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Hearing on Sustainable, Energy Efficient Transportation Infrastructure

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2318 Rayburn House Office Building

Good morning Chairman Wu, Vice Chairman Mitchell, Ranking Member Gingrey and Members of the Subcommittee. I would like to begin by thanking you for this opportunity to share our views and perspectives on our ongoing research and development activities related to reducing lifecycle energy consumption and promoting sustainability for surface transportation infrastructure. On behalf of my colleagues in academia, government and industry, we appreciate this chance to address the technical, regulatory, social and financial challenges to implementing new measures and integrating new technologies into existing transportation networks.

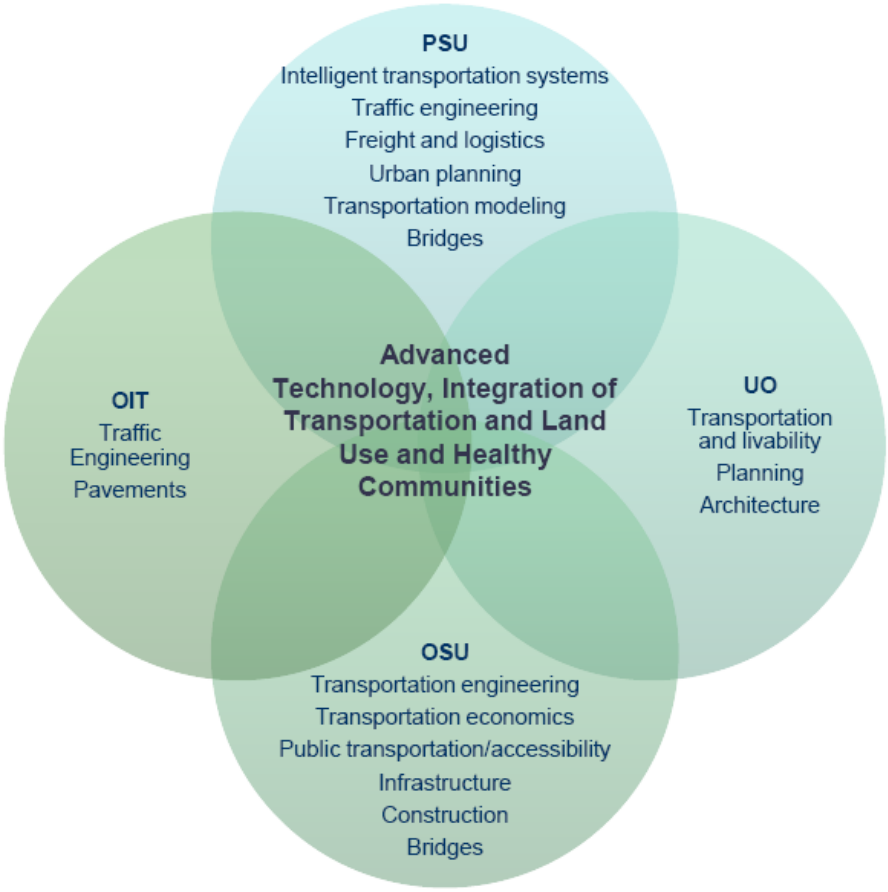
My name is Robert Bertini and I am the Director of the Oregon Transportation Research and Education Consortium (OTREC) and an Associate Professor of Civil and Environmental Engineering and Urban Studies and Planning at Portland State University, in Portland, Oregon.

1. OTREC Background

OTREC is dedicated to stimulating and conducting collaborative multi-disciplinary research on multi-modal surface transportation issues, educating a diverse array of current practitioners and future leaders in the transportation field, and encouraging implementation of relevant research results. OTREC's theme is Advanced Technology, Integration of Land Use and Transportation, and Healthy Communities. OTREC is a National University Transportation Center created by Congress in 2005 and is a partnership between Portland State University, the University of Oregon, Oregon State University, and the Oregon Institute of Technology. With a grant from the U.S. Department of Transportation, OTREC sponsors research, education and technology transfer projects at our partner universities. OTREC programs relate to the OTREC theme and support national transportation initiatives and needs. Through collaboration and partnerships with transportation agencies, industry, and other universities in the Northwest, OTREC aims to address the transportation needs of Oregon, the Northwest, and the nation. The OTREC theme is focused on contributing to USDOT strategic objectives including: safety, mobility, global connectivity, environmental stewardship, security and congestion.

1.1 OTREC Research

OTREC uses a rigorous peer review process to select the best research projects. Since December 2006, OTREC has received nearly 200 proposals and has funded 45 research projects, involving 45 faculty members and 12 laboratories and research groups. All projects include external public and private matching partners with a total of 22 different entities involved; half of the projects include the Oregon Department of Transportation as a partner. OTREC is multidisciplinary, with 12 different academic disciplines currently participating in our projects. The figure below illustrates how the many disciplines at our four campuses are interrelated around our theme:



The peer review process has included 380 unique reviewers for more than 800 reviews. We estimate that approximately 57 graduate students and 24 undergraduate students are working on OTREC-funded projects. In addition we have funded 7 education projects and 6 technology transfer projects. Collaboration is strongly valued by OTREC, our partner universities and our many stakeholders, and has been woven through our activities as an important cornerstone:

- **Historic University Partnership:** The four partner universities— Portland State University, the University of Oregon, Oregon State University, and the Oregon Institute of Technology —signed a historic Memorandum of Understanding in March 2007. Strong communication among all parties is setting a precedent for future joint university efforts.

- **New Collaboration Among Faculty:** Faculty are encouraged throughout the proposal and project process to think of innovative collaborative approaches to research, education or technology transfer. In our first and second rounds of project awards, 13 projects involve faculty at more than one campus, and 28 have multiple investigators.
- **Strong Ties to ODOT and Transportation Community:** More than 20 external partners provide matching funds of cash or in-kind support for faculty-led projects. The Oregon Department of Transportation (ODOT) is a primary partner, jointly funding nearly half of our research projects selected to date.
- **Regional Collaboration:** OTREC is part of the Region X Transportation Consortium, made up of UTCs in Oregon, Washington, Idaho, and Alaska, as well as the four state DOTs, with input and participation by representatives of the USDOT. The Consortium meets twice a year, supports an annual student conference, and is exploring pooled fund research and joint educational initiatives.
- **National Connections:** OTREC strives to meet national transportation research and education needs, and is active with the American Association of State Highway and Transportation Officials (AASHTO), the Transportation Research Board (TRB), the Council of University Transportation Centers (CUTC) and other national activities.

1.2 OTREC Educational Activities

All OTREC activities have student success as a primary goal. Whether it's offering students hands-on research experience with hot topic transportation issues, opportunities to present their research at conferences, including the TRB Annual Meeting, scholarships and fellowships to help them reach their degree goals, or providing continuing education opportunities to practicing professionals, students are central to our mission.

Partner universities currently offer 16 undergraduate and graduate programs with transportation specializations, with more than 100 students enrolled. During this past year 36 students graduated with transportation related graduate degrees and are now working in the transportation field. OTREC also supports transportation student groups at the partner campuses. This support is allowing undergraduate and graduate students to travel to conferences, host guest speakers, coordinate events and field trips, and communicate transportation issues and opportunities to students across the campuses. OTREC also co-hosts an annual Transportation Student Conference with the Region X Transportation Consortium. Students are able to present their research and exchange ideas with their peers in an environment that does not exist in the classroom or at other conferences. The conference includes both student presentations and poster sessions to showcase the great student-led transportation research being done in the Northwest.

