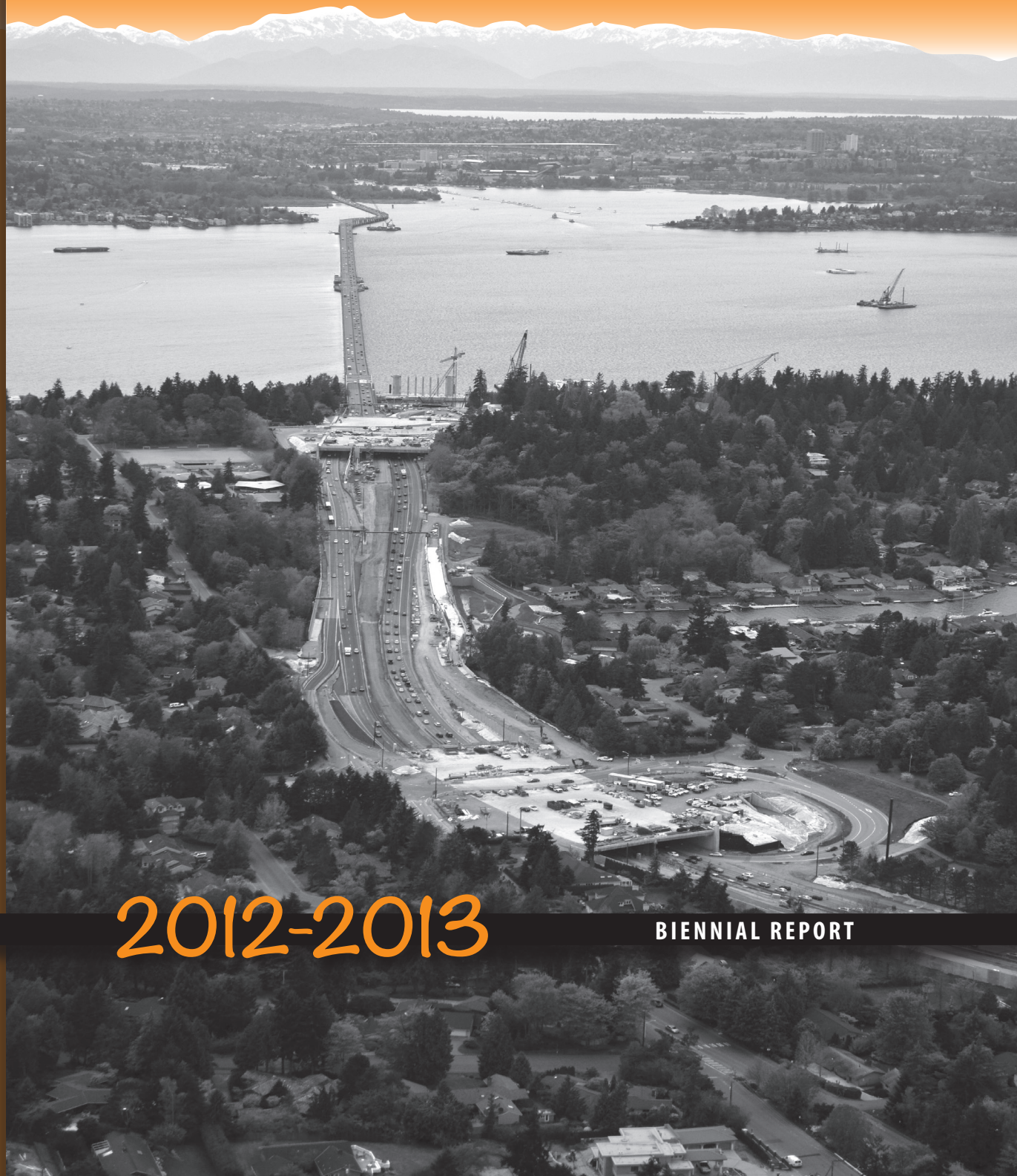
TRAC



2012-2013 BIENNIAL REPORT

WASHINGTON STATE
TRANSPORTATION CENTER

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The research projects you will read about in this report involve issues within many technical disciplines. The State of Washington is fortunate to have strong multi-disciplinary and collaborative partnerships through the Washington State Transportation Center (TRAC) to address them. That approach to research is crucial because transportation practices and the factors that affect them are constantly changing. New policies and regulations alter the transportation environment, new methods and materials enable more cost-effective outcomes, new technologies provide opportunities to operate more efficiently, increased computing capacity improves analytical capability, and the expectations of transportation system users change in reaction to new technology and services. TRAC is ideally set up to help study these changes and to develop ways to cost-effectively take advantage of and address them.

The results from many of the projects summarized in this report were quickly adopted into practice. For example, research products provided or contributed to

- key information about the influence of fuel prices on vehicle miles traveled, greenhouse gas emissions, and revenue that will support policy development
- criteria and benchmarks that will help WSDOT evaluate and monitor investments for safe routes to school
- new information to improve the design and allow the use of reinforced concrete-filled tubes in bridge foundations
- a Department of Ecology decision to allow the use of vegetated filter strips on steep slopes, which gives WSDOT a lower cost treatment option that will result in cost savings without compromising environmental quality
- a policy decision to allow the use of bituminous pavement surface treatments, a lower life cycle cost pavement option, on pavements with higher traffic volumes, and continuing research will help determine when to apply this treatment for maximum performance
- information that will help WSDOT make freight-related project investment choices with the highest benefit.

Such incremental changes are often difficult to quantify, but over time they significantly improve the quality of decision making about and performance of the transportation system.

WSDOT, the University of Washington, and Washington State University are celebrating over 30 years of working together to address important transportation issues. In addition, TRAC researchers collaborate with many other research institutions, public agencies, and private organizations—statewide and nationally—to provide the highest quality research. In the project summaries, you will see the results of the creativity, initiative, and talent of many individuals. Each one is an important contributor to improvements in Washington's transportation system.

Sincerely,

Leni Oman
Director, Office of Research & Library Services
Washington State Department of Transportation

Research at the Washington State Transportation Center (TRAC) addresses the issues of today's transportation systems and the needs of their users. The studies cover a wide variety of fields, and many require interdisciplinary contributions. These studies benefit from the collaborative work within and between research institutions and other organizations in Washington state and beyond. Through these partnerships TRAC is able to leverage not only funding but also knowledge and other research resources, conducting studies cost effectively and efficiently, to provide innovative solutions to transportation-related challenges.

Project Funding and Support

From July 1, 2011, to June 30, 2013, TRAC-UW researchers were involved in 65 research projects, for which the budgets totaled over $7.7 million. The 25 budgets for TRAC-WSU projects totaled over $3.2 million. These figures do not include TRAC 's administrative budgets.

In addition to funding from WSDOT, research funding came from a variety of sources. TRAC received national and international support from the following public agencies in the past two years:

Alaska Department of Transportation and Public Facilities
Alaska University Transportation Center
California Department of Transportation
Colorado Department of Transportation
Federal Highway Administration
Idaho Transportation Department
Joint Center for Aerospace and Technology Innovation
National Cooperative Freight Research Program
National Cooperative Highway Research Program
National Heart, Lung and Blood Institute
National Institute of Diabetes and Digestive and Kidney Diseases
National Institute on Aging
National Institutes of Health
Oregon State Department of Transportation
Pacific Northwest Transportation Consortium (PacTrans)
Research and Innovative Technology Administration
Strategic Highway Research Program
Transportation Northwest (TransNow)
Western Federal Lands Highway Division
U.S. Department of Transportation

A number of TRAC/WSDOT projects were supported by consortia or pooled funds in which 32 state departments of transportation were involved, including those of Alaska, Arizona, California, Colorado, Connecticut, Florida, Idaho, Illinois, Indiana, Iowa, Kansas, Maryland, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New York, North Carolina, North Dakota, Ohio, Oregon, Pennsylvania, Tennessee, Texas, Utah, Virginia, West Virginia Wisconsin, and Wyoming.

In-state public supporters for TRAC projects included

City of Seattle
Community Transit
King County Metro Transit
Pierce Transit
Seattle Children's Hospital and Regional Medical Center
Sound Transit
Washington State Transportation Improvement Board
Yakima Valley Council of Governments

TRAC received private support from or worked as a subcontractor for

Applied Research Associates
Battelle Memorial Institute
Booz Allen Hamilton
Cambridge Systematics
Eco Resource Management Systems Inc.
The Bullitt Foundation

Interdisciplinary Reach

As the field of transportation continues to broaden, TRAC's research reflects WSDOT's growing emphasis on interdisciplinary projects that respond to the interconnected nature of transportation, the natural and built environments, and changing societal and fiscal realities. Over the past two years TRAC research involved more faculty than ever—54—and the largest number and breadth of UW and WSU departments:

Architecture, UW
Atmospheric Sciences, UW
Civil and Environmental Engineering, UW
Civil and Environmental Engineering, WSU
Computer Sciences and Engineering, UW
Construction Management, UW
Criminal Justice and Criminology, WSU
Crop and Soil Sciences, WSU
Economic Sciences, WSU
Electrical Engineering, UW
Entomology, WSU
Epidemiology, UW
Evans School of Public Affairs, UW
Landscape Architecture, UW
Mechanical Engineering, UW
Natural Resource Sciences, WSU
Office of Educational Assessment, UW
Social and Economic Sciences Research Center, WSU
Urban Design and Planning, UW

Cooperation and Collaboration

Through their research projects, TRAC researchers worked with private consulting firms, product manufacturers, other universities and research facilities, cooperative associations, and public agencies. Many studies would not have been possible without the cooperation of these partners, and the collaborations resulted in more successful and valuable results. Below is just a partial list of the partners with whom TRAC researchers worked over the past biennium.

Universities and Research Institutes

Battelle Memorial Institute
Children's Hospital and Regional Medical Center
Desert Research Institute
Stanford University
Washington University School of Medicine
Western Transportation Institute, Montana State University

TRAC also collaborated with the Pacific Northwest Transportation Consortium (PacTrans), the federally funded Region X University Transportation Center. PacTrans is a coalition of transportation professionals and educators from Oregon State University, the University of Alaska, Fairbanks, University of Idaho, University of Washington, and Washington State University. With dual themes of safety and sustainability, PacTrans serves as an engine and showcase for transportation research, education, and workforce development in the Pacific Northwest.

Public Agencies

City of Des Moines
City of Federal Way
City of Grandview
City of Kenmore
City of Kent
City of Mukilteo
City of Roslyn
City of SeaTac
City of Shoreline
City of Wenatchee
King County Metro Transit
National Oceanic and Atmospheric Administration
Port of Seattle
Puget Sound Regional Council

Private Companies

Pavia Systems

Associations

Northwest Regional Modeling Consortium
Washington Trucking Associations

Technology Transfer

Research dollars are wasted if clients are unaware of research results, unable to understand research findings, or unable to implement them. That's why TRAC emphasizes technology transfer as part of its operations. TRAC makes a special effort to ensure that research reports are understandable by developing project summaries and providing guidance to writers. During the 2012-2013 biennium, TRAC processed numerous proposals and produced nearly 30 reports and other publications.

TRAC also continued to maintain and improve its website, http://depts.washington.edu/trac/. Visitors can find information about TRAC, access research reports and project information, and obtain guidance on producing work through TRAC.

TRAC Mission

Research at the Washington State Transportation Center (TRAC) is interdisciplinary, collaborative, and diverse.

TRAC is a cooperative transportation research agency. Its members, the University of Washington (UW), Washington State University (WSU), and the Washington State Department of Transportation (WSDOT), support TRAC to coordinate both public and commercial transportation research efforts and to develop research opportunities nationally and locally.

TRAC's most important function is to provide a link among the state and other research clients, university researchers, and the private sector. TRAC acts as a liaison, connecting those who need applied research at WSDOT or other agencies and those best suited to conduct it at the universities, as well as connecting researchers to data and other resources.

From its offices at the WSDOT in Olympia, the UW in Seattle and WSU in Pullman, TRAC coordinates resources for research, serves as a focal point for student and agency involvement in transportation research, and provides services such as report editing, production, and graphics. The office at WSDOT in Olympia serves as the central point of contact for agency managers interested in working with university researchers and students through a variety of programs. The WSDOT provides research funding and contracts and connects researchers to technical resources.

Bridge research in Washington state has long focused on seismic demands and issues related to earthquakes. This past biennium, issues other than seismic demands came to the forefront, including preservation, cost-saving designs, monitoring the United States' longest prestressed girders, and expansion joint noise. Preservation is one of WSDOT's highest priorities for all its infrastructure, and we are trying to evaluate the lowest life cycle cost for the state's steel bridges in particular, which will no doubt affect other types of bridges as well. In addition, WSDOT is on the cutting edge of bridge design in many ways, from attempting to utilize all construction materials to reducing costs in new girders.

Completed Projects

Expansion Joint Noise Reduction Project on the New Tacoma Narrows Bridge

Highway-related noise continues to be a source of public annoyance. After WSDOT received numerous complaints about the noise generated by the expansion joints on the new Tacoma Narrows Bridge, strategies and treatments were evaluated to reduce noise. The project determined that adding a sound absorptive treatment around the expansion joints would best address the bridge's acoustic, structural, and aesthetic needs. After implementation, the overall sound levels were similar, but the noise generated by the expansion joints at highest and lowest frequencies was reduced, which eliminated public complaints.

Principal Investigator: Sexton, T., WSDOT
Research Manager: Brooks, R., WSDOT
Technical Monitor: Moore, T., WSDOT
Sponsor: WSDOT
WA-RD 785.1

Initial Investigation of Reinforced Concrete-Filled Tubes for Use in Bridge Foundations

Deep caisson bridge foundations are frequently required in bridge construction. These are typically large-diameter drilled foundations with a steel tube inserted into the drilled shaft. The steel tube is filled with reinforced concrete, and this caisson is then combined with the piers of the bridge substructure. Recent research on concrete-filled steel tubes (CFT) has shown significant benefits from their application. However, the current AASHTO Bridge Design Code for bridge piles and shafts does not adequately describe how to design piles or shafts that use a steel casing and reinforced concrete. Current design methods tend to be very conservative and neglect the benefits provided by composite action, which may permit smaller diameter and shorter caisson foundations, resulting in cost savings associated with smaller piles and drilled shafts. This preliminary study considered the composite properties of CFT members with internal reinforcement. The goals were to develop initial answers to uncertainty in the process for designing these components and their connections so that WSDOT can begin to realize their benefits.

Principal Investigators: Roeder, C./Lehman, D., UW
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Khaleghi, B., WSDOT
Sponsor: WSDOT
WA-RD 776.1

Structural Design Parameters of Current WSDOT Concrete Mixes

The structural performance of a concrete mixture is related to the compressive strength, rate of strength gain, and tensile strength of the concrete, as well as its deformation-related properties, such as the modulus of elasticity, drying shrinkage and creep. These properties are primarily affected by the nature of the coarse aggregate, as well as the amount of cementitious binder (paste) in the concrete. Unfortunately, the AASHTO Load and Resistance Factor Design specifications relate most of these properties to compressive strength, with little regard to the actual proportions and component properties of a specific concrete mixture. This project conducted testing to verify that the properties of WSDOT structural concrete mixtures are acceptably close to the expected values. The results improve WSDOT's knowledge of the structural performance properties of its concrete mixtures and allow it to make appropriate changes to its concrete specifications and mix design requirements.

Principal Investigators: Janssen, D./Eberhard, M., UW
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Lewis, R., WSDOT
Sponsor: WSDOT
WA-RD 802.1

Active Projects

Bridge Monitoring: Instrumenting the Longest Prestressed Concrete Girders in the U.S.

The SR 99 South Holgate Street to King Street project, part of the larger Alaskan Way Viaduct replacement program, contains girders spanning 210 feet. Because these are the longest girders in the U.S. and current design guidelines include no validation for girders of this length, WSDOT wants to monitor them to develop better specifications and design guidelines. To that end, this project is instrumenting and monitoring four 210-foot girders on SR 99 to measure the stresses and strains of

Photo provided by WSDOT

Concrete girders such as these will be used as part of the Alaskan Way Viaduct replacement in Seattle. Because of their unusual length, WSDOT will monitor them for stresses, strains, and the effects of deck shrinkage.

the end zone reinforcement of the girders, as well as the effects of deck shrinkage on girder behavior.

Principal Investigator: Badie, S., George Washington University
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Khaleghi, B., WSDOT
Sponsor: WSDOT

Cost Benefits of Washing Bridges to Prevent Deterioration

Currently, WSDOT washes steel bridges irregularly. The frequency of washing a particular bridge may be every five or more years. WSDOT is investigating the feasibility of a more frequent steel bridge washing program and in 2011 began a pilot study to determine the benefits and environmental impacts of such a program. This project built on the pilot study, with the intent of determining current bridge washing practices around the country and identifying the key variables necessary for estimating the impacts of regular washing on a steel bridge's paint and service life. However, a literature review and nationwide survey led to the conclusion that little information on the effects of bridge washing exist, and it is deemed beneficial only on the basis of anecdotal assumptions. The researchers therefore proposed an experiment that will provide hard data on which to base recommendations for a framework for assessing the impacts of bridge washing on paint life.

Principal Investigators: Berman, J./Roeder, C., UW
Research Manager: Willoughby, K., WSDOT
Technical Monitors: Myhr, G./Baroga, R./Keegan, C./Wilson, D., WSDOT
Sponsors: WSDOT, FHWA
WARD 811.1

Extended Discharge Time and Revolution Count for Cast-in-Place Concrete

Existing WSDOT specifications for truck-mixed concrete include placement limits that are a function of time and temperature. However, the specifications are dated and may no longer be applicable, given advances in truck, concrete, and admixture technologies. The investigators for this project are determining whether the existing limits in WSDOT's specifications are still applicable to typical concrete mixtures used in the state of Washington. If not, they will identify key material, environmental, and mixing variables that can be used to ensure good concrete workability, constructability, and performance.

