelly
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
Communications and Power Improvements for Rural ITS Field Devices	Christopher Strong
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
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
Development of a Roadway Weather Severity Index	Christopher Strong
Artemis Clearinghouse	Amanda Hardy
Mobile Laboratory	Robb Larson
Mitigating Wildlife Mortality and Habitat Fragmentation	Tony Clevenger
Paratransit Operations Review	David Kack
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
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

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

Research Success Story

Perhaps the most effective contribution a research organization can make is to nurture the seeds of new research so they can grow and develop. In the past year, WTI has successfully ventured into new research areas or expanded existing research thanks to targeted investments into laboratory facilities, new partnerships, and innovative technology demonstration. Using UTC funds for these "seed initiatives" has had a high return on investment for WTI, RITA and our cooperative partners, and improved our competitive position to secure (cultivate) future funding.

Laboratory Investment

This year WTI completed installation and the first research project in an on-site driving simulation laboratory. This capital purchase allows WTI to expand our capabilities related to human factors and safety, and therefore compete for a wider range of projects. For example, preliminary testing of sound and sensory interfaces as a collision avoidance technique attracted the interest of the Montana Department of Transportation, and led to an innovative project to examine potential uses of dynamic message signs on Bozeman Pass. This new project will have national application to mountain passes and the use of ITS to prevent animal-vehicle collisions.

UTC funding also allowed WTI to create the Transportation Research, Applications, and Instrumentation Laboratory (TRAIL), which allows WTI to test and understand the communication needs of remote field devices. This investment was one factor that helped WTI to secure a competitive proposal with the California Department of Transportation (Caltrans) to address communication needs between a traffic management center and transportation management systems.

Partnership and Development

Balancing highway development needs and wildlife conservation issues is a critical issue for rural transportation agencies. In recent years, WTI has expanded its research into transportation wildlife interactions. UTC funding has greatly facilitated the development of national and international collaborations on these issues. This year, WTI invested in DNA identification techniques that help track the movement of wildlife across the landscape. This effort has led to three additional projects on related issues, with substantial investment from private foundations. In addition to attracting new sources of funding, WTI benefits from establishing ongoing working relationships with private environmental organizations.

Innovative Technology Demonstration

Utilizing UTC funds to develop technology demonstration projects has helped WTI to test innovative potential solutions for stakeholders and partners. Through a current project, WTI has developed a Pocket PC tool for collecting standardized animal road kill data that is spatially accurate, easy to use, and has a data format that is easy to integrate and analyze. This data will help rural transportation agencies to pinpoint high-risk locations and prioritize mitigation measures.

By transforming preliminary research into new technologies, WTI often provides transportation agencies with sufficient evidence to secure additional investment. For example, WTI conducted numerous ITS pilot deployments for California and Oregon through the COATS Showcase project. As a result, this project will soon move forward into its third phase of development and third round of funding from Caltrans and ODOT.

Research Initiatives for 2006

In January 2006, WTI will move into a new location with more space for laboratory facilities. This relocation provides a unique opportunity to expand and improve our on-site research and testing capabilities. Planned laboratories include:

• Driving Simulation Laboratory: The current simulator will be moved to the new location, which has sufficient space to eventually add a second, larger simulator

• Materials Corrosion Laboratory: The current laboratory will be moved; equipment will be added to enhance corrosion testing capabilities

• Geosynthetic Materials Testing Laboratory: WTI has a small materials lab on the MSU campus. The new laboratory will include a major expansion of equipment to conduct comprehensive testing of geosynthetic materials for use in road maintenance and construction.

• Transportation Research, Applications, and Instrumentation Laboratory: The new facility will allow expansion of the current TRAIL lab, with sufficient space to simulate a Traffic Management Center.

• Systems Engineering Laboratory: This new laboratory will consist of ITS field devices, multimedia tools, networking infrastructure, servers, and software to support systems engineering development projects. It will establish a space for team collaboration on testing of ITS and communications technology in a rural setting.

These facilities will allow WTI to provide comprehensive, leading edge research services, and improve our ability to advance the state-of-the-practice on critical rural transportation issues such as safety, traveler information, and infrastructure longevity. These laboratories will further strengthen our ability to attract new collaborations and funding from other agencies with related research interests.

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 actively seeks to attract students to the transportation field, to provide them with quality educational and professional development opportunities in transportation, and to place the students in transportation careers. 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. WTI's education program also includes a comprehensive K-12 outreach program aimed at attracting talented youth to transportation careers.

Student Research Involvement

WTI provides students with a variety of opportunities to gain interdisciplinary research experience in transportation. In 2004-2005, nineteen undergraduates and twenty-one graduate students, representing eleven different academic disciplines, participated as paid research assistants at WTI. In all, students contributed research support on thirty-seven different transportation projects.

Students who gain positive transportation research experience as undergraduates are more likely to continue on to graduate studies and careers in transportation. Recognizing this, WTI provides two unique undergraduate research experience programs. The Research Experience for Undergraduates (REU) program involves up to eight undergraduate students from universities nationwide in a ten-week research project at WTI over the summer. During the academic year, WTI supports up to three MSU undergraduate students in a comprehensive research experience. In both programs, the 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. The undergraduate research experience program produced three conference presentations or posters over the past year, listed below with undergraduates marked by an asterisk:

Al-Kaisy, A. and Freedman, Z. (2005) "Weather Responsive Signal Control: Potential Benefits," Accepted for presentation at the Transportation Research Board 85th Annual Meeting in January 2006 and for publication in the Transportation Research Records.

*Lindsay, Abby, (2005) "Evaluation of the Golden Gate National Recreation Area's Portable Changeable Message Signs." Accepted to poster session at the Transportation Research Board 85th Annual Meeting in January 2006.