1.3 OTREC Technology Transfer

Sharing of knowledge and dissemination of program results are key components of all OTREC programs. All research projects have a technology transfer plan, so that research results are available to potential users in a form that can be directly implemented, utilized, or otherwise applied. OTREC is working towards an expanded and coordinated statewide program of transportation outreach involving accessible communication of research results and continuing education and training courses for transportation professionals in a variety of formats. A study by

OTREC PIs and students is underway to identify the current transportation training opportunities in the region, and to determine how OTREC can best fill training needs for transportation professionals. OTREC is offering a series of short courses and partnering with other transportation organizations to offer more training and professional development opportunities in Oregon.

The OTREC website (www.otrec.us) serves as a primary communication tool, and includes up-to-date news, newsletters, annual reports, recorded seminars, project information, and professional development opportunities. Final research reports with search options will be available. Website capabilities will expand to fill technology transfer needs as OTREC programs evolve. OTREC regularly sponsors guest speakers as part of our Visiting Scholar Program. At PSU, the Center for Transportation Studies (CTS) offers weekly transportation seminars that are broadcast live on the web, and archived in streaming video and podcast. More than 200 seminars have been presented, with more than 145 available as online streaming video, and more than 30 available as Podcasts (.mp3) via iTunes. In addition to registered students, over 500 professionals and guests also attended the seminars. OTREC sponsored several visiting scholars, see: http://www.cts.pdx.edu/seminars.htm.

1.4 Impact of Intelligent Transportation Systems on Sustainability

A broad range of diverse technologies, known collectively as Intelligent Transportation Systems (ITS), holds the answer to many of our society's transportation problems. ITS are comprised of existing and new technologies, including information processing, sensors, communications, control, and electronics. Combining these technologies in innovative ways and integrating them into our multimodal transportation system will save lives, time, and resources—including benefits such as reducing energy, fuel, emissions, accident exposure, noise and more. Delay reductions almost always mean increased productivity and quality of life since people's value of time is significant, and more so for business-related travel where drivers are being paid an hourly wage. Safety improvements also have direct benefits (fewer crashes mean fewer fatalities, injuries, health care costs and property damage) and indirect benefits since many crashes cause congestion.

Transportation is the backbone of our society—the movement of people and goods provides the foundation of our quality of life and economic prosperity. Fulfilling the need for a transportation system that is both economically sound and environmentally efficient requires a new way of looking at—and solving—our transportation problems. The strategy of adding more and more highway capacity neither solves our transportation problems, nor meets the broad national vision of an efficient, integrated transportation system. We focus on the integration and improvement of all modes—highway, transit, bicycle, pedestrian and freight. Traffic crashes and congestion take heavy tolls in lives, lost productivity, and wasted energy. ITS enables people and goods to move more safely and efficiently through a state-of-the-art, intermodal transportation system.

2. Research Related to Energy Efficiency and Sustainability

OTREC is just one component of a larger program in Oregon and in the Oregon University System to address sustainability. For example, the Oregon Legislature has created the Institute

for Natural Resources (INR), the Oregon Climate Change Research Institute (OCCRI), and a signature research center focusing on the Built Environment and Sustainable Technologies (BEST), and is developing a statewide Sustainability Initiative. There is also a proposal for a statewide Oregon Water Institute (OWI) to address water problems.

Given OTREC's theme, a significant proportion of our research is aimed at improving the operation of the multimodal transportation system, which is directly tied to energy efficiency and sustainability. Other research goals include providing improved equity and options for users of the transportation system, which is the basis for a sustainable economy and high quality of life. Fortunately the efficiency objective for transportation research typically includes the reduction in congestion which translates to standard measurements of travel time, delay and number of stops. Whenever congestion is reduced (via reduced travel time or delay), this is a time-based measure typically reported in vehicle-hours or person-hours of travel (VHT or PHT). When the total travel time is reduced, there is always an accompanying benefit in reduced fuel consumption, energy use, emissions, and other externalities such as noise, accident exposure and contribution to urban heat islands.

Other research that includes travel demand management or alternative mode strategies may result in reductions in vehicle-miles or person-miles traveled (VMT or PMT). For example for a given trip, a "green" traveler information system that provides information regarding alternative modes such as bus or rail, might encourage a user to forgo a trip by personal vehicle and choose transit instead. This reduction in VMT will also have a congestion reduction effect, with accompanying benefits such as reduced fuel consumption, energy use, emissions, and other externalities such as noise, accident exposure and contribution to urban heat islands.

Some research related to incident management, for example, has a large multiplier effect—when the duration of an incident is reduced by 50%, the resulting delay is reduced by 75%. It is important in transportation research to find these kinds of opportunity areas where a low investment can have extremely high benefits.

In the context of OTREC's mission as a University Transportation Center, we have identified more than 40 planned and ongoing projects that relate to energy efficiency and sustainability.

2.1 Ongoing and Planned OTREC Research

Consistent with our mission and under the guidance of our strategic plan, approximately two-thirds of OTREC's ongoing and planned research projects address energy efficiency and sustainability. As described below, we have grouped these projects into two categories: Intelligent Transportation Systems and Sustainability; and other Sustainability-Related projects. Keeping in mind that many of these projects are currently in their initial stages, we look forward to reporting specific project outcomes in the coming months and years.

2.1.1 OTREC Intelligent Transportation Systems and Sustainability Research Projects

Approximately one-third of OTREC's ongoing and planned research is related to Intelligent Transportation Systems (ITS) and Sustainability. Most of these project aim to improve the

efficiency of the transportation system in support of national, state, regional and local transportation priorities. By focusing on improving the operation of the system in a more integrated way, without massive capital expenditures, it is possible to improve the efficiency of the transportation network so that all levels of the network and all modes work together in a more seamless way. Projects are described in detail in the following sections. The advantages of ITS and sustainability-related projects include strategies for improving the efficiency of the multimodal transportation system, leading to improved safety and reduced travel time, fuel consumption, energy use, emissions, and other externalities such as noise, accident exposure and contribution to urban heat islands.

Several projects focus on sustainable transportation pricing and tolling strategies, recognizing that new technologies and publically acceptable financing systems are needed for a sustainable future—these could include specific "green" strategies. A number of OTREC projects deal with integrated corridor management strategies, via such strategies from the ITS toolbox such as incident management, ramp metering, measuring and improving arterial performance and improved traffic signal coordination on arterials via adaptive systems. These strategies focus on managing a multimodal corridor more proactively, taking advantage of existing capacity. Recognizing the nation's congestion reduction goals, several projects focus specifically on understanding and mitigating congestion by improving our understanding of stop and go traffic dynamics. Given the critical issue of travel time reliability, an innovative OTREC project will examine issues related to how drivers (and shippers) value travel time reliability. This work will be important for future implementations of advanced traveler information systems.

The issue of traveler information is also important as a sustainable strategy. By providing users with reliable information about travel times via different modes, routes or times of day, users can make better decisions which can result in an overall improvement in efficiency. OTREC has several projects underway in this area. As a fundamental foundation for research and evaluation, a robust, accessible, and interoperable data infrastructure is critical. OTREC has several projects underway that focus on this issue, and strive to use the data infrastructure as a basis for generating performance metrics. It is possible to design programs and projects that by their very nature generate data that can later be used for evaluation, but early attention must be paid to this issue before projects are specified and implemented.

A sustainable transportation system is one that can be resilient in the face of emergencies—thus several OTREC projects focus on understanding the impact of climate change and potential flooding on the transportation infrastructure and on the effects of winter weather. Finally, recognizing the critical role that freight transportation plays in our society, several OTREC projects aim specifically at the freight sector in working to make the transportation system more efficient, to leverage data collected as part of a statewide pre-clearance system, lessen the energy needs for freight transport and to improve reliability.