Principal Investigator: Trejo, D., Oregon State University
Research Manager: Willoughby, K., WSDOT
Technical Monitors: Gaines, M./Williams, K., WSDOT
Sponsor: WSDOT

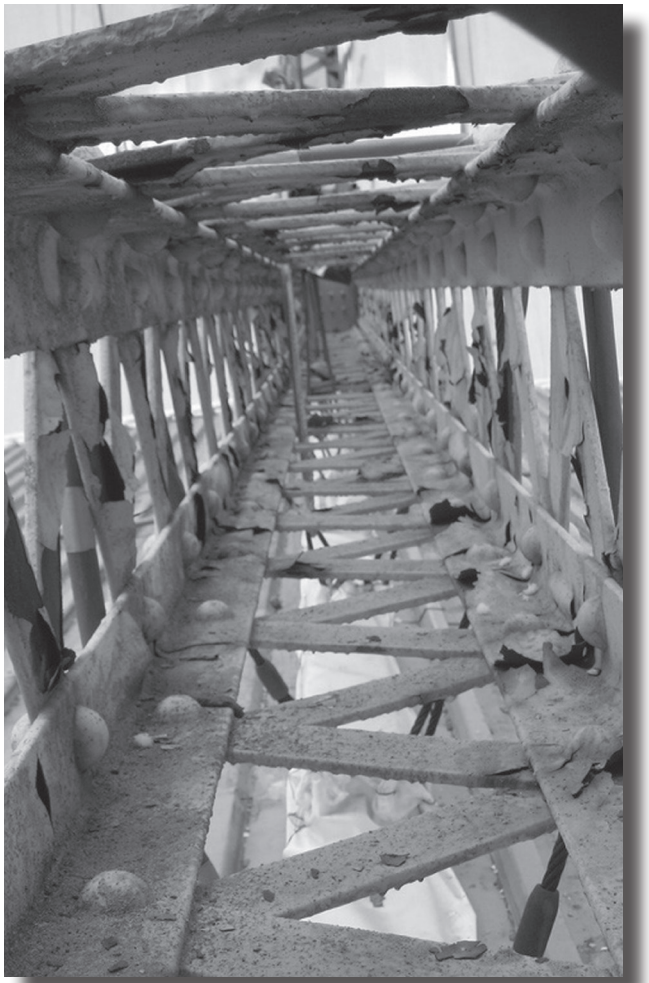


Photo provided by WSDOT

Researchers are investigating how often WSDOT should wash its steel bridges to best prevent rust, maintain paint and service life, and minimize environmental impacts.

Technical Support for Structural Health Monitoring and Condition Assessment for the Chulitna River Bridge

The Chulitna River Bridge, built in 1970, is located on the Alaska Parks Highway between Fairbanks and Anchorage. The Parks Highway is the most direct route connecting Anchorage, Fairbanks, and Prudhoe Bay, and heavy vehicles with loads of up to 410,000 pounds regularly travel it. The original 790-foot bridge was a five-span, continuous bridge with two exterior steel plate girders. It had a 34-foot cast-in-place concrete deck. In 1993 the original bridge deck was replaced with precast concrete deck panels and widened to over 42 feet. To accommodate the increased loads, the two original exterior plate girders were strengthened, three new longitudinal steel trusses were installed, and steel bracing was added to the piers. For this project, researchers have designed and installed a real-time fiber optic structural monitoring system to determine whether the girders are over-stressed for standard highway loads and permitted vehicles. As a subcontractor to the Alaska University Transportation Center, TRAC researchers are providing technical support and advice for the design of instrumentation and interpretation of data.

Principal Investigator: Dolan, J.D., WSU
Technical Monitor: Littell, M., AUTC
Sponsor: Alaska Department of Transportation

Update of the BRIDG Software Package for LRFD

Federal regulations require that departments of transportation continuously monitor and rate their steel and reinforced/prestressed concrete bridges' conditions. Washington engineers evaluate and rate state bridges by using WSDOT's in-house BRIDG software package. WSDOT also has a database of computer models for all of its steel and reinforced concrete bridge structures that work with the BRIDG software. These enable fast and efficient analyses when engineers need to update structural conditions or determine capacities for over-weight vehicles. However, although the existing software is fully functional and was carefully and extensively compared to alternative software packages, the techniques it employs for load generation and evaluation do not include modern Load and Resistance Factor Design standards. This project is adding those missing components to the existing software package while maintaining its compatibility with the bridge computer models.

Principal Investigator: Mackenzie, P., UW
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Coffman, H., WSDOT
Sponsor: WSDOT

Washington's rich natural resources require that we safeguard our air and water quality and preserve and protect wildlife habitats. Research finds new ways to keep highway stormwater runoff from adversely affecting our watersheds, rivers, and the Puget Sound. Identifying and removing barriers for fish and wildlife passage across highways, bridges and structures protects important species, as does finding ways to construct ferry terminals and bridges without harm to fish, sea mammals, and sea birds. New methods for reducing animal-vehicle collisions protects both wildlife and the traveling public. Monitoring air quality from vehicle emissions is a key strategy to improving public health. Reducing impacts from highway and construction noise also supports livable communities. Finally, as we better understand the predicted effects of climate change, research is helping us develop tools to assess how Washington's vast highway infrastructure will be affected.

Completed Projects

Climate Change Impact Assessment of the Pacific Northwest and Alaska

Of common concern to the four Pacific Northwest states are problems resulting from climate change that affect the planning, design, construction, maintenance, management, and operation of transportation systems. To address this concern, this project developed a baseline assessment of climate change impacts and issues affecting transportation in the Pacific Northwest and Alaska to support development of adaptation strategies. Beginning with a preliminary risk characterization and vulnerability assessment, this research identified critical infrastructure affected by climate change impacts in Alaska, Idaho, Oregon, and Washington. The study addressed the nature of climate changes and the potential impacts on the physical condition and serviceability of the regional surface transportation system. This project also provided a model and data for agencies to build upon to refine their vulnerability and risk analyses for decision making.

Principal Investigators: MacArthur, J., Oregon Transportation Research and Education Consortium; Figliozzi, M./Walker, L., Portland State University; Mote, P./Ideker, J./Gitschlag, T., Oregon State University; Lee, M./Phan, T., University of Alaska, Fairbanks
Research Manager: Lindquist, K., WSDOT
Technical Monitor: Roalkvam, C.L., WSDOT
Sponsors: Washington (Lead), Alaska, Idaho, Oregon
WA-RD 772.1

Compost-Amended Biofiltration Swale Evaluation

From May 2009 through June 2010, a compost-amended biofiltration swale and a standard (control) biofiltration swale were monitored in the median of SR 518 to obtain hydrologic and water quality performance data that could support the issuance of a General Use Level Designation permit from the state Department of Ecology for the compost-amended swale. The monitoring was intended to ascertain whether this highway stormwater treatment method successfully met performance criteria in order to be accepted as a best management practice (BMP) for basic biofiltration, enhanced (dissolved metals removal) filtration, and oil treatment. The results of this project were presented to the Department of Ecology, and the BMP has been approved for use in highway stormwater management.

Principal Investigators: Lenth, J.,/Dugapolski, R., Herrera Environmental Consultants
Research Manager: Brooks, R., WSDOT
Technical Monitor: Maurer, M., WSDOT
Sponsor WSDOT
WA-RD 793.1

Compost Leachate

Fresh compost applied to bioretention systems or drainage areas, which WSDOT maintains to manage highway runoff, initially releases substantial amounts of organic and inorganic constituents when exposed to rainfall or water infiltration. The initial leachate is often characterized by a brown coloration, suggesting the presence of organic materials, and it is also known that nutrients such as nitrates and phosphorus are leached out. Questions remain about the composition and amounts of constituents leached out of compost. Through a literature review, this project began the process of looking at the chemical composition and amount of constituents leached from freshly applied compost and how the leachate changes over time.

Principal Investigators: Flury, M./Hinman, C./Cogger, C., WSU
Research Manager: Brooks, R., WSDOT
Technical Monitor: Mauer, M., WSDOT
Sponsor: WSDOT

Eastern Washington Steep Slope Research for Management of Highway Stormwater

The Clean Water Act requires management of highway stormwater runoff through the use of best management practices (BMPs), which are effective methods for removing pollutants and reducing stormwater volumes to protect water quality. In addition, new regulations require a low impact development approach to stormwater management, which maximizes infiltration, evaporation, and transpiration by utilizing a site's natural features to mimic the pre-developed hydrology. Highway embankments provide an ideal location for integrating low impact development and stormwater BMPs, specifically vegetated filter strips (VFS) and dispersion. Locating VFS and dispersion along an embankment also has the desirable

effect of reducing the spread of noxious weeds and promoting indigenous grasses. This research was instrumental in gaining Department of Ecology approval to allow vegetated filter strips on slopes of up to 33 percent, enabling this method to be used at many existing and proposed locations in both eastern and western Washington without flattening the roadway footprint or widening the right of way. Combining stormwater and roadside vegetation management practices and eliminating the need to flatten steep slopes will mean reduced costs to the public.

Principal Investigators: Haselbach, L., WSU/Navickis-Brasch, A., WSDOT
Research Manager: Brooks, R., WSDOT
Technical Monitors: Maurer, M;./Schaffner, L./Lahti, G., WSDOT
Sponsors: WSDOT, TransNow
WA-RD 771.1

Monitoring Habitat at Hoh River Engineered Log Jams

Engineered log jams (ELJs) have become popular as an alternative to riprap for bank stabilization because of their potential ecological benefits. WSDOT has used ELJs to stabilize the chronically eroding banks of the Hoh River near milepost 174.4 of Highway 101 and also proposes to use ELJs to stabilize the Hoh River banks near milepost 175.9, where riprap has chronically failed. However, although ELJs were expected to provide ecological benefits, they had not been thoroughly evaluated. The Hoh River sites offered an opportunity to evaluate the habitat benefits of ELJs on Chinook salmon, Coho salmon, steelhead, mountain whitefish, and sculpin, the most common species at both sites, with a before-and-after study. The project found that differences in fish abundance, size, or growth at the two sites were quite variable. The testing and analysis procedures used to collect the fish data for this study will be considered in collecting data at future ELJ sites.

Principal Investigator: Peters, R., U.S. Fish & Wildlife Service
Research Manager: Brooks, R., WSDOT
Technical Monitor: Park J., WSDOT
Sponsor: WSDOT
WA-RD 786.1

Permeability of Existing Structures for Wildlife

This project developed a Passage Assessment System to evaluate the ability of existing transportation infrastructure to facilitate wildlife movement from one side of a roadway to the other. The wildlife passage assessment system differentiates among structures that are currently functional, those that could be enhanced, and those that are not functional by looking at different types of wildlife and how they respond to roads and crossing structures. Structural functional classes were also defined to classify road infrastructure, such as bridges, culverts and pipes, to create a common understanding of terminology related to wildlife crossings. The outcomes of this research are mechanisms that allow transportation agencies to identify both opportunities and barriers to wildlife passage along roads.

Principal Investigators: Cramer, P./Kintsch, P., Utah State University
Research Manager: Brooks, R., WSDOT
Technical Monitors: McAllister, K./Carey M., WSDOT
Sponsor: WSDOT
WA RD 777.1

Snow Depths from the Heights: Developing a Mission-Specific Civilian Unmanned Aircraft System

Unmanned aircraft systems (UASs) have become smaller, more capable, and less expensive mainly because of military investment in the UAS industry. Current generation UASs can be transported in small vehicles and launched from a road or a small truck but are still large enough to be equipped with cameras that can provide high quality aerial information and can carry payloads such as sensors. These capabilities have generated considerable interest in civilian applications of UASs, including environmental sensing. This project explored the use of UASs in collecting snowpack data to support roadside avalanche control operations and water resources analysis. Use of UASs could potentially make these functions less expensive and less hazardous for public agencies. The researchers evaluated the feasibility of placing different sensors on a UAS that could be used to measure snow depth and snow conditions. The most promising sensors were tested on a manned aircraft operating over the Cascade Mountains.

Principal Investigators: McCormack, E.D./Lundquist, J., UW
Sponsor: Joint Center for Aerospace & Technology Innovation

Wildlife Monitoring at I-90 Snoqualmie Pass East, Prior to the Installation of Wildlife Crossing Structures

The I-90 Snoqualmie Pass East project is located along a 15-mile stretch of I- 90 that passes through the Okanogan-Wenatchee National Forest. The project corridor has been identified as a critical connectivity zone for Pacific Northwest wildlife populations, linking natural habitats to both the north and south of the project area. WSDOT will help alleviate adverse effects to wildlife caused by increased traffic volumes, a wider highway, and higher traffic speeds by enhancing ecologi-

Photo provided by WSDOT

Researchers developed a Passage Assessment System to help transportation agencies identify both opportunities and barriers to wildlife passage along roads. Above is the Gold Creek animal undercrossing on I-90.

cal connectivity at 14 Connectivity Emphasis Areas throughout the project area for multiple species and ecological processes. This will also improve traveler safety. Wildlife monitoring both before and after the installation of these project mitigation measures will ensure that efforts to enhance ecological connectivity achieve their intended goals. To that end, from 2008 to 2012, researchers conducted preconstruction baseline wildlife monitoring within the I-90 Snoqualmie Pass East project area. The resulting report characterizes the rate and location of wildlife-vehicle collisions, assesses the extent of sub-grade and at-grade crossings by wildlife, and assesses species occurrence within the project area. Monitoring will continue so that mitigation measures can be identified.

Principal Investigators: Long, R./Begley, J./MacKay, P., Western Transportation Institute
Research Manager: Brooks, R., WSDOT
Technical Monitor: Broadhead, C., WSDOT
Sponsor: WSDOT
WA-RD 803.1

Active Projects

Below Pavement Stormwater Storage: Literature Review and Synthesis

As a result of an August 2008 Pollution Control Hearings Board ruling, the Washington State Department of Ecology developed new stormwater management performance standards on which to base the application of low impact development techniques and principles to new development and redevelopment projects in western Washington. A result of those standards is that most of the stormwater runoff from impervious surfaces will have to be retained and either infiltrated or released very slowly over a long period of time. This will require more storage areas for the stormwater runoff or innovative ways of getting runoff back into the ground, including the possibility of redistributing highway runoff below the pavement. This literature review is assessing findings on pavement impacts from water below the pavement. The results will help in developing design guidance for permeable pavement treatments on or near transportation facilities.

Principal Investigator: Haselbach, L., WSU
Research Manager: Brooks, R., WSDOT
Technical Monitors: Maurer, M./Uhlmeyer, J./Schaffner, L., WSDOT
Sponsor: WSDOT

Media Filter Drain: Modified Design Evaluation and Existing Design Longevity Evaluation

The Highway Runoff Manual states that Media Filter Drain (MFD) material, formerly known as Ecology Embankments, must be removed and replaced on a 10-year cycle, or before that if it stops performing as specified. Unfortunately, the MFD material is expensive to remove, dispose of, and replace.

In addition, there are no agreed upon testing protocols for determining whether the material is still performing as specified. The oldest MFD within the WSDOT system was installed in 1996, and the last time it was tested it was still performing satisfactorily. However, the 10-year requirement remains in the Highway Runoff Manual. To determine whether the 10-year requirement for removal and replacement is needed, this project is testing several MFD installations. Initial results indicate that the service life for MFD may be as long as 25 years, which would allow more cost-effective strategies to be employed for installation upgrades or replacements.

Principal Investigators: Haselbach, L./Poor, C., WSU
Research Manager: Brooks, R., WSDOT
Technical Monitors: Maurer, M./Schaffner, L., WSDOT
Sponsors: WSDOT, PacTrans

Near-Road Air Quality

New federal regulations require state and local agencies to monitor near-roadway emissions and quantitatively assess potential air quality impacts ("hot spots"). State transportation agencies need to understand the implications of the new near-road data that are collected by creating analysis methods and must also develop tools to implement effective mitigation. Many states are unable to internally address all of the new emissions modeling and measurement requirements with existing funding and expertise. Therefore, a collaborative effort was created to pool resources to help meet the new near-road air quality requirements and develop information that can respond to stakeholders' requests for advice and information.

Principal Investigator: Sontec Technologies
Research Manager: Brooks R., WSDOT
Technical Monitor: Sexton T., WSDOT
Sponsors: California, Texas, Virgina, and Washington

Population and Flight Path Studies for Assessing Mitigation Measures to Minimize Impacts on Alkali Bees within US 12 Phase 7

Phase 7 of WSDOT's long-term US 12 project will widen the highway from Nine Mile Hill through the Tochet-Lowden agricultural district in Washington. Farmers in that area use native alkali bees to help produce alfalfa seed. Alkali bees need established bee beds of two to ten acres and a surface crust of salt or alkali to preserve moisture in the below-ground nests. These bees are subject to habitat loss, as cultivation, grazing, or even disturbance by off-road vehicles can damage bee beds. For this project, researchers are surveying the bee population density in beds that might be affected by the highway widening. Bee populations are protected by the national 2008 Farm Bill, and the data collected from this effort will be used to develop project designs that will decrease the impacts of highway construction on farmers and the bee populations.

Principal Investigator: Walsh, D., WSU
Research Manager: Brooks, R., WSDOT
Technical Monitor: Broadhead, C., WSDOT
Sponsor: WSDOT

Reduction of Underwater Sound Levels from Pile Driving Operations

The underwater sound generated from impact and vibratory hammer operations necessary for constructing terminals, docks, and other structures in marine waters may adversely affect fish, birds, and mammals that are protected by federal law. Researchers have collected data from terminal construction projects on Vashon Island and Port Townsend to develop models to understand how underwater pile driving generates sound and how sound propagates with range, as well as to find effective mitigation strategies. This has led to the development of a novel pile that produces significantly less noise. Testing of scaled pile prototypes indicated a 25-decibel decrease in noise levels during impact driving. A project to field test full-scale piles is planned for 2014. The data from the test will be used to confirm the effectiveness of the new pile design and to tune the developed sound spread models. More effective noise attenuation will protect important marine species while also allowing efficient construction operations in marine waters.

Principal Investigators: Reinhall, P./Dahl, P.H., UW
Research Manager: Brooks, R., WSDOT
Technical Monitors: Carey, M./Laughlin J./Huey R., WSDOT
Sponsor: WSDOT
WA-RD 781.1

Solar Effects on Navigation Systems

Concerns about whether predicted solar storms would affect the navigation capabilities of Washington State Ferries prompted this research to compare results from the Satellite Compass Heading device with the baseline performance of the Gyrocompass Heading device, an accepted and reliable alternative system currently used for Washington State Ferries navigation. The data collected from monitoring the two systems have not shown significant errors in navigation. Washington State Ferries will present this information to the U.S. Coast Guard in order to gain approve to use the Gyrocompass Heading devices.

Principal Investigator: Groth, K., Groth Systems
Research Manager: Brooks, R., WSDOT
Technical Monitors: Hamilton, B.,/Johnson, M., WSDOT
Sponsor: WSDOT

Photo provided by WSDOT

Construction crews test a "bubble curtain" as a steel pile is driven into the Columbia River bottom. More effective underwater sound attenuation from impact and vibratory hammer operations will protect important species while also allowing efficient construction operations.