Al-Kaisy, A. and *Kerestes, E. (2005) "Evaluation of the Effectiveness of Single-Lane Two-Way Traffic Control at Maintenance & Reconstruction Zones," Presented at the Transportation Research Board 84th Annual Meeting, Washington, D.C., 9-13 January 2005.

Three undergraduates participating in the research program have since gone on to pursue graduate degrees in transportation at Montana State University.

In 2004-2005, fourteen graduate students benefited from WTI's graduate fellowship program, which supports exceptional students pursuing transportation-related advanced degrees. 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. Graduate Fellow Brandy Sularz presented a paper, co-written with WTI Research Engineer Chris Strong, at the 2005 Transportation Research Board annual meeting. (Sularz, Brandy and Strong, Chris, Developing Measures of Effectiveness for Evaluating ITS in California's National Parks, Transportation Research Board, No. 1970, National Research Council, National Academy Press, Washington D.C.,2004). Laura Stanley, Graduate Fellow and doctoral student in Industrial Engineering, presented Driver Performance While Interacting with the 511 Travel Information System in Urban and Rural Traffic, at the Third International Driving Symposium on Human Factors in Driver Assessment Training and Vehicle Design held in Rockport, Massachusetts in June 2005. The paper was written by Laura Stanley, Michael Kelly, and Suzanne Lassacher. Laura Stanley also presented Development of a Web-Based Household Travel at the Institute of Transportation Engineers District 6 Meeting in Kalispell, Montana (July 2005). Graduate fellows Peter Smolenski and Jeff Johnson co-authored a paper with Principal Investigator Eli Cuelho entitled Evaluating Concrete Bridge Deck Performance, which was accepted to the 2006 Transportation Board Annual Meeting.

Six graduate fellows entered transportation careers after completing their Masters degrees in 2004-2005.

Student Research Involvement

Project	Undergraduate	Graduate
Alaska 511	1	
Alternative Transportation in Yellowstone National Park		1
Animal-vehicle Crash Mitigation Using Advanced Technologies		1
Bozeman Pass Wildlife	2	3
Compressibility and Heave Characteristics		1
Effect of Inclement Weather on the Safety and Efficiency of Traffic Control at Signalized Intersections	1	
Enhancement of Statewide Operations (TMC)		1
Evaluation of Golden Gate National Recreation Area's Portable Changeable Message Signs	1	
Evaluation of Non-Linear and Tension Cutoff Material Modeling Features for Pavement Base Aggregate	1	
Evaluation of RWIS Sensors (COATS Showcase)	1	
Evaluating Driver Distraction		1
Fredonyer Summit Evaluation (COATS Showcase)	1	
Geosynthetic Pullout Behavior	1	
Gyratory Compactor Feasibility Study		1
ITS Applications in California National Parks		1
Materials Corrosion Laboratory	1	
Mobile Laboratory	1	
MSU Building Adjacent Parking Study		1
NOVIS (COATS Showcase)		1
ODOT ITS Benefits	1	
Performance Measures for Two-Lane Highways		1
Pilot Test of Automatic Vehicle Location on Snow Plows	1	
Redding Incident Management Responder		1
Relationship Between Visual Measures and Driver Safety	1	
Saco Bridge Evaluation	2	1
Synthesis of Information on Anti-Icing/Pre-Wetting		1
Transportation Toolkit for Federal Lands		1
Transportation, Research, Applications, and Instrumentation Laboratory (TRAIL)	1	
Traveler Information Database Requirements Analysis		1
US 89	1	
US 93 Animal Crossing Evaluation	1	1
Video Surveillance Trailers (COATS Showcase)		1
Wind Warning		1
Winter Traction Materials	1	1
X-Ray Computed Tomography Applications in Geotechnical Engineering		1

Professional Speakers

A number of professional speakers shared their transportation expertise with students on the Montana State University campus. In October, three MSU graduates now employed at Morrison Maierle discussed their experiences and challenges as transportation engineering professionals. Former ITE International President, Steve Hofener, conducted an interactive slideshow in February on transportation treatments found throughout the world, and Pat Noyes discussed incident management with MSU students.

Montana Employment Showcase

In December, the MSU-ITE student chapter hosted a career fair for transportation students. Montana engineering firms were invited to meet with MSU students, answer questions and discuss job opportunities in a casual setting.

Student Professional Development Activities

Conferences and Technical Tours

In 2004-2005, sixty-seven undergraduate and graduate students had the opportunity to participate in professional development and career awareness activities sponsored by WTI. Activities included participation in professional conferences and technical tours. Student participation in professional development activities is detailed in the table below.

Date	Conference/Meeting	Student Attendance
October 27-31, 2004	ITE Field Trip & Technical Tours; Denver, CO	10
November 4-5, 2004	ITS Rocky Mountain Annual Meeting/Joint Engineers Conference; Helena, MT	5
January 8-12, 2005	Transportation Research Board Annual Meeting; Washington, DC	7
February 27-March 2, 2005	ITE Technical Conference & Exhibit; Las Vegas, NV	7
May 19-22, 2005	TE Intermountain Section Meeting; Jackson, WY	5
June 24, 2005	Montana Department of Transportation tour; Helena, MT	9
July 10-12, 2005	ITE District 6 Annual Meeting; Kalispell, MT	21
August 7-11, 2005	ITE International Meeting; Melbourne, Australia	3

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 for current graduate students, and especially important to upper-level undergraduate students entering careers or graduate programs in transportation. Forty-eight students attended professional transportation conferences in 2004-2005.