Sustainable Transportation Pricing and Tolling Strategies

- *2007-03: Socio-economic Effect of Vehicle Mileage Fees, Phase 1 and 2008-81, Phase 2*: This project considers the socio-economic impacts of the new highway user fee structure made possible by advanced technology. The Oregon Road User Fee Task Force has proposed

a vehicle mile tax to replace the gasoline tax. The purpose of this study is to develop a model which provides an analytical framework from which to quantify the impact of changing to the proposed vehicle-mile tax. The Oregon Department of Transportation (ODOT) will use the results from this study to help formulate the specific form of the vehicle-mile tax (flat tax, a graduated tax, a higher tax for less fuel efficient vehicles, a differential tax for urban/rural areas, etc.). ODOT needs quantitative information on the socio-economic impact of such a tax, to use in public relations. A huge factor in determining the ultimate adoption of such a tax structure will be the public acceptance of the change and, in turn, they need to have full information on what it will do. There are also implications for environmental stewardship as a vehicle-mile tax has also been suggested as an emissions tax. Finally, once the technology is in place for a vehicle-mile tax, it becomes possible to implement a vehicle-mile tax that may vary by time of day and location, providing an efficient congestion pricing tool.

- *2008-116: Understanding Driver Behavioral Changes Associated with Road User Fees*: The Oregon Department of Transportation (ODOT) conducted a test of an innovative technology to replace fuel taxes with mileage fees. In the test, some vehicles were charged a flat fee per mile and others were charged differential fees that were higher for travel in the Portland metropolitan area during weekday peak hours and lower for other travel. The objective of this project is to extend the analysis of changes in behavior by subjects in the ODOT Road User Fee Pilot Project, and to draw on other sources, to compare the behavioral changes observed in this experiment with those found in other contexts. There is potential to gain further information on characteristics that caused or prevented changes in participants' driving patterns. A variety of statistical analyses will be conducted to evaluate both the extent of response to a vehicle mileage fee and the interaction with both demographic and attitudinal characteristics of the participants. A GIS analysis will be used to link household location with better measures of transit service. Results would include a better understanding of how pricing interacts with other factors in affecting driving patterns and in particular in affecting driving during peak periods. It would also provide a better understanding of the revenue potential from such charges.

Integrated Corridor Management

- 2007-79: *Identify and Address Institutional Barriers Delaying Incident Clearance*: Effective incident management can substantially reduce congestion while expediting incident clearance. In Oregon, the Oregon Department of Transportation has a comprehensive incident management program in place. Due to cooperative efforts among ODOT, Oregon State Police, local police, and emergency providers most incidents are cleared rapidly and traffic operations resume normally. However, a major traffic-related incident can take considerable time to clear and the closure of a major highway during peak travel periods can cause major problems. The economic impact can be considerable when road closures and delays occur in a metropolitan area such as Portland. It is not known to what extent institutional constraints may account for inefficiencies that result in extended time elapsing from incident detection through final site clearance. The research proposed in this study will address several key objectives. Using a variety of data resources, the research team will examine recent traffic incidents in the Portland area to determine the extent to which the incident and associated traffic obstructions impacted systemic traffic operations. The

research team will also develop an enhanced implementation plan for addressing institutional barriers that may affect the rapid clearance of incidents occurring on Oregon highways. Finally, this research effort will ultimately help identify specific legislative initiatives or administrative procedures that should be implemented to minimize delayed incident clearance and estimate the benefit of the recommended changes.

- 2008-190: *Using Archived ITS Data to Measure the Operational Benefits of a System-wide Adaptive Ramp Metering System*: A system-wide adaptive ramp metering (SWARM) system is being implemented in the Portland metropolitan area. While SWARM is designed to be more effective than the current ramp metering strategy, the true benefits of the new system have not yet been quantified. Using an existing data stream, there is a unique opportunity to conduct a true before and after evaluation of the operational benefits of the new SWARM system. The project will also develop an interactive simulation laboratory for evaluating and improving the new SWARM ramp metering system in the Portland metropolitan area. The simulation-based evaluation will help confirm field experiment results, and complement the field experiment by testing alternative solutions to any operational issues identified during the field experiment. This project will also test different control parameters in the SWARM algorithm, and recommend strategies for improving the algorithm.

- *Monitoring Arterial Performance Using Data From Automatic Vehicle Location Devices and Inductive Loop Detectors*: The Portland region has good sensor coverage on freeways, but the arterial system is limited to snapshots of measurements from traffic studies using floating car studies and temporary traffic counts. There is a need to implement automated systems that can provide arterial travel time and performance measures for management of freight and passenger travel. This project will include a review of technological solutions for automating traffic measurement on arterials. Priority surface arterial locations for measurement will be identified, considering geographical balance and specific bottleneck locations. The task will include a case study of arterial operations on Barbur Blvd in the City of Portland. Working with the City of Portland, we will review options for using existing system detectors and CCTV cameras to gauge arterial performance. The research will validate the delay measurement and recommend locations for such systems on Barbur Blvd. The City will then install 2 or 3 systems on Barbur, which will then be evaluated. The approach delay measurement system offers promise for providing an automated way to determine approach delay at a signalized intersection. This task will further validate that system on other intersection approaches. The results will also provide the City of Portland with methods to provide meaningful performance measures for Barbur Blvd. and beyond.

- *Field-Based Evaluation of Corridor Performance After Deployment of an Adaptive Signal Control System in Gresham, Oregon*: The majority of traffic signal control systems in the United States use, as their basis for coordination, static timing plans (also called timing patterns) that have been generated on the basis of typical average traffic volumes. In 2005, the City of Gresham, Oregon selected and deployed the Sydney Coordinated Adaptive Traffic System (SCATS) on Burnside Road, a major 5-lane arterial carrying 38,000 vehicles per day, between Eastman Parkway and Powell Valley Road. A field evaluation was conducted to compare optimized time-of-day coordination and the SCATS system on the basis of changes in travel time, delay, and stops along this road segment. Probe vehicle data

were collected on three routes during peak and non-peak hours in two travel directions. Side street delay was also studied for three intersections in the corridor. Overall, it can be concluded that the implementation of the SCATS adaptive signal control system has improved the Burnside corridor in terms of travel time, stopped delay and number of stops. Travel times on the primary analysis route decreased 2 to 15 percent for weekdays and weekends with the exception of the morning weekday westbound direction which increased 10 percent (likely because the time-of-day plan had heavily favored this direction). Although the secondary evaluation routes did not see as consistent improvements, the majority of changes were still positive. Analysis of side street delay was less conclusive, although the majority of time periods and directions did see improvement.

Congestion Management

- *2007-37: Characteristics of Transitions in Freeway Traffic*: This project seeks to understand the characteristics of transitions as freeway traffic changes from one state to another. Transitions occur gradually over time and space, and their temporal and spatial features are relatively unknown. The dynamics of the transition zone will be explored by analyzing the relationship between the duration of transition (at a fixed location) and various traffic and location variables (e.g. distance from the bottleneck, change in flow before and after a regime change, etc). Researchers are using data from inductive loop detectors for the analyses of transition zones near the tails of queues. These detector data are suitable for analyzing this type of transition since the propagation of a transition zone can be observed over a long distance. The length of transition can be estimated based on the duration observed at a detector location. For the other two types of transitions, datasets from the Next Generation Simulation will be utilized. These datasets provide individual vehicle trajectories whose resolution is suitable for analyzing these types of transitions. The length of a transition zone will be measured directly from the vehicle trajectories. This research will provide a valuable insight on how congested traffic behaves under various transitions that frequently occur on urban freeways. Hence, the results will expand the current knowledge on traffic congestion and serve as a building block for future traffic modeling and management practice.