Stormwater Model Comparison

WSDOT developed and uses the HI-RUN model to determine whether highway stormwater runoff will have a detrimental effect on aquatic organisms, mainly fish. Use of this model includes some updating and training costs that must be borne by WSDOT. FHWA and the U.S. Geological Survey have developed a similar model, called the Stochastic Empirical Dilution Model to test some of the same parameters, mainly dissolved metals in stormwater. This research is comparing the two models to determine which is more practical for WSDOT to use in analyzing stormwater effects on species.

Principal Investigator: Pomeroy, C., University of Utah
Research Manager: Brooks, R., WSDOT
Technical Monitors: Nguyen, A./Maurer, M./Carey, M., WSDOT
Sponsor: WSDOT

The free flow of people and goods is vital to Washington and the families that live here. That's why traffic congestion is one of the state's top transportation priorities.

Washington works in progressive ways to manage highway congestion with tools such as high-occupancy vehicle (HOV) lanes, metered on-ramps, variable-direction express lanes, traffic cameras, variable message signs, traffic monitoring centers, incident response teams, advanced traffic management systems and signal optimization. And the search for innovative methods will not stop. By studying the most cutting-edge and successful traffic management advances in the world, Washington will continue developing smarter highway systems. With an eye toward the future, the state is exploring new congestion-reducing innovations that are making our highways more efficient, less congested, and safer for all. Research in the state is developing measurements and benchmarks to present a clear, more accurate picture of congestion on the state's most affected freeways. The research is focusing on developing ways of measuring efficiency and reliability and on producing improvements that people can see and experience

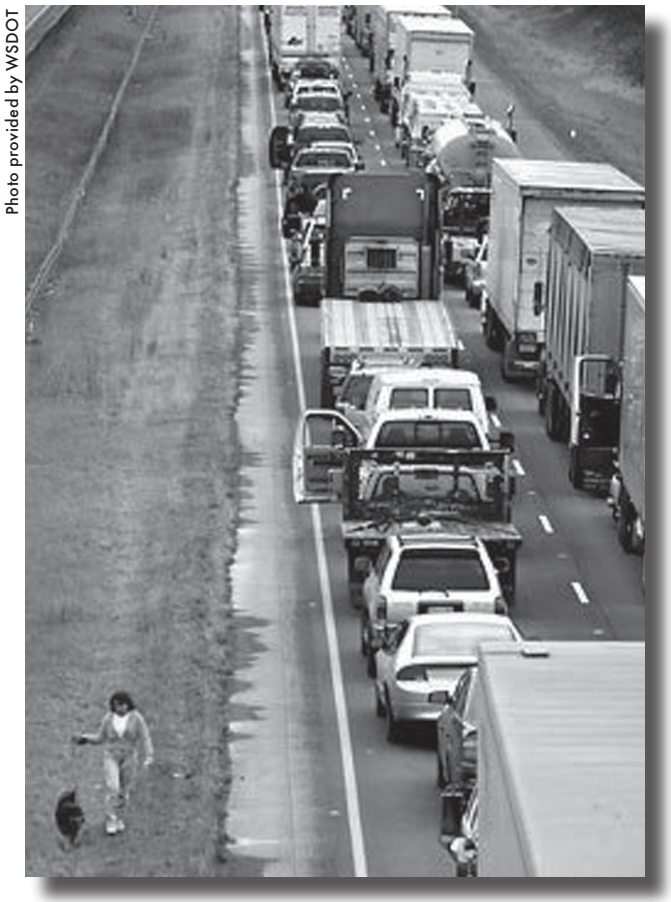
Completed Projects

Clean-Up of Existing Data Sets to Support Dynamic Mobility Application Development

Researchers supplied multi-modal corridor traffic performance data to FHWA covering the I-5 freeway corridor from the King/Pierce county line to approximately the city of Everett. The data set comprised freeway data that included volumes, speeds, and lane occupancy values from inductance loops, travel times, incident and incident response information, and dynamic message sign display data; arterial data from the city of Seattle including arterial volumes and travel times; transit availability and performance data; and weather data. The purpose of the data submittal was to help populate FHWA's Research Data Exchange (https://www.its-rde.net), a freely available data set meant to help researchers gain access to data, which allows faster, lower cost analysis of new dynamic mobility applications.

Principal Investigators: Hallenbeck, M.E./Wang, Y., UW
Technical Monitor: Butler, R., FHWA
Sponsor: Federal Highway Administration

Photo provided by WSDOT



Congestion Analysis and WSDOT Support

To continue efforts to manage the central Puget Sound region's transportation network and enhance traveler mobility, WSDOT has need for timely, detailed technical information on traffic conditions, historical trends, and emerging transportation issues associated with the area's roadways. Since 1995, TRAC has developed data collection tools and analyses to provide this information for Seattle area freeways. This project continued to provide technical support for WSDOT's operational, planning, and policy freeway activities in the form of ongoing freeway performance monitoring analyses, specific focused technical analyses, and software development. This included conducting analyses for updated editions of the WSDOT Gray Notebook (http://www.wsdot.wa.gov/accountability/congestion/). The resulting information helps WSDOT maximize freeway operations, conduct planning studies, and analyze alternative strategies to improve the Puget Sound transportation network.

Principal Investigators: Hallenbeck, M.E./Ishimaru, J.M., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Nisbet, J., WSDOT
Sponsor: WSDOT

Since 1995, TRAC researchers have provided technical support for WSDOT's operational, planning, and policy freeway activities in the form of ongoing freeway performance monitoring analyses, focused technical analyses, and software development.

Congestion Survey

Adding to an already extensive freeway information system, WSDOT recently installed traffic data collection devices on sections of major freeways in the Puget Sound region that had not yet been able to provide traveler information to roadway users. TRAC researchers then investigated motorists' responses to the newly available information. Motorists were surveyed to determine whether they noticed that new information was available on the WSDOT website, 511, or freeway variable message signs; whether the information was useful and accurate; whether they made any changes in route, time of travel, or mode on the basis of the information; and whether they thought WSDOT should continue to collect and disseminate this type of travel information. This gave WSDOT a better understanding of the type of information that motorists desire, how they obtain it, and whether they change their behavior as a result of it. WSDOT is using the results to assess its methods of traveler information delivery and make feasible modifications.

Principal Investigator: Hallenbeck, M.E., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Neeley, M., WSDOT
Sponsor: WSDOT
WA-RD 794.1

Error Assessment for Emerging Traffic Data Collection Devices

The ability to produce reliable and accurate travel time is becoming increasingly important. A number of technologies are available for capturing travel time, volume, and speed information, each with its benefits and drawbacks. Unfortunately, very few studies have evaluated their effectiveness side by side, and therefore, it is often unclear which approach should be used for a particular data collection situation. This project, jointly funded by WSDOT and PacTrans, evaluated multiple travel time, volume, and speed data collection methodologies side by side; determined the relative accuracy, performance, and reliability of the technologies; and developed guidelines for appropriate uses of the data collection technologies.

Principal Investigators: Wang, Y./McCormack, E.D., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Bailey, T., WSDOT
Sponsor: WSDOT, PacTrans

Error Modeling Analysis for Travel Time Data Obtained from Bluetooth MAC Address Matching

Travel time is one of the variables that travelers and transportation agencies most want to track. However, collecting travel time data is challenging because most traffic sensors cannot measure travel time directly. Recently, Bluetooth Media Access Control (MAC) address-based travel time estimation methods have gained attention because they are relatively low cost and are not difficult to install, susceptible to weather, or subject to privacy concerns. For this study, researchers developed a Bluetooth MAC address detection system, extracted travel time data for a highway section by using Bluetooth MAC address matching, evaluated the travel time data errors produced by the Bluetooth-based method, and investigated the error sources. The study produced guidelines for using the developed system for travel time data collection and has given WSDOT an accurate and cost-effective alternative for data collection.

Principal Investigator: Wang, Y., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Bailey, T., WSDOT
Sponsor: WSDOT
WA-RD 782.1

Feasibility of Creating a Vehicle Length Classification Scheme

Vehicle classification data are an important component of travel monitoring programs. Many states collect length-based vehicle classification data, but few states use the same criteria for classifying length. Agencies need to understand the variability among their data collection programs to better use their limited resources in collecting vehicle classification data. The final product of this pooled fund study is a nationally approved, length–based classification scheme and established calibration standards for vehicle length-based measurements. About ten years ago, WSDOT created a vehicle classification scheme based on vehicle length. That scheme places vehicles into 13 distinct categories. As part of this study, WSDOT worked to verify that the traffic data it has collected and reported to date are approximately equivalent to those of the final nationally approved classification scheme. State departments of transportation will use the results of this study to update computer chips in traffic counters to increase their consistency and accuracy.

Principal Investigator: SRF Consulting Group Inc.
Research Manager: Lindquist, K., WSDOT
Technical Monitor: Lakey, K., WSDOT
Sponsors: Minnesota (Lead), Alaska, Connecticut, Florida, Idaho, Illinois, Michigan, New York, Ohio, Pennsylvania, Texas, Washington, and Wyoming

HOV Lane Evaluation and Monitoring Phase XI

Surveys have shown considerable support for the construction of high occupancy vehicle (HOV) lanes in the Puget Sound region. In this ongoing study researchers conducted a multifaceted evaluation of the effectiveness of HOV lanes. The evalu-

ation included yearly analyses of data collected to describe the number of people and vehicles that use the HOV lanes, the reliability of the HOV lanes, travel time savings in comparison to general purpose lanes, violation rates, and public perceptions. These statistics are available at http://www.wsdot.wa.gov/accountability/graynotebook/SI_congestion.htm.
The resulting information is intended to help transportation decision makers and planners evaluate the impact and adequacy of the existing Puget Sound HOV lane system and plan for other HOV facilities.

Principal Investigators: Hallenbeck, M.E./Ishimaru, J.M., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Nisbet, J., WSDOT
Sponsor: WSDOT

I-90 Corridor Traffic Patterns

In support of the environmental stage of the I-90 Tolling and Corridor Improvements Project, this project studied changes in traffic patterns within the I-90 corridor under various scenarios by using a micro-simulation model. Specific work involved 1) developing, calibrating and validating the base year micro-simulation model for the I-90 corridor and selected local streets nearby; and 2) applying the model to simulate various tolling and managed lane scenarios developed through the environmental process to help assess their impact on I-90 usage and potential traffic diversion.

Principal Investigator: Wang, Y., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Yan, S., WSDOT
Sponsor: WSDOT

Motorized Traffic Data (Short Duration Count) Site Selection Study and Strategic Plan Development

A department of transportation's short duration traffic data collection program is its primary mechanism for collecting data on the use of state roadways. In most states these data must serve a variety of analytical purposes, including computing vehicle-miles traveled, estimating annual average daily traffic, and running statewide pavement performance models. However, the large number of roadway miles and geographic areas, combined with limited data collection budgets, make it difficult for state departments of transportation to collect all of the data that could be used in any given year. Therefore, those agencies need to be strategic in their approach to identifying the number and locations of traffic counts they perform. This project reviewed and recommended changes to the process that the Colorado Department of Transportation's Traffic Analysis Unit uses to most efficiently and effectively organize its short duration traffic count program to meet its data needs.

Principal Investigator: Hallenbeck, M.E., UW
Technical Monitor: Abeyta, S., CDOT
Sponsor: Colorado Department of Transportation

Photo provided by WSDOT

Researchers are studying changes in traffic patterns within the I-90 corridor, including the I-90 floating bridge, under various scenarios.

Prioritization of Future Active Traffic Management Deployment

This project had several objectives. First, test a procedure that uses a combination of existing data, defined performance metrics, nationally accepted algorithms, and new software tools to estimate average mobility conditions, travel reliability (volatility), collisions, and incident occurrence for a given area or project. Second, use that procedure to analyze a freeway corridor in Washington state, and estimate the traffic and safety characteristics of selected segments along that corridor. Third, illustrate how to analyze the effects of potential advanced traffic management projects on traffic flow and safety. This project tested the prototype software and procedures being developed in conjunction with the SHRP2 L08 project. That software, a version of the FREEVAL software, computes performance metrics by using algorithms from the 2010 Highway Capacity Manual and new software tools. The software was tested on I-5 in two locations south of Seattle. The conclusion from those tests was that the model can produce the useful outputs for which it was intended, but it tends to under-estimate travel times and delays experienced on the roadway and likely needs additional calibration.

Principal Investigator: Hallenbeck, M.E., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Legg, B., WSDOT
Sponsor: WSDOT
WA-RD 808.1

Traffic Management Center Data Capture for Performance and Mobility Measures

The Federal Highway Administration is developing a guidebook to provide technical guidance and recommended practices on the concepts, methods, and procedures for collecting and archiving traffic management center operations data to allow those centers to monitor, evaluate, and report on their performance, transportation system mobility, and traffic incident management measures. In this project, UW researchers worked with Booz Allen Hamilton to develop the guidebook and related outreach materials.

Principal Investigator: Hallenbeck, M.E., UW
Technical Monitor: Kandarpa, R., BAH
Sponsor: FHWA, Booz Allen Hamilton

Traffic Monitoring Guide 2010

Since the mid-1980s, the Federal Highway Administration has published several editions of its Traffic Monitoring Guide. In this project, TRAC worked as a subcontractor to Cambridge Systematics, Inc., to produce the next edition of the Guide. TRAC's staff contributed sections dealing with equipment selection, data collection, data processing, and reporting as well as providing technical input and review on all other chapters in the Guide.

Principal Investigator: Hallenbeck, M.E., UW
Technical Monitor: Vandervalk, A.P., Cambridge Systematics
Sponsor: FHWA, Cambridge Systematics

Active Projects

Datamart Migration to Drive Net (Phase 1)

Current tools WSDOT uses for operational analysis are simply outdated. The UW StarLab has produced a prototype, Web-based analytical framework for analyzing freeway operations called Drive Net. This project is developing the Drive Net tool's capabilities to integrate multiple traffic and other data sources and to analyze the resulting data. The results should provide better analytical capacity to support the state's Moving Washington strategies and enhance WSDOT's ability to actively manage the highway system.

Principal Investigator: Wang,Y., UW
Research Manager: Brodin, D., WSDOT
Technical Monitors: Legg, B./Bremmer, D., WSDOT
Sponsor: WSDOT

Effectiveness of Safety and Public Service Messages

The objective of this project is to assess the effectiveness of disseminating safety messages and public service announcements on dynamic messaging signs (DMS). The effectiveness of DMS depends on both the usefulness of the provided information and the motorists' ability to understand and willingness to act on the information. By surveying motorists in four selected urban areas, researchers are investigating public acceptance and recognition of safety messages and announcements transmitted on DMS and the effectiveness of the messages in changing traveler behavior. The results of the study are intended to influence or improve agencies' guidelines, policies, and operations regarding the display of safety information and public service announcements on DMS.

Principal Investigator: Boyle, L., UW
Technical Monitor: Dreisbach, Booz Allen Hamilton
Sponsor: FHWA, Booz Allen Hamilton

NCHRP 20-24A: Measuring Performance among State Transportation Departments: Sharing Good Practices—Congestion

Transportation agencies are increasingly using performance measurement to solve complex management challenges. As applications of performance measurement have increased among state departments of transportation (DOTs), senior

managers and technical staff have increased their interest in learning from the performance of their peer agencies. Comparative performance measurement offers a way to share transportation department performance data and knowledge about best practices among agencies, and in turn to enhance managers' ability to judge their own agencies' effectiveness in program and system management. Identifying "best-in-class" practices and "lessons learned" facilitates managers' efforts to learn from experience. This specific project is investigating the collection, manipulation, and reporting of congestion data on roadways. Working with Cambridge Systematics, UW researchers developed a recommended data submittal and reporting process that can be used for MAP-21 reporting. The project is currently on hold as USDOT receives additional input on MAP-21.

Principal Investigator: Hallenbeck, M.E., UW
Technical Monitor: Margiotta, R., Cambridge Systematics
Sponsor: NCHRP, Cambridge Systematics

Pilot Testing of SHRP2 Reliability Data and Analytical Products

The Strategic Highway Research Program 2 (SHRP2) addresses the challenges of moving people and goods efficiently and safely on our nation's highways. In this project, researchers are assisting WSDOT in pilot testing five products developed within the SHRP2 reliability focus area. Research in the reliability focus area emphasizes improving the reliability of highway travel times by reducing the frequencies and effects of events that cause travel times to fluctuate unpredictably. Five products have been developed under SHRP2 for data collection and travel time reliability measurement, monitoring, enhancement, and impact assessment. In conjunction with the UW, WSDOT has received federal funding to test these products and provide feedback to the SHRP2 program on potential improvements.

Principal Investigator: Wang, Y., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Nisbet, J., WSDOT
Sponsors: WSDOT, FHWA

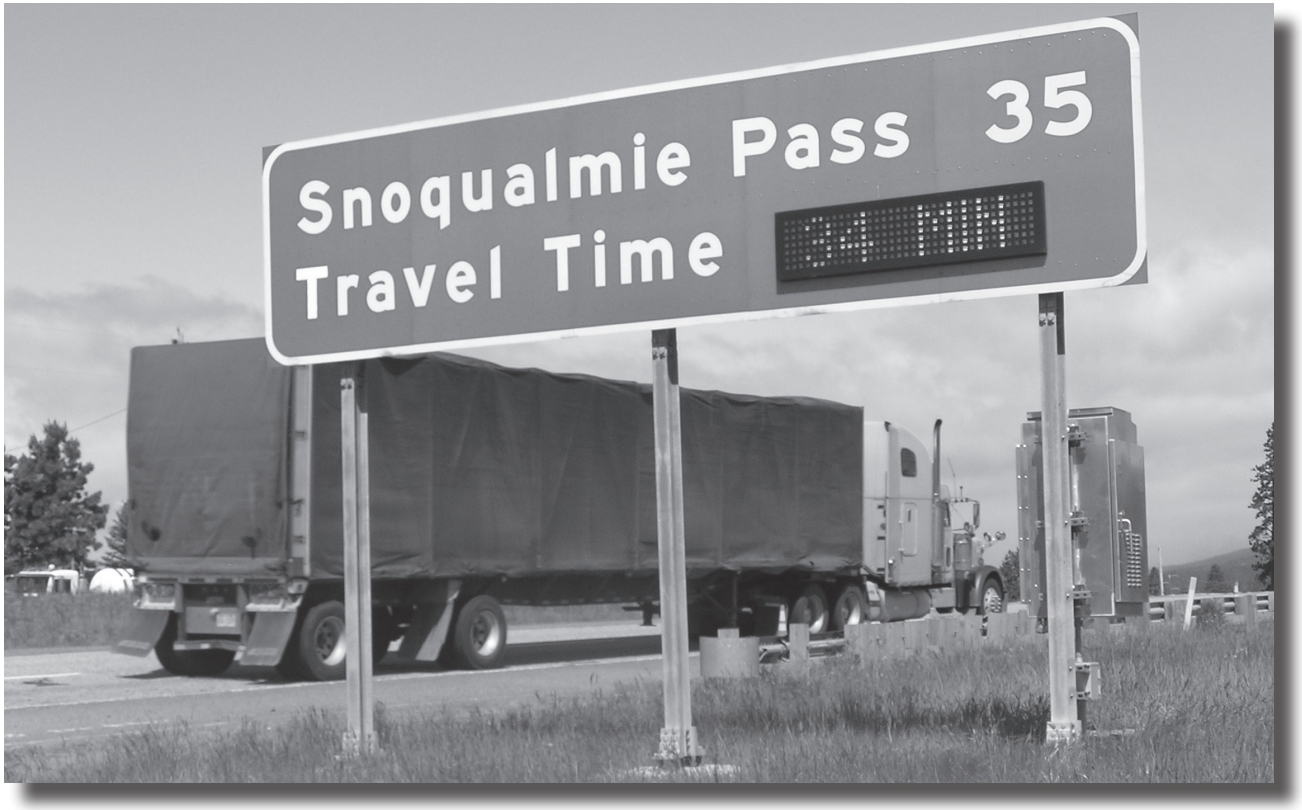


Photo provided by WSDOT

By surveying motorists in four selected urban areas, researchers are investigating public acceptance and recognition of safety messages and announcements transmitted on dynamic messaging signs and the effectiveness of the messages in changing traveler behavior.