Nineteen students also had the opportunity to visit transportation professionals at their place of work, to learn about specific transportation careers, and to view transportation facilities in operation during a number of technical tours sponsored by WTI. Technical tours conducted in 2004-2005 are detailed below.

Denver, Colorado

Ten students from the MSU Institute of Transportation Engineers (ITE) Student Chapter traveled to Denver, Colorado in October in order to observe state-of-the-art transportation facilities and interact with professional transportation engineers in their work environment. Students were able to view effective traffic calming measures in Boulder, including artistically designed planted barriers, traffic circles, and stamped concrete treatments. David Evans and Associates presented innovative engineering techniques used to construct the twin arch cable bridges spanning the Platte River. A demonstration of the latest in surveying technology-Light Detection and Ranging (LIDAR)- was also provided. ITE members gained new insight into transportation challenges facing downtown Denver while touring the area with area transportation professionals. Tour highlights included Coors Field and Union Station. The firm of Fehr and Peers demonstrated traffic simulation software applications for traffic and transit projects, and students were able to experiment with traffic software during a tour of the Denver Econolite office. Finally, students toured the $1.7 billion multi-modal T-Rex transportation expansion project.

Montana Department of Transportation Headquarters (Helena, MT)

In June, nine MSU and REU students toured the Montana Department of Transportation (MDT) headquarters in Helena. MDT staff introduced the students to the variety of careers available in the agency and provided an overview of the history of transportation in Montana, including land and water transportation. STI students were treated to tours of both the photogrammetry unit and the CAD unit at MDT. The tour concluded with a presentation on highway safety and a question and answer session.

Outreach

Filling the transportation workforce with qualified professionals demands creative initiatives all along the educational continuum. WTI's active K-12 outreach program aims to excite youngsters about transportation from the second grade and to repeatedly expose them to transportation as a worthwhile career as they progress through their primary and secondary schooling.

Civil Engineering Outreach

In 2004-2005, the Western Transportation Institute partnered with MSU student chapter organizations to fulfill its outreach mission to elementary school-aged children, while simultaneously assisting student organizations 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. One-hundred and twenty-six youngsters participated in the workshops over the past year together with thirty MSU student facilitators.

National Engineering Week Engineerathon

Montana State University celebrated National Engineers Week by organizing two outreach events for pre-college aged youth. More than 230 area sixth graders visited the MSU campus for the "Engineerathon." The middle school students learned about different engineering disciplines as they rotated through hands-on engineering booths developed and facilitated by MSU College of Engineering student chapter organizations. The Institute of Transportation Engineers (ITE) demonstrated the importance of crash attenuators for passenger safety using a ramp, a toy truck, and a crash-test egg. Other engineering activities included a demonstration of gear ratios in auto and bike design by the Society of Automotive Engineers (SAE) student chapter; a demonstration of how tension and compression act together in loaded bridge beams by Chi Epsilon, the Civil Engineering student honor society; and an oil pipeline project facilitated by the American Indian Science and Engineering (AISES) student chapter.

Girl Scout Badge Day

MSU engineering students also hosted area Girl Scouts to commemorate "Introduce a Girl to Engineering Day," as part of the National Engineers Week. The Girl Scouts earned their "Making it Matter" engineering badge by exploring different engineering concepts with the MSU students. Badge Day was organized and sponsored by the Western Transportation Institute in cooperation with the MSU College of Engineering.

Expanding Your Horizons (EYH)

Hundreds of seventh and eighth grade girls visited Montana State University to learn about careers in math and science during the annual one-day event Expanding Your Horizons. WTI facilitated a hands-on workshop for EYH participants to demonstrate the importance of soils in the construction of roadways, embankments, and buildings. Participants learned some unexpected characteristics of soils during a number of team competitions.

Summer Transportation Institute (STI)

WTI hosted the first Summer Transportation Institute in Montana this summer, joining a network of fifty-one other institutions nationwide. The Summer Transportation Institute is a national program sponsored by the Federal Highway Administration's Office of Civil Rights to expose pre-college aged students to career opportunities in transportation. Nine high school students from cities all across the state of Montana traveled to MSU to participate in this unique residential program. Over the four week program, STI participants learned 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 traveled up the Missouri River in a ferry, and after hearing about careers in aviation from a licensed pilot, they visited the Gallatin Field airport, tower, and fire and rescue facilities. They also learned about aerodynamics and competed with each other in a team glider project. After counting cars at a busy intersection in Bozeman, the students entered their data into a traffic simulation program to discover how traffic engineers use computers to optimize traffic signals. They also took "a

spin" in WTI's driving simulator in order to better understand how researchers safely explore human reactions and behavior while driving.

Beyond transportation, STI participants gained basic skills and knowledge about applying for college, selecting a major, succeeding in college, choosing a career, and developing a resume. Living in the dormitories for four weeks also gave them a taste of college life.

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 Special Programs 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 Brandy Sularz as its 2004 Outstanding Student.

Brandy Sularz received her Master's of Science Degree in Civil Engineering in December 2004 from Montana State University, where she also received her B.S. in Civil Engineering. Her graduate work at MSU was supported by a Graduate Fellowship from the Western Transportation Institute (WTI). As a fellowship student, Brandy researched measures of effectiveness for evaluating Intelligent Transportation Systems (ITS) in California National Parks. From a previous study conducted at WTI, ITS components were selected to be implemented in two California National Parks, Sequoia and Kings Canyon National Parks and Golden Gate National Recreation Area, on a case study basis. Phase 2 of the project involved the evaluation of the ITS components after a specific time period. "National parks are showing an increasing interest in ITS, and Brandy developed a workable approach for how to evaluate ITS projects in a national park," says Research Engineer Chris Strong. "She did an excellent job of synthesizing what has been learned at the national and international levels and making it relevant to national parks."