- *2008-130: Value of Reliability, Phase 1 and 2009-248: Phase 2:* The issue of travel time reliability is becoming more critical for the movement of people and freight. In order to examine issues related to the value of travel time reliability, we plan to test drivers' preferences for alternate commuter routes in a real world setting. The research participants will drive on three different routes in two cities: (1) primarily freeway, (2) primarily arterial roads, and (3) other streets. Freeways have a possible trade-off between high speeds and congestion during rush hour. Arterials typically have a series of traffic signals that may be timed to favor through-traffic. Other routes might have some traffic signals and some stop signs, but they likely have less traffic. By comparing driver perceptions of the alternate commuter routes, it will be possible to determine the weights associated with the different components of travel time. Driver preferences may also be based on qualitative factors such as the attractiveness of the route. Thus one objective of the proposed project is to measure and then model the route preferences of drivers who have experienced real-world alternatives to their regular commute to and from work. Preference data will be obtained after the participants have completed their morning and evening commutes on three alternate routes

(customized for each driver). The added realism of the novel data collection method proposed for this project should enable the value of travel time reliability to be used in route preference models. In turn it will be possible to more accurately predict traffic patterns and produce solutions more likely to ameliorate traffic congestion. An additional objective of the proposed research is to make information about local road networks more available to drivers. This will allow for the better use of existing resources and road capacity for normal operations including when drivers are commuting to and from work.

- *2008-108: Empirical Observation of the Impact of Traffic Oscillations on Freeway Safety*: Traffic oscillations (also known as stop-and-go driving) are a typical feature of congested traffic flow. They are known to increase fuel consumption and emissions, and decrease driving comfort. It is also speculated that larger amplitudes of oscillations (i.e. larger changes in flow or speed) increase the probability of certain crash types (e.g. rear-end crashes). However, no current study exists that irrefutably confirms or disproves this speculation. The objective of this research is to find empirical evidence to substantiate this hypothesis and to quantify the relationship between the amplitude of oscillations and probability of crash event. This proposed research will be conducted using freeway traffic and incident data. It will be supplemented by a statewide database of reported motor vehicle crashes. Various features of oscillations (e.g. amplitude, period, etc.) will be measured from traffic data collected from inductive loop detectors. Existing databases for crashes and incidents will be used to analyze incidents in correlation with oscillations. This study will consist of general analysis to identify which crash types are particularly affected by traffic oscillations and detailed analysis via econometric modeling to quantify the probability of each crash type as a function of various characteristics of oscillations and relevant factors such as freeway geometry, congestion level, and others. These analyses will be conducted for several freeway locations in order to confirm reproducibility and to examine any site-specific features.

Advanced Transportation Information Systems

- *2007-57: Assessment and Refinement of Real-Time Travel Time Algorithms for Use in Practice, Phase 1 and 2008-145: Phase 2:* The Federal Highway Administration (FHWA) has set a high priority on the use of existing dynamic message signs (DMS) to provide travel time estimates to the public. The Oregon Department of Transportation (ODOT) currently has three DMS in the Portland metropolitan area configured to display travel time information. In the near future, ODOT would like to make travel time estimates available on additional DMS, over the Internet on tripcheck.com and via 511. Travel time estimates are valuable to the traveling public; however, the estimates must be accurate to be useful. The FHWA indicates that 90% accuracy is ideal and suggests a minimum accuracy of 80%. Thus, in order to display travel time estimates, it is essential to understand the accuracy of the estimates. The purpose of this study is to extend prior travel time research conducted at Portland State University with additional data collection and analysis to provide statistical confidence in travel time estimates and to determine the best travel time estimation approach for ODOT. Ground truth data in the form of probe vehicle runs will be collected and travel time estimates will be evaluated using that data. Several travel time estimation algorithms will be evaluated and modifications to existing algorithms will be proposed. In addition, this project will provide analysis to help understand the reliability and performance of the

algorithms under various conditions (free-flow, congestion, incidents). A methodology will be developed for determining if travel time estimates fall within an acceptable accuracy limits. At the conclusion of the project, it is desired that a methodology can be recommended that will provide accurate measures of travel time for use with DMS, the Internet and 511 applications.

- *2007-64: Improving Travel Information Products via Robust Estimation Techniques*: Traffic-monitoring systems, such as those using loop detectors, are prone to coverage gaps, arising from sensor noise, processing errors and transmission problems. Such gaps adversely affect the accuracy of Advanced Traveller Information Systems. This project will explore models based on historical data that can provide estimates to fill such gaps. We build on an initial study using both a linear model and an artificial neural network (ANN) trained on historical data to estimate values for reporting gaps. These initial models were 80% and 89% accurate, respectively, in estimating the correct speed range, and misclassifications were always between adjacent speed ranges (in paricular, the free-flow range and congested range were never confused). Going forward, we will investigate other non-linear models, such as Gaussian Mixtures, that provide further statistical metrics, in contrast to the uninterpreted weights of ANNs. Initially we will build and test estimators in off-line mode. We will select a highway segment (comprising multiple detector stations) that is representative in terms of pattern of outages. We will build models for this segment, then examine their performance on estimates for synthetic gaps (so we can compare estimates to reported values). Later, using live loop-detector data we will work towards on-line estimation over the local freeway network, which requires computing estimates in a timely manner. Our end target is improvements in end-user travel information products, such as the Portland-Metro Speed Map on ODOT's Trip Check. Our main evaluation metric will be the trade-off curve bewteen accuracy of prediciton and percentage of gaps that can be filled.

Multimodal Archived Data User Service

- *2009-269: Exploiting a Next Generation ITS Data Warehouse for Improved System Performance and Congestion Monitoring*: The objective of this project is to build on an existing data archive platform, toward development of next generation performance measurement and congestion reduction tools. This project will also review the current paradigm described by the National ITS Architecture's Archived Data User Service (ADUS) and examine the possibility of developing a new generation ADUS, going beyond the creation of a passive storehouse of data. Given current developments in the transportation operations and management area, this project will pursue several possible ADUS extensions including: live re-serving of data, additional services (e.g., selectable imputation methods), derived sources (e.g., pre-aggregated data), coverage of a wider variety of data sources (including contextual data such as weather and events), and active monitoring of performance metrics against the historical baseline. In order to frame this research, a survey of current and potential users will be administered, seeking input regarding requirements for next-generation transportation information portals on topics including types of products and services, performance requirements (e.g., latency, availability) and desired interfaces (FTP, web services, publish/subscribe). The proposed research will develop a system and software architecture that meets those requirements, and will address such issues as how such a portal

should be structured internally, what storage and processing needs exist, how extensibility and availability can be ensured and how such portals could federate on a regional scale.

- *2008-115: Application of WIM Data for Improved Modeling, Design, and Rating*: The objectives of this research are to: collect, sort, filter, and archive WIM data to permit development of long-term continuous records of high-quality WIM data and; use the WIM data archive to monitor WIM sensor health, develop loads for asphalt design, load models for bridge rating and deck design, and monitor freight movement on the highway system, specifically the volume, weight, safety, and time demands. Researchers will collect WIM data from DOT agencies (ODOT and others nationally). The data will be analyzed and filtered to handle anomalous data and archived in a universally available format for use in subsequent research activities. This collection and archiving of data will allow researchers to continue development of one of the longest continuous and highest-quality WIM data archives available in the country. In developing the archive, the research team will develop data-processing techniques to help identify data and system performance metrics. Results from these studies will be compared with those used in the national specification and improvements will be recommended.

- *2008-176: Expanding Development of the Oregon Traffic Safety Data Archive*: There is a growing recognition in the safety community that decisions are more effective if they are knowledge-based. Traffic records such as driver files, crash data, enforcement, highway traffic and geometric information, court records, and emergency medical records are the typical data needed to make effective safety-related decisions. Often these data are in various formats, maintained by distinct agencies, and require specialized knowledge to use and link together to achieve maximum use of the data. While nearly all traffic safety data in Oregon is available on request from various agencies (Oregon Department of Transportation, Oregon Justice Department, U.S. Department of Transportation, Human Services Department) there is no clearinghouse where other interested researchers, students and professionals can easily access the data in a processed, consistent and useable form. Linking data sources on an ad-hoc basis is time consuming and inefficient. This research proposes to systematically develop a knowledge-based clearinghouse of safety-related data in Oregon. This archive, the Oregon Traffic Safety Data Archive (OrTSDA), will serve as a comprehensive source of safety data. When fully implemented, the archive will provide significant benefits to decision-makers, researchers, practitioners, and interested citizens.