The value and volume of goods moving in the Washington state freight system are large and growing. Thirty-seven million dollars of freight moves on Washington state roadways every hour of every day. In 2010, Washington's freight transportation network supported 1.46 million jobs in freight-dependent industries that produced $129 billion in regional domestic product. And Washington is one of the five most trade dependent states in the nation, with $111.5 billion in exports in 2011.

The state's freight policy goal is to develop and prioritize freight transportation system improvement strategies that support and enhance trade and sustainable economic growth, safety, the environment, and goods delivery needs in Washington.

Current areas of freight research include contributing to the development of the state Freight Mobility Plan required by state and federal law. WSDOT plans to release the draft Freight Mobility Plan for public comment in January 2014.

Completed Projects

Defining the Washington State Truck-Intermodal Network

To support WSDOT in developing the Washington State Freight Mobility Plan, this project developed recommendations for criteria for WSDOT to use in defining the Washington state truck intermodal network. The state did not have an existing definition of the freight truck-intermodal system. To establish the criteria, this project reviewed methods used by other states and identified the facilities in Washington specified by the National Highway System. The researchers then compared the facilities to those identified by regional planning organizations and made recommendations.

Principal Investigator: Goodchild, A., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Ivanov, B., WSDOT
Sponsor: WSDOT
WA-RD 783.1

Development of a Truck Freight Benefit/Cost Methodology for Project Planning

To prioritize public investments in freight systems and to ensure consideration of the contribution of freight to overall system performance, states and regions need a better method for analyzing the benefits to freight associated with proposed highway and truck intermodal improvements. This project built on previous and ongoing research to develop an agency-friendly, data-supported framework for prioritizing public investments for freight systems in Washington. The project integrated two ongoing, WSDOT-funded efforts: one to create methods for calculating the value of truck and truck-intermodal infrastructure projects and the other to collect truck probe data from commercial GPS devices to create a statewide Freight Performance Measures (FPMP) program. This integration informed the development of a framework that will allow public agencies to quantify truck freight investment benefits in specific areas, such as major freight corridors and across borders.

Principal Investigators: Goodchild, A./McCormack, E.D., UW; Sage, J., WSU
Research Manager: Brodin, D., WSDOT
Technical Monitor: Ivanov, B., WSDOT
Sponsors: WSDOT, PacTrans
WA-RD 815.1

GPS Data from Trucks—Freight Performance Measures Program

This project was the third and final phase of the Freight Performance Measures Program, whose development was directed by the Washington State Legislature. The Program collects and allows for analysis of GPS truck data from around the state. This phase of the project enabled maintenance, improvements, and updates to a roadway bottleneck identification and ranking process for state freight corridors. This tool will help WSDOT identify locations where highway construction projects may improve traffic flow for trucks.

Principal Investigator: McCormack, E.D., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Ivanov, B., WSDOT
Sponsor: WSDOT

Impact of Smart Growth on Metropolitan Goods Movement

State and regional planning organizations have begun to develop transportation plans that more effectively consider the economic, social, and environmental impacts of freight activities. However, the ways in which freight activities will be affected by smart growth and growth management are still not well understood. To improve that understanding, researchers from the Puget Sound Regional Council and UW identified metrics and performance measures for goods movement and interviewed stakeholders to identify the attributes of smart growth that might affect goods movement. They then developed smart-growth scenarios and input those scenarios into a demand forecasting model for the Puget Sound region. By comparing the scenarios with different baseline and transportation network alternatives, they were able to analyze the relationship between freight and smart growth and evaluate

the ability of the model to capture that relationship. The results will help decision makers more effectively consider both the benefits of costs of land-use decisions that may affect urban goods movement.

Principal Investigators: Bassok, A., PSRC; Goodchild, A./ Carlson, D./McCormack, E.D., UW
Technical Monitor: Rogers, B., NCFRP
Sponsor: National Cooperative Freight Research Program

Improving Statewide Freight Routing Capabilities for Sub-National Commodity Flows

The National Cooperative Freight Research Program is working to increase the availability of freight flow data at the corridor and regional levels. To build upon this national effort, this research project worked in parallel with the national study by developing and testing truck routing rules and logic. This effort gathered information on how truck freight routing decisions are made by cataloguing how routing decisions vary by truck freight service type, commodity shipped, and industry sector served. It included an assessment of how route choices are affected by factors such as urban congestion, travel time and route reliability, highway grade/elevation and curvature characteristics, and business and product-specific supply chain characteristics. WSDOT will use the results to better manage resources for the highest possible return on investment, deliver cost-effective solutions to improve the performance of the freight transportation system, and be environmentally responsible.

Principal Investigators: Jessup, E.L., WSU; Goodchild, A., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Ivanov, B., WSDOT
Sponsors: WSDOT, FHWA
WA-RD 792.1

NCHRP Project 31—Guidebook for Sharing Freight Transportation Data

As a subcontractor to Cambridge Systematics, TRAC researchers assisted in publishing a guidebook designed to facilitate freight data sharing, particularly between public sector agencies and private transportation firms that generate or control freight data. The researchers documented case studies, interviewed individuals involved with successful data sharing efforts, compiled lists of barriers and motivators to sharing freight data, and helped develop a set of guidelines for use by the full range of public and private freight stakeholders.

Principal Investigator: McCormack, E.D., UW
Technical Monitor: Jensen, M., Cambridge Systematics
Sponsor: National Cooperative Highway Research Program, Cambridge Systematics

Yakima Valley Conference of Governments Unified Planning Work Program Freight and Rail Mobility Study

The Yakima Valley Conference of Governments is developing a Freight and Rail Mobility Study. TRAC researchers extracted data from a large statewide database and provided GIS-based truck operations data for Yakima County in support of this study. These data included truck speed and bottleneck information for major transportation facilities in the county. The data will be used to code and refine the Conference's travel demand model that is being updated to incorporate truck freight.

Principal Investigator: McCormack, E.D., UW
Technical Monitor: Shull, R., ERMS
Sponsor: Yakima Valley COG, Eco Resource Management Systems Inc.

Active Projects

Developing a Performance Measurement Approach to Benefit/Cost Freight Project Prioritization

The reauthorization of the federal transportation bill will require a comprehensive and quantitative analysis of the freight benefits of proposed freight system projects. However, to prioritize public investments in freight systems and to ensure consideration of the contribution of freight to overall system performance, states and regions need a better method for analyzing the freight benefits associated with proposed highway and truck intermodal improvements. To address that need, this project is building on previous and ongoing research to develop a data-supported framework to prioritize public investments in freight systems in Washington and Oregon. The project will integrate two ongoing WSDOT funded efforts, one that is creating methods for calculating the value of truck and truck-intermodal infrastructure projects and one that is collecting truck probe data from commercial GPS devices to create a statewide Freight Performance Measures program. This integration will provide a framework tool that allows public agencies in the Pacific Northwest to quantify freight investment benefits in specific areas, such as major freight corridors and across borders.

Principal Investigator: Casavant, K., WSU
Sponsor: PacTrans, WSDOT

Freight Commodity Flows

The goal of this project is to collect data to quantify and characterize the movement of commodities through specified freight corridors. Truck drivers will be surveyed when trucks stop during their trips. The investigators will develop a survey and conduct it in specified corridors four times over the course of

Photo provided by WSDOT

By studying freight project prioritization and commodity flows on corridors, WSDOT can better prioritize infrastructure investments, such as work on the Alaskan Way Viaduct shown here with the Port of Seattle, and improve its ability to determine the impacts of congestion, regulation, and bottlenecks on a transportation system or supply chain.

a year. They will also develop a database that will allow them to analyze and characterize commodity flow for the specified corridors. Determining the commodity flow on corridors aids agencies in correctly prioritizing infrastructure investments and increases their ability to determine the quantitative impacts of congestion, regulation, and bottlenecks on a transportation system or supply chain.

Principal Investigator: Sage, J./Casavant, K., WSU
Research Manager: Brodin, D., WSDOT
Technical Monitor: Knutson, R., WSDOT
Sponsor: WSDOT

Prototype Development and Small-Scale Demonstration for Freight Advanced Traveler Information System—Los Angeles

This USDOT-funded project is researching freight intelligent transportation system solutions in the Los Angeles region, a major freight gateway, to help alleviate congestion, pollution, and delays while promoting improved freight mobility. The purpose of the project is to develop a prototype Freight Advanced Traveler Information System (FRATIS) and then conduct a small-scale demonstration to assess the effectiveness and impacts of implementing a regional FRATIS. As a subcontractor to Cambridge Systematics, TRAC researchers are collecting before and after data from the demonstration and providing assessment support.

Principal Investigator: McCormack, E.D., UW
Technical Monitor: Mark Jensen, Cambridge Systematics
Sponsor: FHWA, Cambridge Systematics

Prototype Development and Small-Scale Demonstration for Freight Advanced Traveler Information System—South Florida

This USDOT-funded project is researching freight intelligent transportation system solutions in the South Florida region, a major freight gateway, to help alleviate congestion, pollution, and delays while promoting improved freight mobility. The purpose of the project is to develop a prototype Freight Advanced Traveler Information System (FRATIS) and then conduct a small-scale demonstration to assess the effectiveness and impacts of implementing a regional FRATIS. As a subcontractor to Cambridge Systematics, TRAC staff are helping to develop emergency preparedness and response activities for the FRATIS, which will consist of a smart phone application designed to collect and disseminate information related to

traffic conditions, road closures, fuel availability, supply locations, and more.

Principal Investigator: McCormack, E.D., UW
Technical Monitor: Jensen, M., Cambridge Systematics
Sponsor: FHWA, Cambridge Systematics

US-395 North Freight Origin-Destination Economic Study

In this project, WSU researchers are working with the WSDOT Eastern Region Planning Office and the new Northeast Washington regional transportation planning office to conduct a freight origin/destination study for US 395 from the Stevens/Spokane county line to the Canadian border. Shippers and haulers operating on US 395 will be contacted and interviewed, and an intercept freight survey will be developed and administered at pre-determined sites and times in coordination with the Washington State Patrol. A database structure will be developed for the collected data. A geographic information system database will be developed to include commodity flows/values, origins/destinations, and freight generators. The information on the destination of the products carried, their origin, and their volume/value will be useful in prioritizing this corridor for future infrastructure investments.

Principal Investigator: Sage, J., WSU
Research Manager: Brodin, D., WSDOT
Technical Monitor: Kay, C., WSDOT
Sponsor: WSDOT

Photo provided by WSDOT

Liquefaction, a direct result of earthquakes, and earthquakes themselves are a major concern in Washington state, which is plagued with many areas that are affected by marginal soils and/or subject to earthquakes. In the past biennium researchers conducted multiple projects involving liquefaction and marginal soils. We are also actively researching ways to improve our designs of walls, bridges, and slopes.

Completed Projects

Design Guidelines for Horizontal Drains Used for Slope Stabilization TPF-5(151)

The objectives of this pooled fund study were to develop a standard protocol for characterizing hydrogeologic sites, to provide design guidelines that utilize both analytic and numerical models to cover a wide range of field conditions, and to develop a manual for the optimal design of a subsurface drainage system. The resulting manual covers the basics of hydrogeologic and geotechnical terminology, site characterization and conceptualization, and groundwater modeling techniques and includes template projects to guide users in identifying important parameters to drainage design. The project also conducted two webinars for geotechnical engineers and hydrogeologists on the use of the design methodologies contained in the report.

Principal Investigators: Pohll, G., Desert Research Institute/ Muhunthan, B., WSU
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Badger, T., WSDOT
Sponsors: Washington, California, Maryland, Mississippi, Montana, New Hampshire, Ohio, Pennsylvania, Texas, and Wyoming
WA-RD 787.1

Active Projects

3-D Numeric Evaluation of Seismic Forces on Bridge Abutments

The response of bridges to seismic shaking is strongly affected by interaction between the soil and structure, soil-pile interaction being the most familiar type of that interaction. Interaction between a bridge abutment and the soil embankment that supports it is also important, particularly for reinforced concrete bridges. Recent studies and field evidence have shown that this form of interaction during earthquakes may significantly alter the bridge response. Of particular interest are the three-dimensional seismic effects of embankments subjected to lateral spreading and flow failures. If these are not accounted for in design and assessment, the result may be unrealistic force estimations and excessively strong and expensive bridge structure design. To aid in design and assessment, this research is developing and validating a methodology for estimating earthquake-induced lateral spreading forces in embankments that takes into consideration three-dimensional effects.

Principal Investigator: Arduino, P., UW
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Allen, T., WSDOT
Sponsor: WSDOT

Full-Scale Shake Table Testing to Evaluate the Seismic Performance of Reinforced Soil Walls, TPF-5(276)

Current seismic design procedures available to state transportation departments may be excessively conservative for many wall types, and they also may be missing design considerations that are important for good seismic wall performance. If current design models can be better understood, or better design models can be developed that efficiently reduce conservatism while accurately capturing the seismic design issues that warrant greater attention, the potential to reduce overall wall costs is significant. To increase our understanding, this project is performing numerical studies and investigating the dynamic performance of two full-scale reinforced soil retaining walls constructed with realistic materials and methods. Given that these walls are substantially taller than those of any similar research (by a factor of 2), a key focus is the influence of wall height on overall system response.

Principal Investigator: Fox, P., University of California, San Diego
Research Manager: Willoughby, K., WSDOT
Technical Monitors: Allen, T./Khaleghi, B., WSDOT
Sponsors: California, Idaho, Mississippi, Utah, Washington

Liquefaction-Induced Downdrag on Shafts and Piles

During soil liquefaction caused by an earthquake, sandy soil layers may undergo compression that results in downward movement of the overlying soil layers. For pile foundations, and depending on the site conditions, downdrag settlement can have significant influence on the performance of deep foundations, resulting in settlement of over 3 feet. In fact, liquefaction-induced downdrag and associated settlement of drilled shafts and pile foundations were observed in the 2010, magnitude 8.8 Maule Chilean earthquake. Those observed deep foundation failures and the potential for similar subduction earthquakes in the Cascade region have created a need to examine the downdrag loads on drilled shafts and pile foundations in Washington. This project is developing robust analytical and simplified numerical models to evaluate the effects of liquefaction-induced downdrag on driven piles and drilled

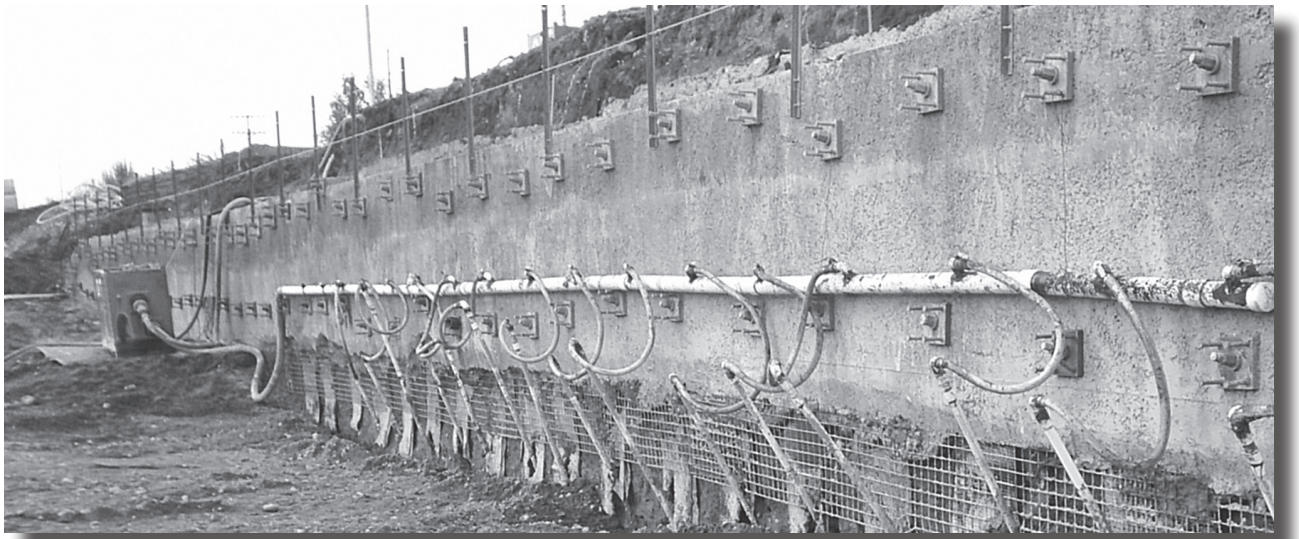


Photo provided by WSDOT

More than one project is investigating methods to better design and build reinforced earth walls that are more seismically responsive and appropriate in a wider variety of soils.

shafts. The results will provide improved understanding of the responses of piles and drilled shafts under different conditions and more reliable information for their design.