During her final semester Brandy was also a teaching assistant for two transportation courses. She is a member of Chi Epsilon, the National Civil Engineering Honor Society, and the Institute of Transportation Engineers (ITE), and a participant in WTI's K-6 engineering outreach program. Brandy started work in January 2005 with DKS Associates in Portland, Oregon, a private consulting firm specializing in all aspect of transportation, including ITS, signal management and operations, and transit and transportation planning. She attributes much of her success to ITE and plans on remaining active in the Oregon Chapter.

Congratulations Brandy!

Student Success Stories

Graduate and undergraduate students at the Western Transportation Institute have distinguished themselves in a number of ways. In addition to an exemplary number of conference presentations, students have produced technical reports for project sponsors. Examples include:

• Pellet, Nicole, Roadway and Landscape Characteristics Leading to Increases in Ungulate-Vehicle Collisions, Montana Department of Transportation, December 2004.

• O'Keefe, Katie and Shi X. Synthesis of Information on Anti-icing and Pre-wetting for Winter Highway Maintenance Practices in North America. Final Report. August 2005.

• Marosek, Christopher, Evaluating the Accuracy of RWIS Sensors, Oregon and California Departments of Transportation, June 2005.

In addition to papers and presentations, transportation students have received a number of external awards. Trevor Iman, WTI Graduate Fellow, received the Institute of Transportation Engineers District 6 Outstanding Graduate Student of the Year for graduate study in traffic and transportation engineering. Doctoral student and WTI Graduate Fellow Laura Stanley was selected for the prestigious ENO Transportation Leadership Development Program. In May, she attended an intense five-day leadership program with other nationally-recognized graduate students in transportation graduate programs. The participants met with the nation's top policymakers and transportation leaders in government, industry, and trade and professional associations in order to develop an insider's perspective on how national transportation policies are determined.

The MSU Institute of Transportation Engineers (ITE) student chapter won the James H. Kell award to design and conduct a student competition at the ITE District 6 Annual Meeting. The student competition provides students with the opportunity to interact during the meeting while applying their transportation knowledge to a "real world" problem.

Education Initiatives for 2006

Recognizing the fact that transportation professionals and agencies must address a broad range of environmental and community concerns when designing and implementing projects, a professional development course was designed and conducted by WTI staff in 2005 for transportation professionals in the region. Dr. Tony Clevenger, Dr. Marcel Huijser and Amanda Hardy, ecologists and researchers at WTI, taught an eight-hour short course during the spring engineering festival at Montana State University. The course, "Road Ecology: Concepts and Applications for Resolving Wildlife and Transportation Conflicts," addressed the fundamental aspects of conservation of natural landscapes and wildlife populations, and explored the means of meeting the dual needs of animals to cross roadways with reduced hazard to motorists and wildlife.

The changing nature of transportation challenges and technologies demands a host of new skill sets within the transportation workforce. To meet these needs, WTI plans to expand its repertoire of training programs for transportation professionals in order to prepare them to effectively manage emerging issues.

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

WTI has traditionally conducted technology transfer through presentation of research at national forums, hosting technical workshops, and disseminating information through print and electronic media. This year, WTI continued these successful efforts while investigating refinements that will target information to specific audiences and respond to the current needs of transportation professionals.

Workshops

WTI conducts extensive technology transfer through research conferences and other forums. Our researchers frequently present their findings at major national and international events. In our own region, we have taken the lead in developing workshops to ensure that smaller and rural agencies have access to state-of-the practice information.
In the last year, we have also found success in sponsoring additional components or support activities at professional research conferences, in order to allow conference organizers to bring in highly qualified speakers, utilize professional support services or focus on the areas of the event that will benefit the most from their expertise. Two recent examples of events are the Rockies Wildlife Crossing Field Course and the 2005 ITE District 6 Meeting.

Rockies Wildlife Crossing Field Course

Collisions with animals are a serious threat to both wildlife and people; thus biologists and highway engineers increasingly look to solutions that keep animals off the roadways and yet allow them to follow their normal patterns of daily or seasonal movements. The Rockies Wildlife Crossing Field Course, was held in Payson Arizona on April 11-13 2005 to further understanding of the issues, solutions and best management practices. The course provided examples of regional connectivity projects and shared the successes and challenges of incorporating effective wildlife mitigation measures into transportation planning and highway construction. The 138 participants came from 16 states and three Canadian provinces, and they included biologists, engineers, consultants, agency officials, non-profits and foundations, and staff from federal and state transportation agencies. Cosponsors included American Council of Engineering Companies of Arizona and Colorado, Arizona Department of Transportation, Arizona Game & Fish Department, Aztec, Carter & Burgess, Center for Transportation and the Environment, Defenders of Wildlife, Federal Highway Administration, U.S. Forest Service, Western Transportation Institute and the Yellowstone to Yukon Conservation Initiative.

The class time was filled with detailed presentations on the science and practice of wildlife linkages, focal species and ecosystem approaches to identifying and designing crossings, monitoring and adaptive management, funding, and a number of excellent crossings projects, just to mention a few. The highlight was a full day in the field viewing the crossings being implemented near Payson. The Arizona Department of Transportation, the Arizona Fish and Game Department, and Tonto National Forest are working together to create safe passage for elk and other animals. When completed, there will be 11 wildlife underpasses and 6 span bridges along the 17 mile route.

WTI expanded its normal sponsorship role by donating staff time and travel money as well as funds for printing. The workshop organizers wanted WTI researcher and wildlife crossing expert Tony Clevenger to speak and lead a classroom session, but they did not have adequate funding to pay for his travel to the course. By paying for both his time and travel expenses, WTI assisted the organizers by reducing the overall amount of funding needed to make the course successful. WTI also contributed funds to pay for professionally printing a course brochure. The high quality brochure was eye-catching as well as informative, and helped to boost attendance by a wide variety of people from many different agencies.