Emergency Transportation Operations

- *2009-257: Future Flooding Impacts on Transportation Infrastructure and Traffic Patterns Resulting from Climate Change*: Climate change is likely to bring more frequent, heavier winter precipitation as temperature rises. Transportation infrastructure and travel patterns are vulnerable to potential changes in runoff regimes and stream geomorphology. The objectives of the project are to investigate the changes in the timing and magnitude of winter runoff under climate change scenarios; determine the lag time of streams to adjust to changes in the discharge regime; and quantify the operational and economic impacts of these changes on transportation chokepoints and damage related to flooding. The following methodology will be used to conduct the proposed work. (1) hydro-climate modeling; (2) stream

geomorphology survey; (3) vulnerability analysis; (4) traffic analysis. The economic impact of the disruptions on workers, freight, and businesses will be estimated. The outcomes of this research will include maps showing potentially vulnerable roads to different magnitudes of flooding, socioeconomic damage of trip disturbance resulting from road closures, and a final report.

- *Dynamic Ice Warning System Evaluation*: ODOT has recently deployed an automatic ice detection and warning system on OR 140 near the Lake of the Woods pass. The ODOT Region 4 Traffic Manager and the District 11 office would benefit from an evaluation to determine the accuracy and effectiveness of the ice detection system. The potential to integrate the existing warning system into the larger regional ITS also needs to be examined. This task will include a quantitative assessment of the fidelity of the current ice detection and warning system. The integration activities will include a literature review, an evaluation of the current hardware and software, field studies to assess accuracy of ice detection, evaluation of the local warning system, evaluation of ITS system integration, particularly with the S. Oregon VMS, and reporting to ODOT. A validated ice warning system will provide ODOT with an assessment of the reliability of the current system in order to potentially deploy additional systems integrated in the S. Oregon VMS system and beyond.

Electronic Freight Management

- *2007-14: Using Existing ITS Commercial Vehicle Operation (ITS/CVO) Data to Develop Statewide (and Bi-state) Truck Travel Time Estimates and Other Freight Measures*: The transportation of freight is an important component of the Oregon economy. While other modes are clearly important for freight transportation, trucking is the dominant mode in terms of tons and value. Currently, there is no system that estimates travel time for many major freight corridors in Oregon. However, the existing infrastructure of Oregon's Green Light program provides an opportunity to generate travel time estimates for many travel corridors in Oregon with little additional investment. The Green Light program enrolls approximately 3,330 trucking companies with 30,200 transponder-equipped trucks (which does not include carriers participating in other electronic screening programs from other states). There are 22 equipped stations in Oregon where these transponders can be read and corridor travel times predicted. These estimates would also be useful to travelers and would be an additional enhancement to Oregon's traveler information system, TripCheck. In addition, these stations also include weigh-in-motion systems which provide axle weights, spacing, and gross vehicle weight estimates uniquely matched to a transponder-equipped truck. The objective of this research is to test the feasibility of using AVI data already being collected from transponder-equipped trucks to develop travel time estimates along major Oregon highway corridors and eventually link these estimates with those produced in Washington. Further, the research will seek to integrate other sources, particularly weigh-in-motion data to capture other key freight measures. As part of the research, it would be determined whether additional transponder readers can be deployed to read information at key points not at weigh station, particularly in the Portland area. It is anticipated that privacy concerns could be addressed appropriately.

- *2008-131: Oregon Freight Data Mart*: Increasing freight volumes are adding pressure to the Oregon transportation system. Monitoring the performance of the transportation system and freight movements is essential to guarantee the economic development of the region, the efficient allocation of resources, and the quality of life of all Oregonians. Freight data is expensive to collect and maintain. Confidentiality issues, the size of the datasets, and the complexity of freight movements are barriers that preclude the easy access and analysis of freight data. Data accessibility and integration is essential to ensure successful freight planning and consistency across regional partner agencies and planning organizations. The main objectives of this project are: a) to maintain a long-term freight database that would be available for Oregon Universities, state transportation agencies, regional planning agencies, and economic development organizations, b) to integrate freight data into the existing and successfully operating PORTAL system, and c) to monitor freight performance measures. The data will be stored on a designated server space at Portland State University and integrated into the PORTAL system which will streamline data accessibility and consistency.

- *2008-133: Freight Distribution Problems in Congested Urban Areas: Fast and Effective Solution Procedures to Time-dependent Vehicle Routing Problems*: Congestion creates a substantial variation in travel times during peak morning and evening hours. This is problematic for all vehicle routing models which rely on a constant value to represent vehicle speeds. And while the ubiquitous availability of real time traffic information allows drivers to reactively alter routes and customer service sequences to better cope with congestion, static routing models are unable to take advantage of these advances in real-time information provision in order to proactively find adequate routing solutions. In addition, changes in travel time caused by congestion cannot be accurately represented in static models. Research in time-dependent vehicle routing problem is comparatively meager and current solution methods are inadequate for practical carrier operations which need to provide fast solutions for medium to large instances. Even faster solution methods are essential to take advantage of real time information. The aim of this proposal is to develop and evaluate new methods for vehicle routing in congested urban areas. The emphasis will be placed on improving the running time of the existing methods using tailored data structures, the efficient handling of local and global variables, hybrid approaches, and parallel computing.

- *2008-134: Practical Approximations to Quantify the Impact of Time Windows and Delivery Sizes on Freight VMT in Urban Areas*: Supply chains and urban areas cannot thrive without the efficient movement of goods and accessibility to services. From a freight planning perspective, it is crucial to understand and quantify how routes and distribution decisions translate into commercial VMT. In urban areas, most of the trips take place within a multi-stop tour or trip chain. In the logistics and operations research literature, modeling efforts have focused on the design of routes but not on the estimation of distances traveled or VMT. Freight planning models cannot quantify the impact of delivery size and time windows in urban areas. There is scant research relating number of stops per tour, delivery sizes, time windows, and VMT per tour. Delivery sizes and time windows have a significant impact on the efficiency and VMT generated by freight movements in urban areas. The fundamental research questions of this proposal are: a) how to obtain practical and intuitive approximations on the length of commercial vehicle tours and VMT travelled in urban areas? and b) is it possible to estimate the impact of time windows and delivery sizes on VMTs?

- *2009-230: Exploratory Methods for Truck Re-identification in a Statewide Network Based on Axle Weight and Axle Spacing Data to Enhance Freight Metrics*: This research seeks to develop an a new method to determine flow patterns of trucks by matching archived vehicle-attribute data such as axle spacing and axle weights at multiple geographic locations. Overall, this research focuses on developing advanced methods and algorithms to anonymously identify and match commercial trucks crossing two data collection stations on roadways; and on investigating how these re-identification methods can be employed to enhance freight metrics. By capitalizing on the vehicle-attribute data from a number of AVC and/or WIM stations in a network, the proposed methods can potentially support and benefit multiple applications, such as determining travel times, quantifying travel time reliability, estimating truck flow patterns (i.e., origins-destinations), estimating empty truck movements, trip length estimation, tracking movements of trucks without transponders, and pavement management. The results of this study will benefit not only Oregon but potentially all other states since truck characteristics do not vary significantly from state to state, and many states also collect axle spacing and axle weight data.