Principal Investigator: Muhunthan, B., WSU
Research Manager: Willoughby, K., WSDOT
Technical Monitors: Allen, T./Khaleghi, B., WSDOT
Sponsor: WSDOT

LRFD Procedures for Geotechnical Seismic Design—Phase 1

The design of bridge foundations, approach embankments, and other geotechnical elements of transportation infrastructure must take into account the potential effects of earthquakes in seismically active areas. Unfortunately, although biases and uncertainties in geotechnical seismic analysis and design procedures are known to exist, they are not accounted for in a coherent, consistent manner in practice. As a result, the designs of structures in seismically active areas frequently have different actual probabilities of acceptable performance. This situation results in the inefficient use of available design and construction funds, and of unintentionally different levels of public safety. This research is developing a framework for computing load and resistance factors for the seismic design of geotechnical elements of transportation infrastructure and to implement that framework for pile foundations. The framework will allow engineers to determine load and resistance factors that will produce designs with reliabilities consistent with those achieved by Load and Resistance Factor Design procedures. Such procedures will allow engineers to design structures in all seismic environments with consistent reliability.

Principal Investigators: Kramer, S., UW; Baker, J., Stanford
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Allen, T., WSDOT
Sponsors: WSDOT, California

Strength and Deformation of Mechanically Stabilized Earth Walls at Working Loads, SPR-3(072)

This pooled fund study has developed an improved method, called the K-stiffness method, for designing the internal stability of mechanically stabilized earth (MSE) retaining walls. This method appears to produce designs for MSE walls that are more cost effective than those produced by the AASHTO Simplified Design Method. However, the K-stiffness method has been developed and validated only for high quality, sandy backfill soils. The final two phases of the study extended the applicability of the K-stiffness method to marginal quality backfill materials and full-scale field walls, which were monitored for validation and are in the process of being analyzed. The validation and analyses are critical to incorporating the K-stiffness method into the AASHTO Load and Resistance Factor Design specifications.

Principal Investigator: Bathurst, R., Royal Military College of Canada (RMCC)
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Allen, T., WSDOT
Sponsors: Alaska, Arizona, California, Colorado, Idaho, Minnesota, Missouri, North Dakota, New York, Oregon, Washington, Wisconsin, Wyoming, RMCC

Research into creating built environments—including transportation elements—that better encourage healthy living behaviors is a field that continues to grow. Understanding the environmental factors that affect adults' and children's physical activity, such as land-use design and transportation infrastructure, is increasingly important in creating neighborhoods that better encourage citizens to be more active and healthy. More research is needed to help public leaders in making informed decisions that improve public health through community design, transportation, and land use.

Photo provided by WSDOT

A longitudinal study is assessing the effects of changes in the built environment—in particular, the introduction of light rail transit—on walking and overall physical activity.

Completed Projects

Childhood Obesity Treatment: A Maintenance Approach

The National Institutes of Health sponsored research to explore the characteristics of neighborhood environments in which children live and to analyze the potential influence of those neighborhood built-environment characteristics on children's physical activity and eating habits. This project conducted a multi-site, randomized controlled trial to test different models of weight maintenance within family-based behavioral treatments for overweight children. In this subcontract to the Washington University School of Medicine, St. Louis, UW researchers geocoded children's home locations in King County, Washington, providing environmental variables to characterize the children's neighborhood environments, and advised the Washington University team on the development of environmental data for the St. Louis region. The data helped scientists analyze the neighborhood environments of children in the multi-site project, which may eventually aid planners in constructing built environments that better encourage healthy living behaviors.

Principal Investigators: Wilfley, D.E., Washington University School of Medicine; Vernez Moudon, A., UW
Sponsor: National Institutes of Health

Active Projects

Effect of Light Rail Transit on Physical Activity: a Natural Experiment

Growing interest in the environmental factors that affect adults' physical activity, such as neighborhood design and transportation infrastructure, has been hampered by study designs that limit the ability to draw causal inference. This project is taking advantage of the introduction of light rail transit (LRT) in south King County, Washington, and likely changes in the neighborhood environment around LRT stations to better study the causal effects of the built environment on walking and overall physical activity. The researchers are assessing 700 adults living either close to or far from an LRT station before and after the introduction of LRT service. In this longitudinal study, participants wear accelerometers and GPS devices, and fill in a travel log for a full week at three points in time. Changes in the neighborhood built environment, as well as changes in other transportation modes, are also being evaluated. This study will enable researchers to draw some conclusions about how the built environment affects adults' levels of physical activity, and therefore help planners create neighborhoods that better encourage citizens to be more active and healthy.

Principal Investigators: Saelens, B., Children's Hospital and Regional Medical Center; Vernez Moudon, A./Hallenbeck, M.E./Rutherford, G.S., UW
Sponsor: National Institutes of Health

Food, Environment, Diet Quality, and Disparities in Obesity

This project is developing objective measures of the built environment, diet quality, and health outcomes by surveying 500 King County participants asked to carry global positioning system devices for a week. This study follows a previous grant on the same topic, which surveyed 2000 King County residents on their eating and food shopping habits. By looking at the built environment and its relationships to food shopping, diet quality, obesity, and related physical activity for residents, the project should help public decision-makers in creating healthier environments.

Principal Investigators: Drewnowski, A./Vernez Moudon, A., UW
Sponsor: National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases

Rural Town Walkability: Measuring the Effect of the Built Environment

The prevalence of physical inactivity and obesity is significantly higher among rural residents, persons with low socioeconomic status, and Latinos. Modification of the built environment to increase physical activity, and walking in particular, holds the potential to reduce obesity and chronic illness among residents of rural towns. By studying rural towns from three distinct geographic regions—New England, Texas, and Washington state—with a varying range of socio-economic and ethnic characteristics, this study measured characteristics of the built environmental that correlate with walking among small town residents and evaluated the degree to which those correlations are influenced by household income, educational attainment, and Latino ethnicity. The researchers used accelerometer and global positioning system measures to validate those correlations. By helping researchers to draw some conclusions about how socioeconomic status and Latino ethnicity interact with the built environment to affect the physical activity of rural residents, this project may aid planners in making rural towns healthier environments for their citizens.

Principal Investigator: Vernez Moudon, A., UW
Sponsor: National Institutes of Health, National Heart, Lung and Blood Institute

Twin Study of Environment, Lifestyle Behaviors, and Health

This research is using a twin design and cutting edge measurement tools and spatial data to examine how the built environment is associated with physical activity and eating habits. It is examining how aspects of the built environment affect physical activity and nutrition in association with body mass index.

Principal Investigators: Duncan, G./Vernez Moudon, A., UW
Sponsor: National Institute on Aging

Photo provided by WSDOT

Several projects are investigating how the built environment affects people's physical activity and diet choices.

Research to make Washington's highways safer has produced low-cost strategies that have reduced the overall accident rate by 50 percent in some cases. Rumble strips, cable barriers, emphasis enforcement, and changes in geometric design are all part of the Target Zero strategies that WSDOT is deploying to make travel safer. Research has been the cornerstone of the implemented improvements, which have shown favorable results in reducing the severity of accidents and the number of accident fatalities. Safety is also paramount to Washington State Ferries and the state's railroads, transit, and air travel, and research produces information and ways to improve their operations to protect the traveling public.

Completed Projects

Characterizing the Load Environment of Ferry Landings for Washington State Ferries and the Alaska Marine Highway System

A safety concern for ferry agencies is uncertainty about load demands on ferry landing structures. For Alaska Marine Highway System facilities, loads imposed on dolphin structures and mooring line loads are of most concern. Washington State Ferries also confronts these uncertainties, specifically for the design of wingwall structures that position vessels during passenger and vehicle loading/unloading. While the structures used by the two agencies are different, the metrics needed to determine appropriate design criteria are the same. Therefore, the instrumentation needed to monitor these facilities in operation should also be similar. To learn more about load demands, WSDOT and Alaska leveraged research funding to instrument ferry loading facilities in both states and collect data for analysis. This collaboration resulted in information that both states may use to guide the design of ferry loading facilities.

Principal Investigators: Metzger, A./Kwiatkowski, H. J., Alaska University Transportation Center
Research Manager: Brooks, R., WSDOT
Technical Monitors: Bernstein J./Bertucci, T., WSDOT
Sponsors: WSDOT, Alaska University Transportation Center, Alaska Department of Transportation and Public Facilities
WA-RD 804.1

Collision Analysis Training

WSDOT technical staff attended five workshops to learn the new Safety Analyst program that allows users to identify safety improvements for the highway system. The program uses accident history, geometrics, and predictive models to target limited funding to the locations that can make the most difference. This new tool will be used to schedule projects for future funding and supports delivery of the new Highway Safety Manual.

Principal Investigator: Van Schalkwyk, I., HDR Engineering
Technical Monitor: Sunde, D., WSDOT
Research Manager: Brooks, R., WSDOT
Sponsor: WSDOT

Fatigue and Strength Tests of Heat-Straightened Ferry Loading Bridge Hanger Bars

The bridges used to load vehicles onto Washington State ferries are supported on one end by hanger bars. These bars carry bridge loads in tension but can buckle in compression as the ferry rises with rising tides while at the dock. Washington State Ferries (WSF) engineers heat-straighten the buckled bars and return them to service. However, it has been unclear whether the bars can be heat-straightened three times and safely reused. For this project, researchers tested heat-straightened and/or bent live load hanger bars to determine whether the bars have adequate fatigue life and ultimate strength. The study found that when heat-straightened three times, the hanger bars had a fatigue life that exceeded their design life, indicating that additional heat-straightening may be possible without concern for reducing fatigue life. This information may be used to more confidently maintain the hanger bars used at WSF ferry terminals.

Principal Investigators: Berman, J./Chaijaroen, V., UW
Research Manager: Brooks, R., WSDOT
Technical Monitors: Bernstein, J./Bertucci T., WSDOT
Sponsor: WSDOT
WA- RD 813.1

Greenroads Development and Assessment

Oregon has been among the national leaders in adopting more sustainable practices related to business and development. The Greenroads Rating System (www.greenroads.us), a sustainability rating system for roadway design and construction, is a helpful tool that Oregon Department of Transportation (ODOT) wanted to use in its pursuit of more sustainable practices. However, Greenroads had to work well with existing and proposed ODOT standards and sustainable practices, and means to integrate it into a sustainability program had be explored and evaluated. This project conducted an evaluation at both the programmatic and technical levels, applied Greenroads to three ODOT projects to determine its compatibility and costs, and subsequently worked to implement recommended changes.

Principal Investigator: Muench, S.T., UW
Research Manager: Cornell, L., ODOT
Technical Monitor: Bradway, M., ODOT
Sponsor: Oregon Department of Transportation

In-Service Evaluation of Major Urban Arterials with Landscaped Medians—Phase III

Redevelopment plans in several Washington cities have included landscaped medians with trees placed close to the roadway. Because WSDOT's clear zone width criterion may not always be met when trees are placed within medians, an in-service evaluation process was adopted to study collision, environmental, operational, and maintenance experiences in the field. This Phase III project updated earlier work published in 2007 and 2009. It examined before and after periods for 13 roadway sections that contained trees in medians with no protection as well as control sections. The study found that the presence of small trees in the median did not significantly increase crash rates, crash severity, or injury crash rates. At test sites, crash rates remained stable six years after the treatments had been completed, indicating that the safety benefits first observed continued over time. Therefore, it appears that adding small trees to landscaped medians does not have a detrimental effect on safety. WSDOT will use this information to advise local agencies wishing to landscape medians on arterials that are state highways.

Principal Investigators: Hallenbeck, M.E./Briglia, P., UW
Research Manager: Brooks, R., WSDOT
Technical Monitors: Leth, M./Briggs, B./Olson, D., WSDOT
Sponsor: WSDOT
WA-RD 636.3

Photo provided by WSDOT

A long-term study of landscaped medians found that the presence of small trees in medians did not significantly increase crash rates, crash severity, or injury crash rates and concluded that adding small trees to medians does not negatively affect safety.

LiDAR for Data Efficiency

Vehicle-mounted light detection and ranging (LiDAR) technology captures geospatial data at highway speeds. The data provide users with dimensional information that can be used in surveying, mapping, roadside asset management, as- built documentation, before/after catastrophe analysis, legal defense, and other critical information for planning, project development, operations, and maintenance activities. This tool not only has the capability to improve the efficiency and accuracy of data collection but also to minimize safety risks to highway workers by limiting their exposure to highway traffic. In addition, data are collected only once but may be used by a range of WSDOT engineering and technical staff, thus avoiding duplication. While this pilot study demonstrated the technology's potential benefits in cost savings and efficiencies for WSDOT business processes, it also highlighted the need for documentation of best practices to ensure consistent and accurate results.

Principal Investigator: Lasky, T., University of California, Davis
Research Manager: Brooks, R., WSDOT
Technical Monitors: Finch, M./Beebe, L., WSDOT
Sponsor: WSDOT
WA-RD 778.1

Performance Analysis of Centerline and Shoulder Rumble Strips

WSDOT began installing rumble strips on undivided highways in 1999 as a countermeasure for roadway departure crashes. Installations on the shoulders were intended to reduce run-off-the-road crashes, while centerline rumble strips targeted reductions in cross-centerline crashes. This study examined the combined effects of centerline and shoulder rumble strips and detailed each of their performances in various driving and geometric conditions.

Principal Investigators: Sujka, M./Manchas, B./Olson, D., WSDOT
Research Manager: Brooks, R., WSDOT
Sponsor: WSDOT
WA-RD 799.1

Rumble Strip Noise Evaluation

Rumble strips are an effective way to help keep vehicles on the roadway and reduce the frequency of crashes. Drivers are alerted by the noise and vibration within the vehicle cabin caused by the uneven rumble strip surface. However, while the in-cabin noise and vibration from rumble strips are intentional and needed for safety, the noise can also be heard outside the cabin, where there is no direct safety benefit. The primary objective of this research was to identify centerline rumble strip (CLRS) designs that can maintain the safety benefits of the WSDOT standard rumble strip design while reducing external rumble strip noise disturbances at adjacent properties.

Principal Investigator: Sexton, T., WSDOT
Research Manager: Brooks, R., WSDOT
Technical Monitors: Olson, D./Donahue, J./Berends, T., WSDOT
Sponsor: WSDOT

SHRP2 S07: In-Vehicle Driving Behavior Field Study—Seattle Site Support

The Strategic Highway Research Program 2 S07 project is a data collection effort for the SHRP2 Naturalistic Driving Study. The study is collecting detailed data on the driving behavior of several hundred participants to better understand the effects of a variety of factors on safety, including driving distraction. Working with Battelle Memorial Institute, UW researchers were responsible for the assessment of drivers who volunteered to participate in the study, including driver enrollment and exit debriefing interviews, as well as data collection and data handling support.

Principal Investigators: Boyle, L./Hallenbeck, M.E., UW
Technical Monitor: Brown, J., Battelle
Sponsors: FHWA, Battelle Memorial Institute

Sustainable Roadside Design and Management for Urban Freeways in Western Washington

As a responsible steward of its resources, WSDOT must develop and maintain functional and aesthetically pleasing roadsides with the lowest possible lifecycle costs. This study examined urban roadsides in Western Washington, based on twelve case study sites and extensive discussions with WSDOT maintenance and design staff, to reach conclusions about how best to achieve low life cycle cost roadsides. It identified two major problems common to urban roadsides: the establishment of transient encampments and intense invasive weed pressures. Because urban roadside environments are extremely varied and serve many functions, the researchers did not recommend a single type of roadside planting or maintenance suitable for all situations. Instead, they stressed the importance of maintaining each type of roadside in ways that minimize the life cycle cost of that particular type of plant community. They also recommended integrated vegetation management as a key tool for planning and implementing urban roadside maintenance.

Principal Investigators: Robertson, I.,/Smith, L., UW
Research Manager: Willoughby, K., WSDOT
Technical Monitors: Willard, R./Anderson, S.,WSDOT
Sponsor: WSDOT
WA-RD 774.1

Active Projects

Design Guidance and Long-Term Monitoring of Flow Deflection Structures

WSDOT currently maintains over 1100 miles of roadway that lie within 100 feet of a water body and over 500 miles of roadway within a 100-year floodplain. Washington's streams and rivers are still reaching a quasi-equilibrium state in many locations, meaning they are constantly changing shape and location as they adjust to their surrounding environment. In many locations of the state, roadways were designed without a full understanding or knowledge of river processes. As a result, new guidance is needed that will provide innovative design solutions for the interface between rivers and roadways while protecting the public's interest in a safe roadway and also maintaining our watersheds. To develop design guidance, this project is evaluating the performance of existing structures by using new radio frequency technology to determine their capability to withstand scour from moving water.

Principal Investigator: Papanicolaou, T., University of Iowa
Research Manager: Brooks, R., WSDOT
Technical Monitor: Kramer, C., WSDOT
Sponsor: WSDOT

Educating Teenage Drivers in the Pacific Northwest Regarding the Dangers of Distracted Driving

Driver distraction refers to diversion of driver attention away from the driving task, and it can result from factors both within and outside of the vehicle. It has been categorized as visual, auditory, biomechanical (such as tuning a radio), and cognitive (such as thinking about other things). Many distractions are a combination of these; for example, cell phones are associated with cognitive, auditory, biomechanical, and potentially visual distractions. This study is examining driver distraction specifically among teenagers, including what tasks they consider to be distracting. As part of the project, the researchers will develop and administer an interactive demonstration of distracted driving to 5,000 teenage drivers in the Pacific Northwest. They will then follow-up to assess whether the interactive demonstration improves teenage driver perspectives toward the hazards of distracted driving, and if it proves successful, they will make the interactive demonstration available for dissemination across the Pacific Northwest.

Principal Investigator: Vila, B., WSU
Sponsor: PacTrans

Roadside Safety Pooled Fund Program

Representatives from ten participating states are serving on a technical committee to identify common safety research needs, select projects for funding, and oversee implementation of results. Research activities within the eight-year program include the design, analysis, testing, and evaluation of crashworthy structures, and the development of guidelines for the use, selection, and placement of those structures. Crashworthy structures include bridge rails, guardrails, transitions, median barriers, portable concrete barriers, end treatments, crash cushions, culverts, breakaway support structures, and work zone traffic control devices. Research is also investigating the influence of highway features such as driveways, slopes, ditches, shoulders, medians, and curbs on single vehicle collisions. The problems identified with these structures and features are addressed through in-service performance evaluation studies, computer simulations, full-scale crash testing, clinical analyses of real-world crash data, and cost-benefit analyses. To date, studies have resulted in FHWA letters of acceptance for new or modified devices, and products have been incorporated into new AASHTO standards and agency manuals.