2005 District 6 Annual Meeting

In July 2005 over 250 ITE members attended the 2005 District 6 Annual Meeting in Kalispell, Montana, sponsored in part by WTI. Additional sponsors included Engineering, Inc., David Evans and Associates, Clary Corporation, HKM Engineering, Morrison Maierle, Inc., WGM Group, Inc., Robert Peccia and Associates, PBS&J, and DJ&A, P.C. Representing all 13 states in District 6 as well as other areas of the country the attendees enjoyed the spectacular natural setting of the Flathead Valley and Glacier National Park.
This conference sponsorship was unique in that WTI donated administrative staff time to help the conference run smoothly. Four WTI administrative staff members attended the conference, ensuring that a staff member was available at every session to assist the speakers with the AV equipment, room setup and other needs. These staff members had received prior training in Powerpoint, trouble shooting for projectors and laptops, as well as general conference information such as hotel layout, location of restrooms and order of events.

WTI also paid for a professional conference planner to assist the ITE District 6 Local Arrangements Committee with reservations, hotel arrangements, attendee registration and fee collection. Since all members of the committee were volunteers, they did not have access to administrative staff. Use of the conference planner allowed the committee members to focus on portions of the conference that benefited from their professional expertise such as the technical sessions, vendor area and technical tours. The result was an efficiently managed conference with great technical content.

Peer Reviewed Publications

Anthony Clevenger

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

"Conservation Value of Wildlife Crossings: Measures of Performance and Research Directions." Clevenger, A.P., 2005 GAIA 14:124-129 (www.oekom.de/gaia)

"Performance Indices to Identify Attributes of Highway Crossing Structures Facilitating Movement of Large Mammals." Clevenger, A.P. & Waltho, N., 2005 Biological Conservation 121:453-464.

Eli Cuelho

"Resilient Interface Shear Modulus from Short-Strip, Cyclic Pullout Tests." Cuelho, E.V. & Perkins, S.W., (2005) Conference GeoFrontiers, Geotechnical Special Publication 140, Slopes and Retaining Structures under Seismic and Static Conditions, ASCE, Austin Texas

"Determining Geosynthetic Material Properties Pertinent to Reinforced Pavement Design." Cuelho, E.V., Perkins, S.W. & Ganeshan, S.K., (2005) Conference GeoFrontiers, Geotechnical Special Publication 130, Advances in Pavement Engineering, ASCE, Austin Texas

Robert Mokwa

"Soil Response in Sub-freezing Environments: The Frost Heave Model." Mokwa, R. L., Transportation Research Board 83rd Annual Meeting, Vol. 83, Washington DC, p.19

Steve Perkins

"Evaluation of Base-Reinforced Pavements Using a Heavy Vehicle Simulator." Perkins, S.W. & Cortez, E.R., Geosynthetics International, V. 12, No. 2, pp. 86-98

"Geosynthetic Material Properties for Use in 2-D Finite Element Pavement Response Models." Perkins, S.W., Eiksund, G.R., Seventh International Conference on the Bearing Capacity of Roads, Railways and Airfields, Trondheim Norway

"Geosynthetic Reinforcement for Pavement Systems: US Perspectives." Perkins, S.W., Bowders, J.J., Christopher, B.R. & Berg, R.R., Conference GeoFrontiers, Geotechnical Special Publication 141, International Perspectives on Soil Reinforcement Applications, ASCE, Austin Texas

"Modeling Effects of Reinforcement on Lateral Confinement of Roadway Aggregate." Perkins, S.W., Christopher, B.R., Eiksund, G.R., Schwartz, C.S. & Svanø, G., Conference GeoFrontiers, Geotechnical Special Publication 130, Advances in Pavement Engineering, ASCE, Austin Texas

"Resilient Interface Shear Modulus from Short-Strip, Cyclic Pullout Tests", Cuelho, E.V. & Perkins, S.W., Conference GeoFrontiers, Geotechnical Special Publication 140, Slopes and Retaining Structures under Seismic and Static Conditions, ASCE, Austin Texas

"Determining Geosynthetic Material Properties Pertinent to Reinforced Pavement Design." Cuelho, E.V., Perkins, S.W. & Ganeshan, S.K., Conference GeoFrontiers, Geotechnical Special Publication 130, Advances in Pavement Engineering, ASCE, Austin Texas

Xianming Shi

"Evaluating the Corrosivity of Chemical Deicers: an Electrochemical Technique." Shi, X. & Song, S. 16th International Corrosion Congress, Beijing China, September 2005

"Managing Winter Traction Materials on Roadways Adjacent to Bodies of Water: Challenges and Opportunities." Shi X., Staples J.M., & Stein, O. Environmental Stewardship in Transportation through Waste Management, Materials Reuse and EMS: 2005 Summer TRB Committee ADC60 Conference. Charlotte North Carolina, July 2005

Laura Stanley

"Driver Performance While Interacting with the 511 Travel Information System in Urban and Rural Traffic." Stanley, L. M., Kelly, M. J., Lassacher, S. Third International Driving Symposium on Human Factors in Driver Assessment Training and Vehicle Design Proceedings, Rockport MA, June 2005.