- *2009-276: Analyzing and Quantifying the Impact of Congestion on Less-Than-Truckload Industry Costs and Performance in the Portland Metropolitan Region*: The manufacturing, service, distribution, retail, and wholesale economic sector is increasingly affected by growing congestion. Unreliable and increased travel times shrink the distribution radius of existing operations and reduce the operational efficiency of drivers and vehicles. Even though there is a clear consensus regarding the negative impacts of congestion, the quantification and measurement of these impacts in distribution logistics is a difficult task due to the lack of detailed routing data. Unlike most freight and trucking congestion studies based on aggregate measures, disaggregated dispatching and actual GPS fleet route data sets will be available for study in this research. The main objectives of this research project are: (a) to understand the impact of urban congestion on commercial vehicle fleets, (b) to quantify and discriminate between the impacts of recurrent and non-recurrent congestion on fleet operations, (c) to study how adverse weather conditions compound the negative impacts of congestion, and (d) to provide congestion performance measures at a network level.

- *2009-277: Analysis of Travel Time Reliability for Freight Corridors Connecting the Pacific Northwest*: Most supply chains cannot thrive without access to an efficient and reliable freight system. The objective of this research is to evaluate travel time reliability in the main freight corridors connecting the Pacific Northwest to California, the Midwest, and Southwest. Statistical analysis of Global Positioning System (GPS) commercial vehicle travel data will be used to study travel time reliability and identify congestion chokepoints affecting corridors to/from the Pacific Northwest. GPS data will be used to determine travel time distributions along different corridors by corridor segment (connecting main cities along the corridor), time of day, and day of week. Unlike previous studies, (a) GPS data will be complemented with detector and transponder based information to improve the accuracy of the travel time estimations in urban areas and to compare measurements and (b) the impact of travel time variability by time of day will be tested. A major objective of the project is to quantify travel time reliability on I-5 and I-84 freight corridors connecting major regional origin-destinations that start, end, or run through Oregon.

2.1.2 OTREC Sustainability-Related Projects

Another one-third of OTREC's ongoing and planned research projects related more generally to sustainability. Some of the projects aim to make transportation and land use systems more efficient, while others deal with making alternative modes such as bicycling and walking more attractive. We anticipate that this research will result in measures that can be implemented that will make our communities more efficient and sustainable by encouraging a shift toward travel that requires less energy. An additional set of projects deals with freight planning issues that also aim to reduce the carbon footprint of our freight transportation sector, specifically in the food supply arena.

Land Use and Transportation Linkage

- *2007-68: Co-Evolution of Transportation and Land Use*: The interaction between land use and transportation has long been the central issue in urban and regional planning. This project examines the land use-transportation interaction from an evolutionary perspective—once a certain set of goals are determined and pursued by politicians and planners, their land supply and transportation investment decisions are to a large extent driven by their previous decisions and the supply-demand dynamics in the urban system. Different from existing integrated land use and transportation models that assume exogenous network investment decisions, the co-evolution model considers both land use growth and transportation network growth as endogenous and market-driven. The central research question is how market and policies translate into transportation facilities and land use developments on the ground. The co-evolution model achieves a novel Urban Growth Equilibrium, which is a useful concept for planning and policy analysis. An agent-based simulation approach is employed to integrate an existing land use model and the transportation network growth model. The resulting integrated co-evolution model is demonstrated in a series of policy sensitivity tests.

- *2008-137: Dynamic Activity-Based Travel Forecasting System*: The proposed research project has as its primary goal the development of a dynamic activity-based demand model system for Metro that will be capable of meeting these objectives through explicit consideration of time of day and accumulated activity times in the propensities of individuals to construct tours. Although activity-based travel demand models have been developed or are currently under development in several cities in the U.S. and elsewhere, sensitivity to time-dependent path information seems to be lacking in these efforts. Specifically, extant models tend to treat activity episode generation, duration, location, starting time, and travel mode choices as essentially independent, which they are able to do because they ultimately produce trip tables for static network assignment methods. Model components to be developed under this project include: activity pattern choice, daily starting time choice, tour generation, tour mode choice, next stop purpose, next stop location, next stop mode, next stop timing and system simulation event tracker.

- *2008-152: Overlooked Density: Re-Thinking Transportation Options in Suburbia, Phase 1 and 2009-216: Phase 2*: This project aims at understanding of how regulation and site design practices may be modified to transform existing and new suburban multi-family housing

areas into places that offer a range of travel modes and potentially reduce the exclusive use of automobiles. This proposal investigates the integration of land use and transportation and also focuses on the role of site design as a critical aspect in the creation of livable, less congested and multi-modal suburban communities. Using a case study approach, this research will include transportation and demographic surveys of suburban multifamily residents, audits/analysis of existing site designs, and interviews with planners, developers, and designers of multifamily housing developments. In order to expose students to the challenges of creating integrated and sustainable suburban multifamily development, this project will also include an educational component in which a class of students will travel to study and document existing models of suburban multifamily development in Eugene, Oregon and Phoenix, Arizona. Both of these cities have seen growth of this housing type in the last decade and will serve as test cases of how different site design approaches have affected transportation behavior. Students will work with local officials, developers and architects to understand code and development related issues, and will then propose alternatives to existing models of development.

- *2008-163: No More Freeways: Urban Land Use-Transportation Dynamics without Freeway Capacity Expansion*: This research aims to answer the following critical land use-transportation planning questions: (1). Under what conditions will freeway capacity expansion become counterproductive to urban planning goals (where is the saturation point and are we there yet)? (2). How would urban land use and transportation dynamics evolve if an investment policy prohibiting all freeway capacity expansions was implemented (i.e. no-more-freeway). (3). What would be the implications of such a policy on mobility, accessibility, land use pattern, transportation finance, and social welfare? Improved knowledge on these issues should benefit planers and decision-makers who pursue mobility and sustainability objectives and have the power to shape future cities. The general public will also benefit from more informed transportation investment decisions. The proposed research builds upon an integrated modeling tool developed in previous research – ABSOLUTE (Agent-Based Simulator Of Land Use-Transportation Evolution) – which translates planning policies such as the "no-more-freeway" policy into alternative urban growth paths and possibly urban growth equilibria.

- *2008-160: Long Term Evaluation of Individualized Marketing Programs for Travel Demand Management*: With increasing concerns over traffic congestion, fossil fuel use, air pollution, and livability, coupled with severe constraints on funding for new transportation infrastructure, cities and regions are increasingly looking to a wider range of options to address transportation problems. Transportation demand management (TDM) is one of those options used over the past 30+ years with varying success. More recently, the concepts of social and individualized marketing are being applied to TDM at the household level and for all types of trips. This research project has two specific aims: (1) to evaluate whether the benefits of these individualized marketing programs continue to at least one year after the project ends; and (2) to examine whether the theory of planned behavior can help explain the behavior changes identified. To do so, we will conduct additional follow-up surveys of randomly-selected residents and program participants, examine secondary sources of data, and expand planned surveys.

- *2008-184:Understanding School Travel: How Residential Location Choice and the Built Environment Affect Trips to School*: This project will examine the relationship between parents' residential location decisions with the built environment and travel mode to school asking several questions: how is school travel implicitly or explicitly considered in families' decision-making process for residential location, a process that generally involves trade-offs a family faces in addressing its various needs? what and how do local environmental factors, such as land use patterns, street network characteristics, transportation opportunities, and housing stock characteristics around school sites play a role in housing location choice, and in turn home-school proximity? To what degree does family location preference is constrained by school siting and other environmental factors, and how does the constraint affect school travel behavior? We will survey random samples of families with children attending selected public schools in the City of Eugene's 4J school district. We will collect information on children's school travel behavior, household background, parents' attitude toward school travel means, and their consideration of school travel in residential location choice. Schools will be selected based on type, quality, size, and location. A comprehensive strategy aimed at reducing school auto-trips should consider providing more walkable environments and reducing the demand for auto-travel.