Principal Investigator: Bligh, R., Texas Transportation Institute
Research Manager: Brooks, R., WSDOT
Technical Monitors: Olson, D./Donahue, J./Petterson, J., WSDOT
Sponsors: WSDOT, Alaska, California, Florida, Louisiana, Minnesota, Pennsylvania, Tennessee, Texas, West Virginia
http://www.roadsidepooledfund.org/

Safety Performance Factors for Two-Lane Rural Road Prioritization and Suburban and Urban Arterials

WSDOT and other agencies continue to work toward a goal of zero fatal and serious injury crashes on the nation's highways. To that end, numerous tools are being developed to help agencies better quantitatively assess safety. This quantification is necessary because the public wants to know that each dollar spent on safety provides a return on its investment. Nationally, the most accepted means of safety quantification is through the use of safety performance functions. Significant research has been undertaken nationally to develop these safety performance equations. They can be found in the Highway Safety Manual, Safety Analyst, Crash Modification Clearinghouse, and the Interactive Highway Safety Design Model. Importantly, each of these performance functions must be calibrated to

Photo provided by WSDOT

WSDOT is working toward a goal of zero fatal and serious injury crashes. This sign displays the number of days since the last serious collision on US 2 between Everett and Stevens Pass.

each state's particular characteristics. This research is developing calibration factors for Washington state in the areas of two-lane rural roads and suburban and urban arterials.

Principal Investigator: Shankar, V., Pennsylvania State University
Research Manager: Brooks, R., WSDOT
Technical Monitors: Milton, J./Zeller, S./Neely, M., WSDOT
Sponsor: WSDOT

Sustainability Best Practices for the Federal Lands Highway Program

This project is investigating the sustainable roadway design and construction practices of the Office of Federal Lands Highway (FLH), an organization within the Federal Highway Administration that provides financial and technical assistance for roads that service federal and Indian lands. This investigation is (1) assisting the FHL in identifying and documenting sustainability best practices, (2) developing a short process that the FLH can use to evaluate roadway sustainability rating systems for future use, and (3) creating a Web-based application for conducting pavement life-cycle assessments. Seven case studies utilizing the Greenroads Rating System (www.greenroads.org) are being conducted on FLH projects to help identify sustainability best practices in use and areas for improvement. Findings are showing that, given its relationships with other federal agencies, the FLH is uniquely positioned to implement innovative and cutting-edge sustainability practices. Roadprint, the online life cycle assessment tool for pavements, is available free at http://www.pavementinteractive.org/roadprint.

Principal Investigator: Muench, S.T., UW
Research Manager: Armstrong, A., WFLHD
Sponsor: Western Federal Lands Highway Division

West Coast Green Highway Communication Strategy

The states of Washington, Oregon, and California and the province of British Columbia are collaborating on development of the West Coast Green Highway, an initiative intended to benefit West Coast citizens through sustainability projects. The number of "green highway" projects in British Columbia, Washington, and Oregon is growing, and nearly all of them depend on public/private partnerships among industries, government, nonprofits, and universities. This collaboration presents challenges to providing the consistent communication and traveler information about these projects that are needed throughout the corridor. To address those challenges, this project is developing and implementing communications strategies for the West Coast Green Highway by creating marketing and branding strategies and tools; planning and organizing road rallies and developing accompanying materials such as maps and other displays; and conducting research on outreach and education strategies.

Principal Investigator: Beard, G., Portland State University
Research Manager: Lindquist, K., WSDOT
Technical Monitor: Buell, T., WSDOT
Sponsor: WSDOT

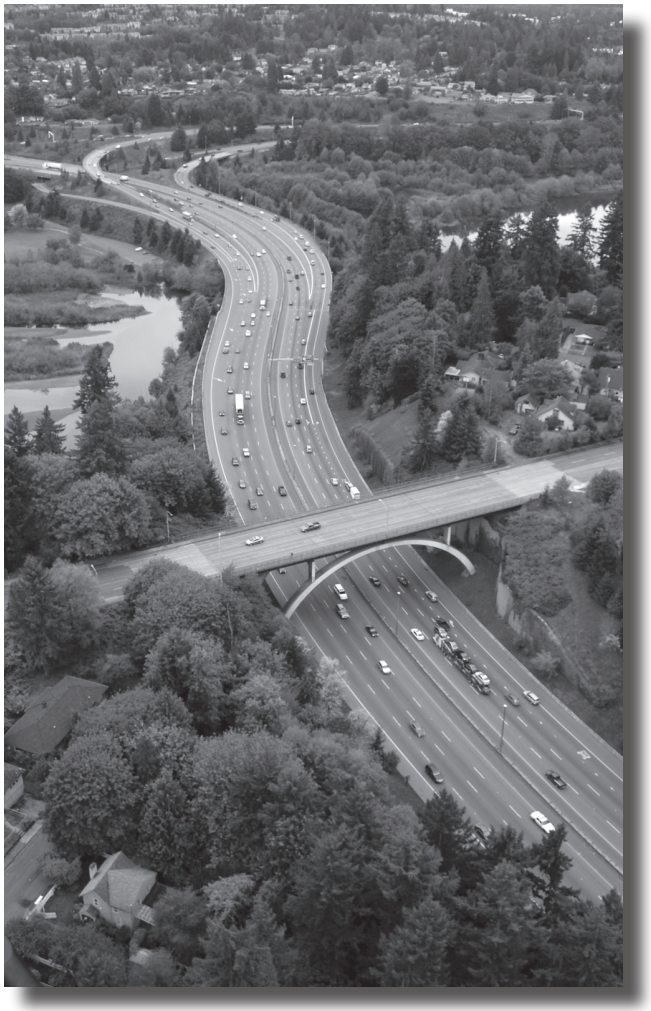


Photo provided by WSDOT

Transportation professionals agree that congestion problems cannot be simply built away; additional, innovative solutions are needed. Intelligent transportation systems, or ITS, provide technologies that enable people to make smarter travel choices.

Intelligent transportation systems encompass a broad range of wireless and traditional communications-based information, control, and electronics technologies. They provide transportation professionals with tools to collect, analyze, and archive data about the performance of the system. Having these data enhances traffic operators' ability to respond to incidents, adverse weather, or other capacity constricting events.

When ITS are integrated into the transportation system infrastructure, and in vehicles themselves, these technologies help monitor and manage traffic flow, reduce congestion, provide alternative routes to travelers, enhance productivity, and save lives, time, and money.

Completed Projects

Enhancements to OneBusAway Transit Traveler Information System

Researchers enhanced a set of traveler information system tools, called OneBusAway, that help transit riders more effectively use the Puget Sound region's transit systems. OneBusAway, launched in summer 2008, integrates real-time information from transit agencies and delivers it via the Web, a variety of smart phone applications, text messages, and automated voice messaging to give riders a clearer picture of the status of their trip (http://onebusaway.org). From its inception, surveys of OneBusAway users showed increased overall satisfaction with public transit, decreased wait times, increased transit trips per week, increased feelings of safety, and even increased distance walked among transit users. In this project, researchers developed a real-time alert system to help transit agencies internally capture real-time changes in service (for example, a temporary bus route change caused by an unexpected road closure) and pass along that information to transit riders in timely and informative ways.

Principal Investigator: Hallenbeck, M.E., UW
Research Manager: Shah, N., The Bullitt Foundation
Sponsor: The Bullitt Foundation

Maintenance of UW Weather Resources for WSDOT

Researchers at the UW have developed innovative, Web-based applications to provide current and forecast weather conditions for cross-state travel on state highways to WSDOT personnel and the traveling public (http://i90.atmos.washington.edu/roadview/i90/). The resulting websites combine complex meteorological and roadway data from a number of sources and present them through user-friendly, intuitive Web interfaces. These websites are extensively used and have received strong positive feedback. This project continued work to make a wide range of weather and roadway information available. This information is helping WSDOT to more cost effectively maintain state highways and aids the public in planning their routes for safer travel.

Principal Investigator: Mass, C., UW
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Wells, J., WSDOT
Sponsor: WSDOT

Active Projects

OneBusAway Maintenance Support and Operations

User and agency satisfaction with the performance of the OneBusAway transit information tool, developed as an open-source system by two UW PhD students, resulted in the decision of three Puget Sound agencies—King County Metro Transit, Pierce Transit, and Sound Transit—to jointly provide temporary support for the continued operation of OneBusAway while a more sustainable business model for the long-term operation of the app was developed. The support includes housing the server, website, and interface at the UW; documenting the application's code and operating procedures; providing data from OneBusAway to the participating agencies and the public; and creating a OneBusAway transit ambassador program for returning feedback on transit and OneBusAway accuracy. After this project, Sound Transit will house and manage OneBusAway.

Principal Investigators: Borning, A./Hallenbeck, M.E., UW
Technical Monitors: Watanabe, W., King County; Messner, K., Pierce County; Meyers, D., Sound Transit
Sponsors: King County Metro Transit, Pierce Transit, Sound Transit

Western States Rural Transportation Consortium

This is a Transportation Pooled Fund project funded by the states of California, Oregon, Nevada, and Washington. The consortium seeks to promote innovative partnerships, technologies and educational opportunities to facilitate and enhance safe, seamless travel throughout the western United States. Additionally, the consortium seeks to provide a collaborative mechanism for leveraging research activities that respond to rural transportation issues related to technology, operations, and safety. The current emphasis of the consortium is the

Photo provided by WSDOT

second phase in a multi-phase effort aimed at developing a one-stop shop for providing rural travelers with comprehensive, real-time data for use in planning their trips. This phase is expanding the prototype information delivery mechanism to all four states.

Principal Investigator: Galarus, D., Montana State University
Research Manager: Brodin, D., WSDOT
Technical Monitor: Vessey, R., WSDOT
Sponsor: WSDOT (lead), California, Nevada, Oregon

Researchers continued to enhance and support OneBusAway for use by King County Metro Transit, Pierce Transit, and Sound Transit. The app relies on real-time transit information to give riders a clearer picture of the status of their trip.

Research is a tool to help public agencies examine their processes for efficiencies, develop new tools of practice, and improve services to their customers.

Active Projects

Transportation Research Management Database, TPF-5(181)

This pooled fund project is allowing participating states to develop a program management database based on the California Filemaker Pro database that is used to manage all aspects of research projects. Specific modifications will allow each state's web-based program to serve its own needs. WSDOT is the lead state for administering the funds and the contract.

Principal Investigator: Cambria
Technical Monitor: Carlile, T., WSDOT
Sponsors: Alaska, California, Indiana, Minnesota, Nebraska, New York, and Washington

Technical Assistance for SDOT Performance Review

In this project, UW researchers provided technical assistance to the City of Seattle in reviewing the operational efficiency of the Seattle Department of Transportation (SDOT). The project has been extended to allow the UW team to assist SDOT deliver traffic, infrastructure, and other transportation-related information to the City Council for purposes of policy and budget decision making.

Principal Investigators: McCormack, E./Whittington, J./ Hallenbeck, M., UW
Technical Monitor: Dunkel, J., City of Seattle
Sponsor: City of Seattle

Photo provided by WSDOT

Sharing and retaining institutional knowledge helps agencies keep costs down and performance up.

With funding for new roadways decreasing, the focus of transportation programs has been shifting from new construction to operations and maintenance. Maintenance is considered key to not only protecting the state's highway investments, but also continuing to provide a safe, efficient transportation system. Maintenance professionals face important challenges in meeting the demands of an aging infrastructure, as well as meeting growing public and legislative demands for accountability and managing the rapid pace of technological change.

Completed Projects

Asset Management Case Study

This project was the first step in a series of potential research projects intended to develop an in-depth understanding of building asset management processes, challenges, and opportunities for WSDOT. This project involved an exploratory case study that focused on the vehicle repair shop in the Northwest Region Maintenance Facility in south Seattle. The shop was built in 1954 and is located within a complex containing 33 separate structures, totaling 114,025 square feet of space, that house staff and equipment for freeway maintenance and operation. The objectives of this exploratory case study were to document the reasons for failure of the building to provide a safe working environment for WSDOT personnel in the vehicle repair shop, identify measures that could have prevented the failure, qualify (and to some extent quantify) the impact of the failure on WSDOT services and core mission, and predict the impacts of potential failures in similar facilities.

Principal Investigators: El-Anwar, O./Migliaccio, G.C./Lin, K., UW
Research Manager: Lindquist, K., WSDOT
Technical Monitor: Nguyen, T., WSDOT
Sponsor: WSDOT

Best Practices and Guidelines for Protecting Transportation Department Equipment from the Corrosive Effect of Chemical Deicers

This project sought to identify, evaluate, and synthesize best practices—such as design improvements, maintenance practices, and the use of coatings and corrosion inhibitors—that can be implemented to minimize the effects of deicer corrosion on winter vehicles and equipment. The research included a survey of representatives from transportation departments and the airline, automobile/trucking, waterborne transportation, defense, and other industries regarding current practices and the state of the art. This was followed by phone interviews of the most promising agencies and a laboratory evaluation of select products and practices. The report includes a cost/benefit analysis of selected practices and products that help departments of transportation more cost effectively maintain their winter roadway equipment.

Principal Investigator: Shi, X., Western Transportation Institute
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Mills, M., WSDOT
Sponsors: WSDOT, Alaska University Transportation Center, Western Transportation Institute
WA-RD 796.1

Active Projects

Pacific Northwest Snowfighters TPF-5(035)

The Pacific Northwest Snowfighters (PNS) is an association of transportation agencies dedicated to ensuring the safety of winter maintenance products through structured testing and evaluation. The group has established procedures for testing deicing and anti-icing chemicals and maintains specifications that these products must meet to be considered for widespread use. PNS has become a nationally recognized leader in standardizing chemical products for snow and ice control, and the specifications developed by PNS help guide transportation agencies around the country in the selection of chemical products for winter maintenance applications. Products selected for inclusion on the PNS Qualified Product List must pass a series of tests for friction, corrosion, and chemical and toxicological properties and must meet environmental and health standards.

Research Manager: Willoughby, K., WSDOT
Technical Monitor: Mills, M., WSDOT
Sponsors: Colorado, Idaho, Montana, Oregon, Washington

Photo provided by WSDOT

WSDOT participates in the Pacific Northwest Snowfighters, an association of transportation agencies dedicated to ensuring the safety of winter maintenance products through testing and evaluation.

For the transportation system to most efficiently and effectively move people and goods, planners must look at the entire transportation network and how it functions. Recent research has focused on quality of life, community livability and cohesion, environmental quality, land use and transportation, and economic, social and cultural values and trends. Collaboration at all levels is ongoing to better coordinate planning for land use, intermodal transportation linkages, electric vehicles and related infrastructure, and the environment.

Completed Projects

Energy and Emissions Reduction Policy Analysis Tool

The objective of this project was to study reductions in energy usage and greenhouse gas emissions attributable to agency policy changes by using the Federal Highway Administration's modeling tool called the Energy and Emissions Reduction Policy Analysis Tool (EERPAT). EERPAT is based on a model originally created by the Oregon State DOT, to which FHWA added further function and a graphics interface. The FHWA is conducting a pilot study program, in which WSDOT is participating, to apply the EERPAT at the state and metropolitan regional levels. The goal is for WSDOT to eventually have a statewide model that will enable it to evaluate various past and future scenarios and policies, such as a gas tax increase, increased share of electric and hybrid vehicles, tolling, and more, in order to understand their state-level impacts on energy and emissions.

Principal Investigator: Chen, C., UW
Research Manager: Lindquist, K., WSDOT
Technical Monitor: Janarthanan, J., WSDOT
Sponsors: WSDOT, FHWA

Evaluation Strategies for Managing Demand and Reducing Vehicle Miles Traveled: Planning Tools and Performance Monitoring Framework Projects

This research was intended to help ensure that state investments designed to reduce vehicle miles traveled (VMT) are working cost effectively and in doing so helped WSDOT meet requirements established by the legislature and the governor to reduce greenhouse gas (GHG) emissions. The first project, "A Framework for Monitoring the Performance of Travel Demand Management and VMT Reduction Activities," developed a tool to determine the effectiveness of investments for demand management and VMT and GHG reduction, as well as a framework for monitoring the effectiveness of strategies used in managing demand. The second, "Sidewalk Data in King County's Urban Growth Boundary," compiled King County sidewalk data into a similar format for use. The third, "Tools for Estimating VMT Reductions from Built Environment Changes," reviewed the built environment characteristics associated with travel and the engineering tools that use these characteristics for estimating travel and related factors such as vehicle emissions and health co-benefits. WSDOT is using all three of these studies in planning, demand management, performance monitoring, and VMT and GHG reduction efforts.

Principal Investigators: Vernez Moudon, A./Hallenbeck, M.E./ Stewart, O., UW
Research Manager: Lindquist, K., WSDOT
Technical Monitors: Leotta, K./Reeves, P./Spilker, E., WSDOT
Sponsor: WSDOT
WA-RD 806.1, 806.2, 806.3

Photo provided by WSDOT

By participating in development of the FHWA's Energy and Emissions Reduction Policy Analysis Tool (EERPAT), WSDOT hopes to gain a statewide model that will enable it to evaluate various past and future scenarios and policies, such as increased share of electric and hybrid vehicles, to understand their statewide impacts on energy and emissions.

Executive Workshops to Support Commercialization of Electric Vehicles and Infrastructure

This Pooled Fund project brought together departments of transportation in two workshops intended to help transportation departments share information and reduce the costs of potentially duplicative efforts as transportation electrification gains momentum around the country. WSDOT collaborated with other states in developing strategies and best practices to support commercialization of electric vehicles and infrastructure and in creating the Electric Vehicle Action Tool. The tool provides state transportation departments with approaches, assessment options, and planning tools for implementing electric vehicle technology. The Electric Vehicle Action Tool will assist other states involved in transportation electrification efforts. WSDOT is using it in ongoing planning and development of its electric vehicle infrastructure program.

Principal Investigators: Zhu, C./Nigro, N., Center for Climate and Energy Solutions
Research Manager: Lindquist, K., WSDOT
Technical Monitor: Doyle, J., WSDOT
Sponsors: Washington (Lead), Arizona, California, Georgia, North Carolina, Ohio, Oregon, Wisconsin
WA-RD 801.1

Identifying and Managing Land Development Risks along State Transportation Corridors

Land development can compromise the performance of the state transportation system. Potential risks from land development include increased traffic volumes; parking, loading, and turning impacts; safety issues; light, glare and other driver distractions; stormwater runoff; increased right-of-way acquisition costs, and incompatible development. With these results may come political pressure to fund extensive retrofits or capacity improvements that impose both short- and long-term social, environmental, and financial costs. This project developed tools to help turn the adverse risks of land development into opportunities to make route improvements. The researchers established a repeatable, data-driven method to identify and prioritize sections of state transportation infrastructure vulnerable to risks from land development. They also created a menu of appropriate collaborative strategies for managing adverse risks. The results of this project will enable state transportation planners to compare, prioritize, and benchmark needs for managing land development risk along state transportation corridors and to apply appropriate mitigating strategies in partnership with local governments.