Chris Strong

"Identifying Opportunities for Intelligent Transportation Systems Applications in California's National Parks: Project Overview and Summary of Recommendations." Strong, C., Eidswick, J., & Turner, S. Transportation Research Record 1895, Transportation Research Board, National Research Council, Washington DC: 2004, pp. 170-181

Presentations

Stephen Albert
• "How is Advanced Technology Changing Transportation Infrastructure, Driving and Training Needs?" 2004 Joint Engineers Conference and ITS Rocky Mountain Annual Meeting, Helena MT, November 2004
• "The Future of Rural ITS." 2005 National Rural ITS Conference, Spokane WA, September 2005
• "Travel & Tourism Needs: A Western Perspective and Experience." 15th Annual Meeting & Exposition of ITS America, Phoenix AZ, May 2005

Ahmed Al-Kaisy
• "Evaluation of the Effectiveness of Single-Lane Two-Way Traffic Control at Maintenance and Reconstruction Zones," Transportation Research Board Annual Meeting 2005, Washington DC, January 2005

Tony Clevenger
• "Road Ecology: Concepts & Applications." Spring Engineering Festival, Montana State University, Bozeman MT, March 2005
• "Road Ecology: Landscape Connectivity for Wildlife." Spring Engineering Festival, Montana State University, Bozeman MT, March 2005
• "The Enigma of Wildlife Crossings: Where to Place Them and do They Work." Rockies Wildlife Crossings Field Course, Payson AZ, April 2005
• "Science-Based Approach to Adaptive Management of the Trans-Canada Highway Corridor in the Canadian Rocky Mountain Parks." International Conference on Ecology & Transportation, San Diego CA, September 2005

Eli Cuelho
• "Determining Geosynthetic Material Properties Pertinent to Reinforced Pavement Design." 2005 GeoFrontiers Conference, Austin TX, January 2005
• "Resilient Interface Shear Modulus from Short-Strip Cyclic Pullout Tests." 2005 GeoFrontiers Conference, Austin TX, January 2005
• "Live Load Testing of Reinforced Concrete Bridge Decks." Transportation Research Board Annual Meeting 2005, Washington DC, January 2005

Jaime Eidswick
• "Montana's AMBER Plan." Montana Department of Transportation Construction Conference, Bozeman MT, January 2005
• "Montana's AMBER Plan." Transportation Awareness Program Annual Training, Three Forks MT, May 2005

Amanda Hardy
• "Transportation and Wildlife in the Greater Yellowstone Ecosystem." Big Sky Institute, Bozeman MT, March 2005

Marcel Huijser
• "Wildlife and Transportation: Effects and Mitigation Measures." Lolo Watershed Group, Lolo MT, October 2004.
• "Road Ecology - Accidents with Wildlife: Desperately Seeking Solutions." Spring Engineering Festival, Montana State University, Bozeman MT, March 2005.
• "The Reliability of the Animal Detection System Along US 191 in Yellowstone National Park." 2005 International Conference on Ecology & Transportation, San Diego CA, September 2005
• "Software for Pocket PC to Collect Roadkill Data." 2005 International Conference on Ecology & Transportation, San Diego CA, September 2005

Trevor Iman
"Examining the Effect of Heavy Vehicles on Traffic Flow During Congestion," 2005 International ITE Meeting, Melbourne Australia, August 2005

David Kack
• "Everyone is Telling Me to Coordinate, Where do I Begin?" 16th National Rural Public & Intercity Bus Transportation Conference, Roanoke Virginia, October 2004.
•"Strategies for Creating Additional Transportation Services in Rural Communities." Easter Seals Project Action Mobility Planning Services Institute, Washington DC, March 2005.
•"Strategies for Increasing Transportation Options Through Coordinated Private/Public Transportation Services." Easter Seals Project Action Mobility Planning Services Institute, Washington DC, March 2005.

Mike Kelly
• "Driver Performance While Interacting with the 511 Travel Information System." 2005 National Rural ITS Conference, Spokane WA, September 2005.
• "Defensive Driving Training Research for Teen Drivers." 36th Annual Montana Traffic Education Workshop & Conference, Billings MT, April 2005

Manju Kumar
• "Environmental Stewardship and Winter Highway Maintenance." 2005 National Rural ITS Conference, Spokane WA, September 2005

Patrick McGowen
• "Decreasing the Age of Vehicle Fleets: Is It worth It from a Safety Perspective?" 2005 Institute of Transportation Engineers District 6 Annual Meeting, Kalispell MT, July 2005

Michael Oudshorn
• "Designing Primary Responder Applications with Web Services in a Hostile Environment." IASTED International Conference on Parallel and Distributed Computing and Networks PDCN 2005 as part of the 23rd IASTED International Multi-Conference on Applied Informatics Conference Program, Innsbruck Austria, February 2005

Xianming Shi
• "Evaluating the Corrosivity of Chemical Deicers: An Electrochemical Technique." 16th International Corrosion Congress, Beijing China, September 2005
• "Managing Winter Traction Materials on Roadways Adjacent to Bodies of Water: Challenges and Opportunities." Environmental Stewardship in Transportation through Waste Management, Materials Reuse and EMS 2005 Summer Transportation Research Board Committee ADC60 Conference, Charlotte North Carolina, July 2005
• "The Use of Road Salts for Highway Winter Maintenance: An Asset Management Perspective." 2005 Institute of Transportation Engineers District 6 Annual Meeting, Kalispell Montana, July 2005

Laura Stanley
• "Driver Performance While Interacting with the 511 Travel Information System in Urban and Rural Traffic." Driving Assessment Proceedings, Rockport MA, June 2005.
• "Development of a Web-Based Household Travel Survey for the Regional Transportation Commission of Southern Nevada." 2005 Institute of Transportation Engineers District 6 Annual Meeting, Kalispell MT, July 2005