Walking, Bicycling and Healthy Communities

- *2007-18: Active Transportation, Neighborhood Planning and Participatory GIS, Phase 1 and 2008-98: Phase 2*: This project is aimed at developing, implementing, and evaluating new community-based walkability tools. This proposed project is designed to utilize new mobile GIS technology in the development of tools that communities themselves can use to assess, map, analyze, and deliberate within their efforts to improve local walking conditions. These goals will be achieved through the development, testing, evaluation, and transferring of GIS and PDA-based tools focusing on measuring and mapping the pedestrian environment.. The tools will be developed in a way that maximizes public involvement by local municipalities, school districts, transit agencies, and citizen groups while minimizing the training needs of a general, non-GIS using public. With the data, communities can conduct self assessments of local scale walkability, identify specific geographic areas of unsafe conditions, prioritize areas of greatest need, engage with local transportation officials more productively, and be better prepared to leverage enhancement funds. The purpose of the tools is twofold: 1) to collect relevant information about the walking environment that can lead to greater safety and an increase in pedestrian utilization; and 2) to catalyze community involvement that can urge public involvement and sustain other efforts to encourage greater walking. There are four primary components of this proposal: 1) refine an existing walkability audit tool for Safe Routes to School; 2) develop additional walkability PDA and GIS based audit tools focusing on ADA standards, Complete Streets, and walking environments around transit stops; 3) test each of these tools in communities throughout the country interested in addressing walkability at the local scale; and 4) to conduct an evaluation of the utilization of these tools in the various communities. Once the tools are developed in the research lab, they will be field tested within a community setting.

- *2007-20: The Influence of Community Walkability and Safety on Active Transportation Among Low Income Children*: In the proposed study, we will examine the contributions of

walkability measures and perceived neighborhood safety (traffic and crime-related) on active transportation among an ethnically diverse group of low income children. Second, we will investigate the relationship between children's active transportation and overall physical activity and obesity. The data set that will be used for this research is a cross sectional survey of 765 parents and guardians of children in Florida aged 5-18 who receive Medicaid, the health coverage program for the low income. Using this data set, we will develop multivariate regression models to identify the independent influences of walkability and safety on active transportation, while controlling for children's individual characteristics. We will test whether walkability factors are equally important in communities that are perceived to be safe and those that are unsafe. Then, we will examine the relationship between active transportation and overall physical activity and obesity for this low income population of children. The findings from this study will add to the emerging body of literature on the influence of community characteristics on active transportation and will uniquely focus on ethnically diverse, low income children. This study's findings will provide insight regarding policy approaches that may be effective for encouraging low income, minority children to use active transportation. Improving physical activity levels for low income children holds great promise for improving health status, and for reducing income and ethnicity-based disparities in health outcomes.

- *2007-33: Understanding and Measuring Bicycling Behavior: A Focus on Travel Time and Route Choice*: An on-going project is: examining the relationship between urban form and people's decision to bicycle; examining other intervening factors influencing the decision to bicycle, such as weather, topography, attitudes and perceptions, and socio-demographics; and testing the use of readily available technology (personal digital assistants with GPS) to objectively measure physical activity of bicyclists. That project first included a phone survey of Portland area residents about bicycling behavior. The second part of the project, currently underway, involves 150-200 bicycle riders carrying a PDA/GPS unit with them when they ride. This new project supplements and builds upon that work in two ways: 1. Collect GPS data from an additional 100 bicycle riders. Recruitment for the additional participants will focus on people with demographic characteristics and located in areas that were underrepresented in the original sample. This will allow for more robust results. 2. Analyze all collected GPS data to answer additional questions. The current project focuses on developing and testing the PDA/GPS technology and analyzing bike riding in relation to urban form variables. The proposed project will evaluate the following new questions, among others: what is the difference in travel time between bicycling and driving? how does this difference vary spatially? how do cyclists' routes differ from the shortest network distance? how do cyclists choose their routes? How do network characteristics (e.g. bike lanes or heavy traffic) influence those decisions?

- *2007-43: Factors for Improved Fish Passage Waterway Construction*: Roughened chutes (simulating natural stream passages) are a cost effective means to provide fish passage at locations where existing culverts and bridges are structurally sound yet do not meet current fish passage rules and regulations. Currently, the construction of roughened chutes consists of using equipment and water-wash methods to place the streambed materials; compaction consists of water consolidation and use of bucket and track (using the wheels and tracks of equipment). Excessive subsurface voids can be a significant problem that settles the larger

rock and allows the gravel and fines to be washed away. The loss may result in subsurface flow which may impedes passage for fish. Among the factors contributing to this loss, both hydraulic design and construction methods may play significant roles. This project is designed to investigate the role that construction technique plays in the loss of simulated streambed materials. The overall objective of this research project is to determine a list of significant construction factors affecting loss of fines in roughened chutes and develop a tool that provides better direction for the construction of roughened chutes.

- *2009-227: Evaluation of Bike Boxes at Signalized Intersections*: Analyses of motor vehicle and police reported crash data reveal that nearly 68 percent of bicycle crashes in Portland occur at intersections which are consistent with national trends. Of these intersection crash types, a common crash pattern is the "right-hook" where right-turning motorists collide with through or stopped bicycles. To partially address these conflicts between bicycles and right-turning motor vehicles, the City of Portland will be installing up to 12 "bike boxes" at signalized urban intersections. We propose conduct a comprehensive, classical, observational before-after study of the effectiveness of the installed experimental traffic control devices and responses of all system users impacted by the installation of the bicycle boxes. Our approach will answer such research questions as: do the bike boxes reduce conflicts or the potential for conflict between motorized vehicles and bicycles? do the bike boxes create any new or potential conflicts between motorized vehicles and bicycles? how does motor vehicle driver and bicyclist behavior differ with and without the bike boxes? what design features affect behavior and conflicts? do the bike boxes affect pedestrian safety, behavior, or conflicts with motor vehicles or bicyclists? what are the impressions of the drivers and bicyclists using the intersections about how the bike boxes affect safety and operations?

- *2009-249: Improving Regional Travel Demand Models for Bicycling*: There is very little research in the U.S. on bicycling. What does exist provides some general indications, but is limited in scope and often employs unreliable methods. Moreover, the primary tool used by public agencies to plan urban transportation systems – travel demand models – rarely includes bicycles as a separate mode. Without more sophisticated modeling tools, planners are not able to accurately evaluate infrastructure options that involve cycling. One reason models do not adequately address the bicycle as a mode of transportation is a lack of data. Models are built using travel and activity surveys, which usually don't include enough bicycle travel to develop better models. This project will address these problems. For the past two years, we have collected data from over 150 bicyclists on their bicycle trips using GPS. Past research has evaluated why and where people bicycle, including identifying different types of cyclists. Focusing specifically on route choice behavior, it has been possible to compare the characteristics of the cyclists' routes with those of the shortest paths. The research project proposed here takes that several steps further. The GPS data already collected will be used to develop a bicycle component to Metro's travel demand model. This will be done, in part, by estimating the relative utilities of various types of facilities and factors, e.g. bike boulevards, arterials with and without bike lanes, low traffic streets, hills, etc. In addition, the results will be used to improve a bicycle route planning guide (ByCycle) that is currently available.

- *2009-229: Implementation of Active Living Policies by Transportation Agencies and Departments*: The overall aim of this project is to examine how and why some public agencies adopt policies that are intended to create a built environment that that supports physical activity and active living. Understanding how and why is essential to promote reformation of planning and policy processes to support active living. The project will focus on transportation agencies, including city and county departments of transportation and public works, congestion management agencies, metropolitan planning organizations (MPOs), other regional transportation agencies, and state departments of transportation. To address the overall aim, we will answer the following questions: what actions (e.g. policies, plans, standards, programs, etc.) can transportation agencies take to support active living? which agencies have taken these actions? why have these agencies adopted policy innovations that support active living? what factors influence adoption? to what extent is health and active living a motivation for these actions? why don't more agencies adopt such actions? what are the obstacles to active living? Methods include a thorough literature review (print and web), an inventory of state DOT actions, interviews with innovative state DOTs, examining a random sample of MPOs and regional transportation plans, a survey of local and regional agencies that are undertaking best practices, and a random survey of MPOs and city/county agencies.