Principal Investigators: Vernez Moudon, A./Hallenbeck, M.E., UW
Research Manager: Lindquist, K., WSDOT
Technical Monitor: Houser, K., WSDOT
Sponsor: WSDOT
WA-RD 805.1

On-Line Performance Tracking Pilot

The on-line system called Starfish was developed for WSDOT as a pilot tool for centralizing performance data tracking, monitoring, and reporting on progress toward accomplishing strategic goals. As a project management tool, it was designed to eventually track built-in workflow processes, statewide engagement, and individual project accountability. Initially, Starfish was tested by the Public Transportation Division for possible initial development for department-wide use and later tailoring, if useful, by other state agencies.

Principal Investigator: Tarnai, J., WSU
Research Manager: Lindquist, K., WSDOT
Technical Monitor: Hartsell, R., WSDOT
Sponsor: WSDOT

Oregon Road User Charge Pilot Project

The Road User Charge Pilot Project (RUCPP) is intended to test road user mileage reporting technologies and back-office accounting systems to address the challenges of sustainable transportation funding and related transportation issues. It originated in Oregon and was joined by Washington and Nevada in 2012. The RUCPP tested various approaches and technologies for motorists to measure and report mileage as the basis for a per-mile road usage charge. Beginning in November 2012, selected participants signed agreements, selected plans, and adopted in-vehicle devices for measuring their road usage. For three months Washington participants received monthly invoices indicating their road usage and associated charges, less taxes paid on fuel as estimated by the system; however, they did not actually make any payments. The results of this work will be useful to WSDOT as a participant in an Oregon-led western states transportation pooled fund project to continue addressing policy questions, obtaining feedback, and learning more about technology issues and challenges related to road usage charging.

Principal Investigator: D'Artagnan Consulting LLP
Research Manager: Lindquist, K., WSDOT
Technical Monitor: Doyle, J., WSDOT
Sponsor: WSDOT
WA-RD 807.1

Safe Routes to School: Moving Forward: Safe Routes to School Progress in Five States

Driving children to school increases traffic congestion and is linked with higher rates of children's chronic health conditions. WSDOT was the lead agency in a Safe Routes to School (SRTS) Pooled Fund project with Alaska, Florida, Mississippi, Texas, and Wisconsin. The study's objectives were to establish benchmark rates of children walking and biking to school and provide recommendations for further evaluating the effectiveness of SRTS investments. This SRTS study offered preliminary signs that the SRTS program is helping to increase rates of walking and bicycling to school, and that SRTS funds are delivering a return on investment. As the SRTS program continues and more projects end, the research framework established in this study can be used to further explore these findings and refine SRTS programs so they may be even more effective.

Principal Investigators: Vernez Moudon, A./Stewart, O., UW
Research Manager: Lindquist, K., WSDOT
Technical Monitor: Claybrooke, C., WSDOT
Sponsors: Washington (Lead), Alaska, Florida, Missouri, Texas, Wisconsin
WA-RD 743.1, 743.2, 743.3

SHRP2 Pilot Project—Applying the TCAPP Tool to the SR 509 Extension Project

WSDOT participated in a pilot study to test a collaborative decision-making tool called Transportation for Communities—Advancing Projects through Partnerships (TCAPP). TCAPP is a decision support tool that systematically builds collaboration into transportation decision-making by enabling the appropriate people to be at the table at the right time with the best information to make good choices that will withstand scrutiny. Using the tools and techniques provided by the TCAPP Corridor Planning protocol, the WSDOT project team worked with stakeholders to successfully define the scope of Phase 1 of a project to extend State Route 509 south of Seattle. The collaboratively developed scope reduced the initial SR 509 project implementation cost by about $400 million while preserving most of the project benefits.

Principal Investigator: Hallenbeck, M.E., UW
Research Manager: Lindquist, K., WSDOT
Technical Monitor: Yan, S., WSDOT
Sponsors: WSDOT, FHWA

Washington's Complete Streets and Main Street Highways Program: Case Studies and Practice Resource

The concept of Complete Streets means that transportation planners and engineers consistently design and operate the roadway with all users in mind—including bicyclists, public transportation riders, and pedestrians of all ages and abilities. This research provided guidance for street designs that could safely meet the needs of all users while preserving community environment and character. The results were used by WSDOT in preparing a Main Street Highways Report to the state legislature. WSDOT also prepared a Case Study and Practices Resource, identifying and examining the precedents and principles of the Complete Streets program as it applies to the state's main street highways. This resource explains and expands on the Complete Streets Act (ESHB 1071), the goal of which was to establish a complete streets grant program.

Principal Investigator: Nicholls, J., UW
Research Manager: Lindquist, K., WSDOT
Technical Monitor: Reeves, P., WSDOT
Sponsor: WSDOT
WA-RD 780.1

Active Projects

Commute Trip Reduction Survey Processing

State law requires that a commute trip reduction plan include an annual review of employee commuting and that progress toward meeting the single-occupant vehicle reduction goals be reported to the county, city, or town and be consistent with the method established in the commute trip reduction plan. The law also requires that work sites be surveyed to determine whether they are making progress or have met the law's reduction goals. This project is providing an annual review of employee commuting at worksites and is reporting progress toward meeting the single-occupant vehicle reduction goals to the appropriate county, city, or town. This information is critical for evaluating programs and progress toward goals.

Principal Investigator: Smith, D.R., UW
Research Manager: Lindquist, K., WSDOT
Technical Monitor: Nguyen, A., WSDOT
Sponsor: WSDOT

Commute Trip Reduction Toolset

The WSDOT Public Transportation Division collects numerous types of information for required reporting on commute trip reduction activities, and the Social and Economic Sciences Research Center at WSU assists by developing, maintaining, and hosting an online system called the Commute Trip Reduction (CTR) Toolset. The CTR Toolset includes modules for announcements, worksite management, online surveys, an employer program reporting system, and tools for administrators. The CTR Toolset is critical in helping WSDOT easily obtain employer

and employee commute trip information in order to report the results of WSDOT's CTR programs.

Principal Investigator: Allen, T., WSU
Research Manager: Lindquist, K., WSDOT
Technical Monitors: Leotta, K./Nguyen, A., WSDOT
Sponsor: WSDOT

INVEST Sustainability Self-Evaluation Tool

In collaboration with the Federal Highway Administration, WSDOT is implementing FHWA's sustainability self-evaluation tool, called INVEST. This tool will assess and improve sustainability practices at WSDOT, and the project will provide case studies and lessons learned about INVEST to FHWA to be shared nationally. WSDOT will use the INVEST System Planning module to evaluate three recently completed corridor studies in the Puget Sound area and will use the Project Development module to evaluate the SR 520 Bridge Replacement and HOV Program projects. These evaluations will help WSDOT to determine current performance, identify programmatic barriers to sustainability, apply recommendations to one or more current planning processes or projects, and support collaboration with external partners to further sustainability in the transportation system.

Research Manager: Lindquist, K., WSDOT
Technical Monitor: Houser, K., WSDOT
Sponsors: WSDOT, FHWA

Effects of Fuel Prices on Vehicle Miles Traveled, Greenhouse Gas Emissions, and Revenue

Long-range transportation plans require assumptions about future travel demand and future fuel tax revenue. Unfortunately, there is great uncertainty about whether rising oil prices or limited availability will curtail driving, reduce fuel tax revenue, or lead to lower greenhouse gas emissions (GHGs). This research will help WSDOT document the increased supply of natural gas and estimate its future price and availability. It will assess the extent to which natural gas is likely to substitute for petroleum and estimate the potential loss of fuel tax revenue attributable to that substitution as well as changes in GHG emissions in Washington attributable to increased use of natural gas. It will also estimate the extent to which price and performance effects will influence vehicle miles traveled in Washington state. The study results can also be used to refine travel demand and revenue forecasts and to improve estimates of GHG emissions.

Principal Investigators: Heaslip, K./Bosworth, R., Utah Transportation Center
Research Manager: Lindquist, K., WSDOT
Technical Monitor: Prestrud, C., WSDOT
Sponsors: WSDOT, FHWA

Photo provided by WSDOT

Researchers are helping WSDOT estimate potential losses in fuel tax, as well as changes in greenhouse gas emissions, attributable to the substitution of natural gas for petroleum.

An Innovative Survey Design to Understand Sustainable Travel Behaviors

Faced with smaller budgets, metropolitan planning organizations are increasingly unable to continue the current practice of conducting a large travel survey every ten years. Those surveys may also be unable to capture the effects of transportation policies, insufficient in the investigation of travelers' attitudes and perceptions, and inadequate in capturing non-motorized travel and households with low levels of vehicle travel. To address those issues, this study is investigating the use of rolling traveler surveys. The researchers are seeking to understand the limitations and opportunities presented by travel surveys with rolling enrollment as they relate to survey design, implementation, and modeling. They are also assessing the potential of a rolling sample design to address modeling-related questions, particularly the effects of land use and infrastructure-related strategies on VMT reduction.

Principal Investigators: Chen, C./Vernez Moudon, A./Shen, Q., UW
Sponsors: PacTrans, WSDOT

Mileage-Based User Fee Alliance

The mileage-based user fee (MBUF) concept is a user-based taxing system that charges drivers for the miles they drive on the roadway system. This concept requires a taxing authority to collect a tax based upon the number of miles traveled by each vehicle. To implement the concept will require the resolution of many institutional, policy and technical issues. However, Up to now, coordination among states in researching MBUFs has been difficult. In response, the Minnesota Department of Transportation is leading this Pooled Fund project, the Mileage-Based User Fee Alliance. The objective of the MBUF Alliance is to provide a constructive learning environment and a space for collaboration and networking among individuals and groups interested in MBUFs. The MBUF Alliance will also coordinate efforts to build awareness of mileage-based user fee programs in the U.S. and around the world and will promote research to test the feasibility of mileage-based user fee programs.

Research Manager: Lindquist, K., WSDOT
Technical Monitor: Doyle, J., WSDOT
Sponsors: Minnesota (Lead), Washington

On-Line Public Transportation Summary Reporting

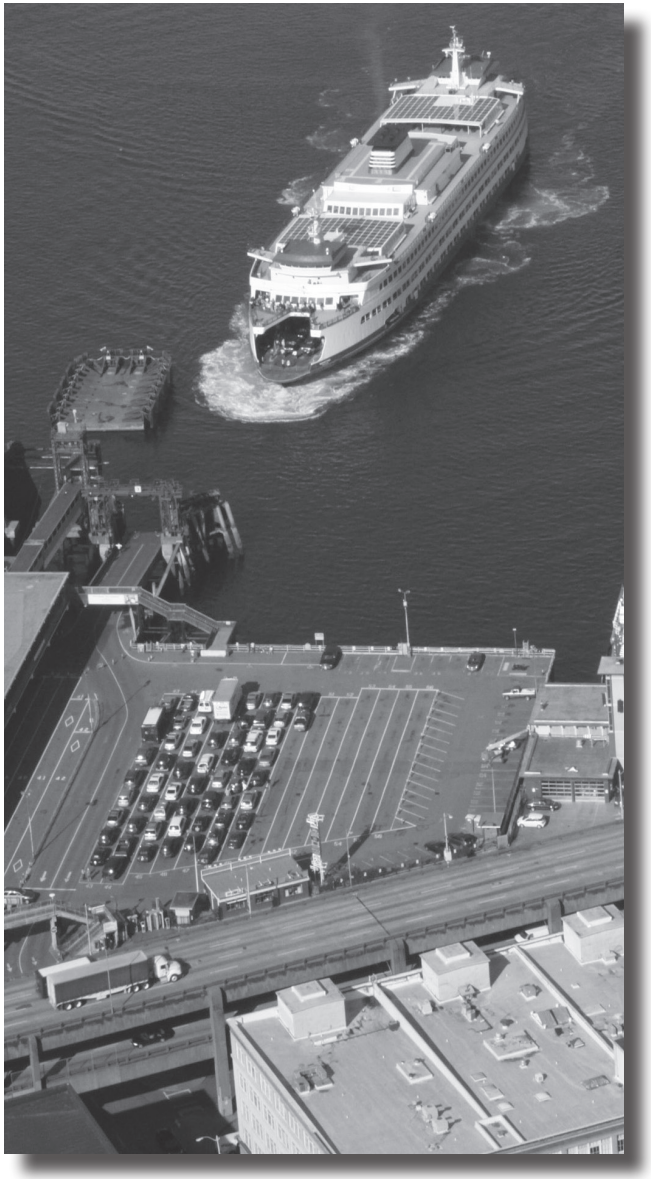
The Public Transportation Reporting System is an on-line system for collecting transit system operational and financial data. This project hosts and maintains the on-line Public Transportation Summary Form, which is used by 31 transit agencies across the state. The Social and Economic Sciences Research Center at WSU developed the Web form to match WSDOT's specifications for data for its annual report to the state legislature

Principal Investigator: Moore, D., WSU
Research Manager: Lindquist, K., WSDOT
Technical Monitor: Gross, R., WSDOT
Sponsor: WSDOT

Sustainable Design Guidelines to Support the Washington State Ferries Terminal Design Manual

Washington State Ferries is developing a new ferry terminal design manual. WSDOT is also currently challenged with two major initiatives related to facilities' energy and water use that could potentially affect terminal design: an executive order from the governor for WSDOT to develop a sustainable transportation plan and increasing use of low impact development

Photo provided by WSDOT



A new ferry terminal design manual will reflect research that results in sustainable design guidelines and recommended methods for low impact development to address stormwater quality and quantity.

technologies to control stormwater. To assist the developers of the terminal design manual in potentially incorporating sustainable design elements, researchers are producing sustainable design guidelines, assessing the needs of WSF staff, investigating ways to address stormwater quality and quantity with low impact development methods, and providing recommendations on the use of composite materials.

Principal Investigators: Wolcott, M./Haselbach, L./Yonge, D., WSU
Research Manager: Willoughby, K., WSDOT
Technical Monitors: Bertucci, T./Helgath, S./McIntosh, N./ Fordour, K., WSDOT
Sponsor: WSDOT
WA-RD 816.1

Western States Road User Charge Consortium

The purpose of the Western States Road User Charge Consortium (WSRUCC) is to conduct collaborative research and explore the development of this potential new transportation funding method, which would collect a road usage charge from drivers based on their actual road usage. The consortium is also seeking to foster competition in providing road usage charge services, allowing for motorist choice; to encourage compatibility with readily available and affordable consumer products and technologies (such as smart phones, in-vehicle navigation systems, and other data-dependent vehicle technologies); and to achieve the primary purpose of collecting taxes to fund roadway maintenance and improvements while allowing for each state's unique needs. The Oregon Department of Transportation will lead the consortium of western state members, which will undertake select topics, research projects, and activities in a variety of areas. The information gained from this study will assist in developing best practice information and guidance for future application of road user charge programs.

Research Manager: Lindquist, K., WSDOT
Technical Monitor: Doyle, J., WSDOT
Sponsors: Oregon (Lead), Nevada, Washington

Photo provided by WSDOT

The goal of pavement research is to produce longer lasting pavements and to manage them effectively.

The current areas of focus have included evaluating new technologies, preserving the infrastructure, and finding new ways to use the materials we have to produce pavements that are as good as or better than those of previous years. The key to almost all the pavement research is preserving and improving our infrastructure. Materials, both naturally occurring and recycled, have been evaluated to determine their use, and we are constantly researching ways to exceed our current design and construction standards. The overriding goal of these research projects has been to produce longer lasting pavements through cost-effective decision-making.

Completed Projects

Concrete Performance Using Low Degradation Aggregate—Phase 2

Marine basalt aggregates are commonly used in Washington state, but their degradation can be pronounced. Although degradation of the aggregate is well understood, less well understood was how using this type of aggregate in concrete would affect the pavement performance. Current specifications restrict the use of low degradation aggregate in hot mix asphalt pavement and sub-base applications as well as in concrete pavements, but it was unclear whether concrete pavements would suffer ill effects from the use of this aggregate. This study tested lower quality aggregates from Washington state to investigate the long-term performance of concrete pavements made with marine basalt aggregates. The tests showed that aggregate degradation has an important effect on the freeze-thaw resistance of the concrete and that lower quality aggregates did adversely affect the concrete properties. Therefore, the researchers recommended that specifications continue to restrict the use of low degradation aggregates.

Principal Investigators: Qiao, P./McLean, D.I., WSU
Research Manager: Willoughby, K., WSDOT
Technical Monitors: Williams, K./Polodna, M., WSDOT
Sponsor: WSDOT
WA-RD 790.1

Development of a Thin Overlay, 4.75-mm Asphalt Mix for Pavement Preservation

WSDOT typically uses 12.5-mm nominal maximum aggregate size thick hot mix asphalt treatments for paving the state's roadways. The focus of this study was to find mixes that would allow WSDOT to use treatments that are thinner but just as cost effective. The researchers evaluated existing mix design criteria from other agencies, developed project selection criteria for thin, 4.75-mm nominal maximum aggregate size overlays as a pavement preservation strategy, determined candidate pavements based on the Washington State Pavement Management System, and recommended potential mix designs and best practices for when and where to use the mixes for thinner overlays.

Principal Investigator: Shen, S., WSU
Research Manager: Willoughby, K., WSDOT
Technical Monitors: Uhlmeyer, J.,/Williams, K., WSDOT
Sponsors: WSDOT, PacTrans

Evaluation of Warm Mix Asphalt in the State of Washington

Warm mix asphalt (WMA) refers to a technology that reduces the mixing and compaction temperatures of asphalt in order to decrease energy consumption and the emission of greenhouse or other gases. WSDOT allows the use of WMA in place of hot mix asphalt and built eight WMA trial projects in 2008 and 2009. Myriad studies have been conducted on WMA nationally, as well in multiple states, but this study focused on Washington WMA projects and their hot mix asphalt counterparts to compare fatigue, rutting, thermal cracking, and moisture susceptibility. Overall, the researchers found that in Washington, WMA is performing just as well as hot mix asphalt.