Christopher Strong
• "Development of Criteria to Identify Locations for ITS Deployment." 2005 National Rural ITS Conference, Spokane WA, September 2005
• "Evaluating Accuracy of RWIS Sensors." 2005 National Rural ITS Conference, Spokane WA, September 2005
• "Development of Criteria to Identify Locations for ITS Deployment." 2005 Institute of Transportation Engineers District 6 Annual Meeting, Kalispell MT, July 2005
• "How Rural Transportation Differs from Urban." 2005 Institute of Transportation Engineers District 6 Annual Meeting, Kalispell MT, July 2005
• "Survey of Transportation Challenges on Reservations." 2005 Native Nexus Conference Montana State University, Bozeman MT, April 2005
• "Developing Measures of Effectiveness for Evaluating ITS in California's National Parks." 2005 Transportation Research Board Annual Meeting, Washington DC, January 2005

Conference Booths

The WTI booth was displayed at two industry conferences in the past year, the 2004 Joint Engineers Conference and ITS Rocky Mountain Annual Meeting as well as the 2005 National Rural ITS Conference.

The 2004 ITS Rocky Mountain Annual Meeting held in conjunction with the 2004 Joint Engineers Conference (JEC) November 4-5, 2004 in Helena, Montana. Sponsored in part by the American Council of Engineering Companies of Montana (ASEC), American Society of Civil Engineers (ASCE), Institute of Electrical & Electronic Engineers (IEEE), Institute of Transportation Engineers (ITE), Montana Society of Engineers (MSE), Society of American Military Engineers (SAME), Structural Engineer's Association of Montana (SEAMT), and the ITS Rocky Mountain Chapter, the conference brought together a diverse group of over 275 individuals. Session and continuing education units reflected this diversity with topics ranging from AutoCAD Productivity to Fuel Cell Technology and Basics of Intelligent Transportation Systems. The diversity of attendees created a great technology transfer opportunity as WTI booth staffers interacted with professionals from many different engineering fields. Given the multi-disciplinary research conducted at WTI many professionals from fields outside of transportation were interested in our research results.

Steve Albert, Western Transportation Institute, Keith Trimels, Mixon Hill, Inc. and Richard Wolff, Montana State University Electrical & Computer Engineering Department presented on "How is Advanced Technology Changing Infrastructure, Driving and Training Needs?"

(the portion of the article courtesy of ITS America, www.itsa.org)

Held September 10-13, 2005, this year's NRITS Conference provided approximately 200 transportation professionals from around the nation with quality technical information and discussion of how and to what degree of success states are deploying ITS in rural and small urban communities.

This year's conference, themed Moving Forward!, was hosted by the Washington State Department of Transportation (WSDOT) and held in conjunction with the Annual Meeting of ITS Washington. The conference featured two days of sessions about a variety of ITS efforts focused on rural transportation, from "Hurricane Katrina: TxDOT Evacuation Experience" to "Wireless and WiFi at Rest Areas". Technical tours also offered participants the opportunity to observe the operations of the Spokane Regional Multi-Agency Traffic Management Center, the Spokane Regional Transit Operations Center, and the National Weather Service Forecasting Center. Sixteen exhibits were provided by national ITS vendors, including Adaptive Micros Systems, GeoDecisions, RouteMatch Software and more.

The conference officially opened Monday morning with opening remarks from Jerry Lenzi, WSDOT Regional Administrator, Spokane Mayor James West, John Conrad, Assistant Transportation Secretary, Dan Mathis of the Federal Highway Administration (FHWA), and Neil Schuster, President and CEO of ITS America, each speaking on the future of rural ITS, particularly in light of the recent signing of the Safe, Accountable, Flexible and Efficient Transportation Equity Act of 2003, A Legacy of Users (SAFETEA-LU).

According to Schuster, "This year's National Rural ITS Conference gave ITS rural interests an important opportunity to take stock of rural ITS programs in SAFETEA-LU and to strengthen programs to ensure that the rural elements of ITS solutions remain a national priority."

In addition to technical tours and sessions, two events of note were the Super-Session Panel Discussion on the Future Direction of Rural ITS and the meeting of ITS America's Rural Stakeholder Interest Group (SIG), both led by Steve Albert, Director of the Western Transportation Institute, Chairman of the Rural SIG, and organizer for the 2006 NRITS Conference. Both events generated constructive and dynamic dialogue between the pubic and private sectors on the development of a national rural ITS operational program.

"This year's conference has encapsulated rural needs and nationally significant projects, and the dialogue on the future of rural ITS session and the Rural SIG will serve as a roadmap for both invigorating the rural transportation community and its broad stakeholder base and addressing the rural challenges," remarked Albert.

Conference Booths *Continued*

The conference also provided ample opportunity for networking, allowing east and west coast public and private sector representatives to compare "lessons learned" on topics such as ITS deployment and maintenance, as well as form partnerships for future projects and research.

WTI staff members Steve Albert, Mike Kelly, Chris Strong, and Manju Kumar presented during several conference sessions.

For more information regarding the 2006 NRITS Conference to be held in Big Sky, Montana, August 13-16, visit http://www.2006nrits.org.

Website

WTI will be doing a major update to its website in the coming year to ensure the project related information is easier to browse and the graphical components will be updated to reflect the new Montana State University graphic guidelines. Improved internal administrative processes ensure information about research projects, reports and contacts is current however; the information is difficult to browse given the current navigation bar. An initial user study will be conducted to ascertain how users are currently navigating the research portion of the website. Results of the user study will determine the new navigational bar design as well as a new site map.

Newsletters

The WTI newsletter was published in March and September 2005 to inform readers about our latest research, education and outreach activities. Both editions of the newsletter can be downloaded as pdf files from www.coe.montana.edu/wti/what/publications.html. The newsletter was sent to approximately 2199 readers. This surpasses our circulation goal by 137%.

The March 2005 WTI Newsletter included these articles.

- Transportation and the Environment
- Using PDA/GPS System to Collect Roadkill Data
- Redding District Incident Management Responder Study
- Tribal Automated Accident Reporting System
- Driving Simulator Provides Key Data in Transportation Research
- WTI Assists Burgeoning Big Sky with Transportation Issues
- Biodiesel Policy Alternatives Developed for Montana State Legislature
- Yellowstone Park and WTI Address Traffic Problems on US 89
- Yellowstone and Glacier Travel Information will soon be Accessible on 511 Systems
- Major Overhaul Planned for Glacier Park's Going-to-the-Sun Road
- Native Grass Sod: A Potential Solution to Erosion Problems Along California Highways?
- Brandy Sularz Selected as "Student of the Year"
- Summer Transportation Institute: Ready for Take-Off
- MSU Students Lead Engineering Week Activities
- Professional Courses Developed from Road Ecology Research
- Snowbelt States Seek Advancements in Corrosion Testing Protocols
- DOT Officials View Animal Detection System Installations
- New Video Highlights ITS in California National Parks
- Transportation Research Positions Available
- Come to the "Last Best Place" for the 2006 National Rural ITS Conference

The September 2005 WTI Newsletter included these articles.

- WTI Earns University Transportation Center Status fro a Second Time
- Benefits of UDOT Weather Operations/RWIS Program to be Evaluated
- New Report Focuses on Innovative Methods of Winter Highway Maintenance
- Researchers to Conduct Evaluation of Alaska 511 System
- Defensive Driving Course for Teens May Reduce Accident Rates
- New STARS Project to Collect Updated Data on Overweight Vehicles
- Montana Receives Assistance from WTI to Upgrade Traveler Information Database
- Montana DOT Contracts with WTI to Create More Efficient Statewide Operations
- Snow Plow-Mounted AVL Sensors Being Researched for Montana
- Which Road Maintenance Techniques Work Best in Montana?
- Researchers Look for Effective Measures to Mitigate Steel Corrosion in Concrete
- New Method May Replace Decades-old Soil Density Test
- Road Ecologists to Study Wildlife Connectivity on Snoqualmie Pass
- Interagency Review Team to Develop an Ecosystem Based Mitigation Plan for Highway 93 Corridor
- Montana Communities Expand Transit Options Through Coordination
- Research Staff Appointed to Leadership Roles on TRB Committees
- WTI Researcher First to Receive New ITE Award
- Come to the "Last Best Place" for the 2006 National Rural ITS Conference
- Research Experience for Undergraduates
- Summer Transportation Institute for High School Students a First for Montana

Technology Transfer Success Story

The goal of our technology transfer program is the diffusion of practical research knowledge from our researchers to others. By taking the extra step of packaging the experiences from our research projects into practical knowledge workshops for fellow professionals we hope to share our lessons learned, and give back to the transportation community by helping others advance their knowledge. This will make research efforts more efficient by reducing duplication of mistakes and demonstrating the most effective methods. An example of these workshops is two professional courses developed by WTI researcher Tony Clevenger.

A growing interest in recent research and publications by WTI staff about road ecology and wildlife crossing systems has led to the development of two university-based short courses on these topics for industry professionals. Tony authored the curriculum for both of the courses. Clevenger is a co-author of the book "Road Ecology: Science and Solutions," which looks at how roads impact the environment and the techniques being applied to mitigate these impacts on wildlife, land, water, and plant ecosystems.

Using the Rocky Mountains as a case study, the first eight-hour course "Road Ecology: Concepts and Applications for Resolving Wildlife and Transportation Conflicts," addressed the fundamental aspects of conservation of natural landscapes and wildlife populations, and explored the means of meeting the dual needs of animals to cross roadways with reduced hazard to motorists and wildlife. Clevenger, Marcel Huijser and Amanda Hardy of WTI taught the course during the engineering festival at Montana State University-Bozeman in March, 2005 to over 30 engineering professionals.

The second professional development short-course is an offshoot of another WTI project, sponsored by FHWA, called "North American Wildlife Crossing Design Guidelines," in which Clevenger compiled guidelines for planning and designing functional wildlife fencing and crossing structures. The information that was gathered in this project will make up the content of the professional development course targeting transportation practitioners and biologists. This course will be available for presentation in the coming months.

Initiatives For 2006

The Technology Transfer initiatives for 2006 will focus on two major events that WTI will host next summer. On June 21-22, 2006, WTI will host the 2006 CUTC Summer Meeting in Big Sky, Montana. This meeting will span two days and offer new UTC directors and other personnel the opportunity to learn more about the UTC Program. The overarching goal of the meeting is to warmly welcome the new university transportation centers funded by the passing of the SAFTEA Transportation Funding bill. Old members will be able to share lessons learned from their experiences operating centers, while new members will fully participate in business meetings and lend a new perspective to the discussions. A separate track is also being planned for the business managers so they can more fully discuss the reporting requirements and financial operations of a successful center. The meeting will also help center directors establish working relationships that will facilitate ongoing collaboration between the centers-both old and new.

WTI will also host the 2006 National Rural ITS Conference, in Big Sky, Montana August 13 - 16, 2006. With the majestic backdrop of the Rocky Mountains and Lone Mountain, the 2006 National Rural ITS Conference will provide opportunity for transportation professionals to obtain information on current rural transportation issues, exchange valuable ideas and information regarding the challenges faced in rural transportation. In addition participants will be given the opportunity to sharpen networking skills and identify collaboration opportunities. Workshops will provide forums for WTI researchers and other leading ITS experts to pass on the latest advancements in rural transportation research, so they can be more quickly incorporated into practice.