Principal Investigator: Wen, H., WSU
Research Manager: Willoughby, K., WSDOT
Technical Monitor: DeVol, J., WSDOT
Sponsor: WSDOT
WA-RD 789.1

Pavement Preservation Roadmap

Constraints on state and local agency resources have increased the importance of using best practices and policies to properly manage and maintain roadway assets. Given the importance of pavements to the functioning of the roadway network system, the extensive asset inventories that each public agency must manage, costs of data collection and management, selection of appropriate treatments, and proper application of treatments, it is important to carefully consider how to best allocate scarce resources to ensure proper management of roadway assets. To increase WSDOT's understanding of the status of pavement management in the state, this project sought to identify usage and implementation gaps in local agency asset management practices that were due to decreased resources and to develop guidance for local agencies on best practices and tools to effectively manage their roadway assets. The project also identified knowledge gaps within WSDOT and local agencies regarding pavement preservation and maintenance practices and provided WSDOT with recommendations on

Photo provided by WSDOT

A TRAC study concluded that warm mix asphalt, a technology that reduces mixing and compaction temperatures to decrease energy consumption and the emission of greenhouse gases, performs just as well as hot mix asphalt in Washington.

training and outreach to meet needs for increased pavement preservation and maintenance demands statewide.

Principal Investigator: White, G., Pavia Systems
Research Manager: Willoughby, K., WSDOT
Technical Monitor: McIntyre, R., WSDOT
Sponsor: WSDOT
WA-RD 800.1

Pavement Tools Consortium, TPF-5(090)

The Pavement Tools Consortium fostered the continued development and implementation of computer-based paving tools, most notably the Pavement Interactive but also the Pavement Guide, Media Library, HMAView, Stockpile blender, XPactor, and EverFE. The major focus of the consortium was to enhance pavement-related training and construction operations.

Principal Investigators: White, G., Pavia Systems; Mahoney, J.P., UW
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Willoughby, K., WSDOT
Sponsors: FHWA, California, Florida, Idaho, Illinois, Kansas, Maryland, Minnesota, Texas, Washington
http://www.pavementinteractive.org

Verification, Refinement, and Applicability of the LTPP Classification Scheme

The Long-Term Pavement Performance program recognized problems posed by inconsistencies in the algorithms and data that states use to estimate vehicle volumes by vehicle classification and corresponding axle weights applied by trucks on their roadways in the conduct of pavement performance and design studies. Working with Applied Research Associates (ARA), UW researchers investigated the size and extent of errors attributable to the use of different vehicle classification schemes across the country. They reported on the implications of those errors for estimates of traffic pavement loading and worked with ARA to use those error estimates to understand the resulting errors to pavement life calculations that occur as a result of inaccurate and inconsistent vehicle classification. The project also made recommendations about how to compute and apply default vehicle weight estimates that can be used by multiple states. They also produced software, called PLUG, to assist engineers in correctly applying those nationally developed, weigh-in-motion data defaults for estimating vehicle loads at other state data collection sites.

Principal Investigator: Hallenbeck, M.E., UW
Technical Monitor: Selezneva, O., ARA
Sponsor: FHWA, Applied Research Associates

Active Projects

Determination of Optimum Hot Mix Asphalt Density Based on Pavement Performance

WSDOT spends substantial funds on hot mix asphalt (HMA) pavement, and it is critical that the HMA be of high quality to maximize pavement performance. Both the literature and field experience have shown that lower than desirable densities result in shorter pavement lives. On the other hand, densities higher than necessary waste limited dollars. Therefore, researchers are seeking to determine the optimal density for WSDOT HMA mixtures and ways to best achieve that target. They are evaluating current HMA density criteria by reviewing performance information taken largely from WSDOT's Pavement Management System and the QA Specification/Statistical Analysis of Materials database. On the basis of these evaluations, they will reassess the current statistically based HMA specification and propose appropriate changes to enhance HMA performance.

Principal Investigator: Mahoney, J.P., UW
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Uhlmeyer, J., WSDOT
Sponsor: WSDOT

Determining Changes in Greenhouse Gas Emissions (1990-Present) due to Changes in Pavement Technologies

This project is quantifying the changes in state greenhouse gas (GHG) emissions from 1990 to 2010 that can be attributed to pavement condition, design, management, materials, and construction and is also developing a life cycle assessment tool that WSDOT can use to quantify GHG, energy, and other emissions associated with any past or future pavement construction project. One project finding is that materials practices in 2010 reduced GHG emissions by about 15 percent from 1990 values. Another is that although road roughness can have a substantial influence on GHG emissions, it has been negligible because dwindling funding has only allowed WSDOT to maintain, but not improve, road roughness from 1990-2010. Other influences, such as improved construction equipment, have also been negligible. A better understanding of the influences of pavements on GHG emissions will allow WSDOT to target specific improvements that will have the largest impact on GHG emissions. The life cycle assessment tool is available online for free at http://www.pavementinteractive.org/roadprint.

Principal Investigator: Muench, S.T., UW
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Uhlmeyer, J., WSDOT
Sponsor: WSDOT

Evaluation of Recycled Concrete Aggregate for Use in Portland Cement Concrete Pavements

The goals of this study are to investigate the effects of substituting recycled concrete aggregate (RCA)—aggregate produced from crushed concrete—for virgin aggregate in portland cement concrete pavements and to provide recommendations on using RCA in new concrete. Currently, WSDOT does not allow RCA in concrete cement pavement, but there are compelling reasons for using recycled products in pavements. The researchers are investigating three different sources of RCA and are substituting virgin aggregate with RCA at varying percentages (0, 15, 30 and 45 percent) to determine its effects on concrete properties.

Principal Investigators: McLean, D./Wen, H., WSU
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Williams, K./Uhlmeyer, J., WSDOT
Sponsors: WSDOT, PacTrans

Expected Life of and Best Practices for Pavement Maintenance Treatments

Because paving dollars are scarce, WSDOT is conducting more preventive maintenance; however, data about the different pavement maintenance treatments, how long they last, and their costs are limited. This in-house project is investigating the effects of different pavement maintenance treatments on various levels of pavement conditions to determine the longevity and cost effectiveness of the treatments. This effort, begun in 2012, is selecting pavement sections and applying different preventive maintenance treatments to each. WSDOT is adding sections each year to gather more data.

Principal Investigators: Uhlmeyer, J./Luhr, D./Selstead, G., WSDOT
Research Manager: Willoughby, K., WSDOT
Sponsor: WSDOT

NCHRP 9-49A, Performance of Warm Mix Asphalt Technologies: Stage II—Long-Term Field Performance

Warm mix asphalt (WMA) is a technology that reduces the mixing and compaction temperatures of asphalt to lower energy consumption and the emission of greenhouse and other toxic gases. In comparison to hot mix asphalt, WMA may help achieve higher densities, especially for cold season paving and long-hauling, and contributes to sustainability. However, the field performance of WMA has not been thoroughly studied. The objectives of this project are to identify the material and engineering properties of WMA pavements that are significant determinants of their long-term field performance and to recommend best practices for the use of WMA technologies. The researchers will identify a list of candidate WMA projects and develop and conduct field measurements and laboratory

analyses. Results will include new field measurements and test methods that practitioners can use for the mix design of WMA. In addition, the results will improve the ability of the Mechanistic-Empirical Pavement Design Guide to predict the performance of WMA pavements.

Principal Investigators: Shen, S./Wen, H., WSU
Technical Monitor: Harrigton, E., NCHRP
Sponsor: NCHRP

Optimal Timing of Bituminous Surface Treatments on Hot Mix Asphalt and BST Pavements

With a recent policy change, WSDOT has the ability to resurface all roadways that have an average daily traffic level of 5,000 vehicles or less with bituminous surface treatments (BST) in lieu of hot mix asphalt. Half of the state's 19,000 lane miles carry less than 5,000 average daily traffic and are therefore candidates for BSTs. Given life cycle costs, the costs for BSTs are one-fourth those of hot mix asphalt overlays, making a BST an attractive preservation option. However, not enough is known about the optimal timing of placing a BST onto a hot mix asphalt wearing course to maximize the life of the overlay. The findings of this research will improve the cost effectiveness of BST pavement surfaces, resulting in better pavement performance and more efficient investment of scarce paving dollars.

Principal Investigator: Mahoney, J.P., UW
Research Manager: Willoughby, K., WSDOT
Technical Monitors: Uhlmeyer, J./Luhr, D., WSDOT
Sponsor: WSDOT

Performance Evaluation of Hot Mix Asphalt with Recycled Asphalt Pavement in Idaho

The use of recycled asphalt pavement (RAP) in hot mix asphalt is beneficial to both the environment and economy. Its use allows virgin aggregates and asphalt binders to be reserved, which helps reduce construction costs, energy consumption, and green house gas emissions. Currently, Idaho Transportation Department allows the use of RAP for hot mix asphalt. However, Idaho has no requirements for the long-term performance of hot mix asphalt containing high percentages of RAP binder. In addition, because no performance tests, such as fatigue and thermal cracking, are required during mix design and production, factors other than binder RAP percentage may affect hot mix asphalt performance. Therefore, this study is evaluating the effects of RAP and its components on hot mix asphalt performance. The results of the research will be a set of guidelines that Idaho may consider in updating its current specifications for use of RAP in order to ensure good hot mix asphalt performance.

Principal Investigator: Wen, H., WSU
Technical Monitor: Parrish, N., ITD
Sponsor: Idaho Transportation Department

Photo provided by WSDOT

An ongoing NCHRP study is investigating the material and engineering properties of warm mix asphalt pavement that significantly determine the pavement's long-term field performance.

Review of Non-nuclear Density Gauges as a Possible Replacement for Idaho Transportation Department's Current Nuclear Density Gauges

The density of in-place hot mix asphalt (HMA) and unbound materials may be the most influential factor in the performance of a pavement. However, the common tests for density—taking cores for HMA and using the sand cone method for unbound materials—are destructive, time-consuming, and costly. In addition, their results cannot be obtained quickly enough to help control construction quality. Nuclear density gauges are quick and non-destructive, and Idaho Transportation Department uses them extensively for construction quality control and quality insurance for both unbound materials and HMA. Unfortunately, nuclear gauges have many disadvantages, including inconsistency and utilization of a radioactive source that is heavily regulated and requires extensive training. Therefore, an alternative, non-nuclear density device is warranted. This study is assessing the capabilities, performance, and cost of commercially available non-nuclear density gauges and comparing their results with those of nuclear devices when used to determine the in-place density of unbound materials and HMA. The end result should be recommendations to Idaho regarding the replacement of its current inventory of nuclear density gauges.

Principal Investigator: Wen, H., WSU
Sponsor: Idaho Transportation Department

Photo provided by WSDOT

WSDOT is a member of the State Pavement Technology Consortium and the Tire/Pavement Noise Research Consortium as a way to both share and gain the latest information on designs, methods, and technologies.

Simulation Software for Constructability Analysis, CA4PRS, SPR-3(098)

In rehabilitating freeways with large traffic volumes, agencies want to design and construct pavement sections that will last at least 50 years and will cause minimal traffic delays during future maintenance and rehabilitation activities. However, on heavily trafficked freeways, limitations are often placed on construction closures because of traffic delay concerns. The challenge becomes how to design, analyze, and construct long-lived pavements while minimizing traffic delays. The CA4PRS software has been developed to address this issue. This project is upgrading the software to deal with different roadway scenarios.

Principal Investigators: Lee, E.B., University of California, Berkeley and EBL Consulting Services; White, G., Pavia Systems
Technical Monitor: Uhlmeyer, J., WSDOT
Sponsors: WSDOT, California, Minnesota, Texas

State Pavement Technology Consortium, SPR-3(074)

The State Pavement Technology Consortium (SPTC) now consists of three state departments of transportation—Minnesota, Texas and Washington—and supports collaboration among the states in all aspects of pavement and construction. Various research projects have been performed within the pooled fund, and typically semi-annual or annual meetings are held. The most recent research is developing a mobile field data application.

Principal Investigator: Katara, S., Pavia Systems
Technical Monitor: Willoughby, K., WSDOT
Sponsors: Minnesota, Texas, Washington

Tire/Pavement Noise Research Consortium, TPF-5(135)

This pooled fund program was created to provide a forum for discussions of tire/pavement noise issues and for development of nationally relevant research topics. Multiple ambassador tours of the various partner states have been conducted to collect tire/pavement noise measurements and investigate other research topics. Other research that has been conducted includes development of a National Instruments system for recording and analyzing tire/pavement noise, a calibrator for on-board sound intensity equipment, and a tire loading scale.

Principal Investigators: Donovan,P., Illingworth & Rodkin; Rasmussen, R., Transtec
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Sexton, T., WSDOT
Sponsors: California, Kansas, Minnesota, Montana, North Carolina, Ohio, Texas, Washington, FHWA

Transportation Improvement Board Program Updates

The Transportation Improvement Board, established by the Washington State Legislature, distributes statewide gas tax revenue in the form of grants to cities and counties for funding transportation projects. The 2013 grant cycle will distribute approximately $111 million in funding among 420 competitively selected local projects. For this project, UW researchers and the Greenroads Foundation are assisting the Transportation Improvement Board in updating the scoring system that its Urban Arterial Program uses to select projects for funding and in re-engineering its Small Cities programs. Outcomes will include an assessment of the Program by grant recipients, a new set of sustainability criteria for the Program to use in scoring projects, and overall, more robust, efficient, and sustainable small cities programs.

Principal Investigator: Muench, S.T., UW
Technical Monitor: Gorcester, S., WSTIB
Sponsor: Washington State Transportation Improvement Board

Technology Transfer is a core element of the TRAC mission. Research dollars are wasted if clients are unaware of research results, unable to understand research findings, or unable to implement them. For that reason, TRAC has always emphasized technology transfer as part of its operations.

To enhance access to TRAC research, projects are entered into the national Research in Progress database managed by the Transportation Research Board. Short Research Notes are also produced to briefly describe the project need, findings, and planned implementation of the results. Specific transfer projects over the past two years included developing documentation and training tools for an on-line rideshare program and continuing to support a traffic management center intern program at WSDOT.

Photo provided by WSDOT

Thorough documentation of the RideshareOnline.com platform is helping transportation coordinators to better support their organization's employees or members in using Rideshare Online, a Web-based service designed to make ridesharing easier.

Completed Projects

PacTrans Multi-institutional Education Project

Under this grant from PacTrans, the federally funded Region X university transportation center, researchers helped to build, test, and refine a website for marketing and disseminating the best in transportation engineering educational materials. Year 1 of the project involved investigating how faculty search for and obtain instructional materials for transportation engineering education. On the basis of those findings, the research team designed a repository for an initial set of curricular materials and tested the functionality and usability of the website. The site currently allows users to upload new materials and metadata that describe them and their intended use; easily search for, identify, and download materials; and provide feedback to both the authors and subsequent users. In Year 2, PacTrans will expand the curriculum held by the repository, with emphasis on materials for engineering continuing education. The intent is to continue to expand the repository, thus providing an effective mechanism for distributing materials developed by university transportation centers from around the country, as well as those developed under the auspices of the National Science Foundation, American Society of Civil Engineers, and other organizations that help develop state-of-the-art engineering educational materials but lack effective, national distribution systems for them.

Principal Investigators: Brown, S., WSU; Hallenbeck, M.E., UW
Sponsor: USDOT Research and Innovative Technology Administration (PacTrans)

Rideshare Online Tools

RideshareOnline.com provides tools that help businesses and communities make their trip reduction efforts more effective, efficient, and accountable and help individuals save money, time, and the environment. The tools offer features that make sharing the ride, teleworking, walking, and bicycling easier and more rewarding. The new system is available to commuters, employers, and community organizations throughout Washington, Idaho and Oregon. This project developed user-friendly documentation and online training videos to help current transportation coordinators use the https://rideshareonline.icarpool.com platform more effectively and efficiently and to assist new network administrators in more quickly learning to utilize the technology.

Principal Investigators: Hallenbeck, M.E./O'Brien, A., UW
Research Manager: Lindquist, K., WSDOT
Technical Monitor: Suchan, S., WSDOT
Sponsor: WSDOT

Traffic Management Center Intern Program

This project allowed the UW and WSDOT to cooperatively provide professional experience, training, and research opportunities at WSDOT's Traffic Management Center to students from the UW's Department of Civil and Environmental Engineering. Under the supervision of WSDOT engineers, students learned about and helped to operate ramp meters, closed-circuit television incident identification, variable message signs, highway advisory radio, and traffic condition update reports on regional phone lines. They also helped conduct research and analysis tasks. With this project, the WSDOT gained a reliable way to staff the Traffic Management Center without increasing costs, and UW engineering students were able to acquire valuable experience in a real-world setting.

Principal Investigator: Rutherford, G.S., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Wilson, N., WSDOT
Sponsor: WSDOT

Active Projects

Digital Dissemination Platform of Transportation Education Materials Founded in Adoption Research

National interest in improving engineering education in the U.S. is high. However, while progress has been made to improve courses and curricula, it is greatly hindered by inefficiencies associated with duplicative development efforts. To prevent duplication, more knowledge is needed on how and why faculty and teachers adopt curricula. To gain that knowledge, this project is investigating how faculty adopt curricula when developing a new course or revising an existing course and will use that information to develop an architecture and sustainable plan for a Web-based dissemination venue. In parallel with this work, faculty from the University of Alaska, Fairbanks, are developing and testing courses focused on working professionals.

Principal Investigator: Brown, S., WSU
Sponsor: PacTrans

Transportation Synthesis Reports

Transportation practices are in a constant state of evolution and improvement. To ensure that WSDOT is using best practices and the most cost-effective strategies, the Office of Research and Library Services prepares summaries of currently available information on topics of interest to WSDOT subject matter experts. On-line and print sources, including newspaper and periodical articles, research project reports, and practices of other state transportation departments, countries, and regional organizations, are cited. State of practice information may include quick surveys of all other state transportation departments or phone interviews with selected states. In the 2011-2013 biennium, 16 synthesis reports were prepared. Published summaries can be found at http://wsdot.wa.gov/Research/Synthesis/.

Principal Investigators: Lindquist, K./Wendt, M., WSDOT
Sponsor: WSDOT

This list includes reports produced by TRAC-UW and TRAC-WSU for WSDOT and other research sponsors, as well as reports published by WSDOT that were produced in-house and by other public and private researchers, from July 1, 2011 – June 30, 2013

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Photo provided by WSDOT

University of Washington Faculty

July 1, 2011–June 30, 2013

Architecture

Jim Nicholls, Lecturer

Atmospheric Sciences

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Washington State University Faculty

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Jeremy Sage, Assistant Research Professor

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Social and Economic Sciences Research Center

Thom Allen, Study Director
Danna Moore, Interim Director
John Tarnai, Director

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