- *2009-224: Healthy Communities and Urban Design: A Multi-Disciplinary National Analysis of Travel Behavior, Residential Preference, and Urban Design*: This proposed research project is firmly and directly connected to that fundamental core through an examination of the connection between urban form and transportation behavior within and between cities across the country. This project seeks to understand the relationship between urban form and active transportation (walking and biking) by comparing behavior within new urbanist and traditional suburban neighborhoods in carefully selected neighborhood pairings in cities across the United States. In twenty different cities we have selected one new urbanist and one traditional suburban neighborhood by initial GIS analyses of their urban forms. By including these "pairings" of neighborhoods within cities, and by including multiple cities across the country, we can both control for local policy and cultural conditions within a single city, and control for differences across cities. Thus, we will be able to analyze the relationship of urban form to active travel in a way that has not previously been done.

Sustainable Freight Transportation Systems

- *2008-154: Food Delivery Footprint: Addressing Transportation, Packaging, and Waste in the Food Supply Chain*: Bringing food products to the majority of U. S. consumers generally involves frequent and lengthy trips from the food growers and producers through a distribution network to the institutional, grocery, and restaurant businesses. Increasingly, businesses are assessing the impact of their purchasing decisions on their carbon footprints. These decisions have complex implications for the environment based on the mode of transportation employed, the corresponding packaging used to transport the goods, and the resulting waste and disposal transportation. The objective of the proposed research is to examine the environmental implications of the purchasing decisions made by these intermediary food businesses. We will start by assessing the current condition; then conduct life cycle assessments of different types of materials and identify alternatives that meet

packaging requirements (e.g. shelf stability etc) with reduced environmental impacts. Ultimately this project will serve as the foundation for a broader assessment of an organization's carbon footprint which would extend to other forms of energy usage, transportation, and materials management. This represents an enhancement of current 'food miles' assessment methodologies, which primary consider greenhouse gases emitted during food transport. The research results can be used to develop purchasing and logistics strategies and models for supplier collaboration to reduce carbon foot print as well as overall transportation and waste costs.

- *2008-195: Freight Performance Measures: Approach Analysis*: This research has two main objectives: develop a set of freight performance measures that can effectively guide state-level multimodal transportation investment; identify existing freight data sources and recommend a freight data inventory system that supports the performance measures. This research will develop data-oriented approaches to freight performance analysis that focus on evaluating the cost-effectiveness of various alternatives in achieving identified policy priorities. This method is more likely to be supported by existing and/or expected future freight data sources than more comprehensive planning approaches, while focusing on a smaller number of policy objectives at a time. ODOT will use the results from this study to help make freight investment decisions, plan future freight data collection activities, and communicate the benefit of multimodal investment to politicians and the general public.

- *2009-226: Maintaining Safe, Efficient and Sustainable Intermodal Transport through the Port of Portland*: The overall objective of this project is to help maintain safe, efficient, and sustainable intermodal navigation in the lower Columbia River by understanding, and suggesting remedies for, a problem that threatens both navigation and salmon habitat. More specifically, we will: use analyses of LOADMAX and historical water level data to document long-term changes in key datum levels and other tidal properties; use results from water level analyses, dynamical models, remote sensing, channel topography and other data to determine the causes of the decreased water levels in the LCR; develop strategies to combat water level reduction, facilitating timely connections to land transport. The proposed research will apply advanced data analysis tools and remote sensing to a transportation problem and its associated habitat restoration needs, in direct collaboration with the public and private sectors. This research takes a new look at the consequences of dredging and uses of dredged material, and considers the impacts of ongoing climate change.

2.2 Evaluating Environmental Impact of Technology

Within the realm of Intelligent Transportation Systems, a range of technology applications exist which can lead to improved safety which has direct benefits due to fewer fatalities, injuries and less property damage. Safety improvement technologies have secondary benefits since the congestion resulting from a crash is also eliminated which prevents unnecessary delay, energy consumption, emissions, exposure to secondary crashes and noise.

Other technologies result in reduced VHT and/or VHT, which can lead to reductions in energy consumption, emissions, accident exposure OTREC researchers have been involved in

evaluating various technologies in the U.S. and abroad for many years, across all modes. Typically an evaluation will include some standard performance metrics such as:

- Travel time or delay savings (congestion)
- Variability of travel time (reliability)
- Emissions
- Number of trips
- Number of stops
- Mode choice
- Noise
- Fuel and energy consumption
- Carbon footprint (e.g. offset by tree planting)

Fortunately there are several national resources that assist with technology evaluation at the planning, design and implementation stages, including the U.S. DOT ITS Benefits Database (www.itsbenefits.its.dot.gov) and the Intelligent Transportation Systems Deployment Analysis System (IDAS—see http://idas.camsys.com). In order to rigorously evaluate any technology there are several important considerations:

- **Partnerships**: our evaluations of specific technologies have all involved strong partnerships, typically with transportation agencies and the private sector. We have found opportunities to work collaboratively with the transportation industry where we have been able to provide resources for unbiased evaluation when transportation agency staff lack time and resources to focus on research.
- **Problem identification:** it is possible to avoid the phenomenon of a problem looking for a solution by carefully identifying the problem that need to be solved before identifying a specific technology.
- **Data source**: there must be a sufficient data source, preferably as part of the technology deployment itself. In our experience, it is extremely helpful when there is an environment of open data sharing. Transportation agencies in Oregon freely share their data (subject to privacy requirements) with one another and with researchers and the private sector, which is a model that should be followed elsewhere.
- **Before and after**: typically technology deployments that result in the generation of data do not consider the need for both "before" and "after" data. If possible, evaluations should develop a robust set of baseline data before implementing the ultimate system.
- **Involve evaluator early**: if the need for evaluation is built into the project or program early, the costs will be minimized and the potential effectiveness of the evaluation will be maximized.
- **Test bed**: if alternative technologies are available, consider the development of a simple testbed that allows for raw data from several different sources to be collected by a neutral party for direct comparison. The freeway authority in Munich, Germany successfully used this format for evaluating alternative road weather monitoring systems.
- **Technology transfer**: communicating the results of technology evaluation through training, seminars, publications, new media and conference/workshop presentations has been a cornerstone of OTREC's work. In addition we focus on educating students who participate in the evaluations and will become the employees of the transportation agencies and private

firms implementing future technologies. By involving agency staff in the evaluation there is also technology transfer directly to those employees (who may later move up through the agency to leadership roles).

2.3 Future Research and Development Needs

A wide array of research and development is needed in order to improve the energy efficiency and sustainability of the transportation system, and many are underway at OTREC and elsewhere. Recognition that the focus is shifting toward efficient and sustainable operation of the transportation system will require research and development of new sustainable performance based planning, design, operations and maintenance. New incentives for operations and maintenance will need to be developed. It is not possible to be exhaustive but several research needs related to categories of projects described above are listed here:

Sustainable Transportation Pricing and Tolling Strategies: the area of transportation finance is receiving more and more attention, but a sustainable financing system with energy efficiency and sustainability goals does not yet exist. Strategies for implementing emissions fees, or further creative "green" finance systems that are publically acceptable should be developed.

Congestion Management: Since about 30% of the vehicle miles traveled (VMT) occur on freeways (accounting for only 3% of the lane miles), ITS based congestion management strategies should be aggressively pursued, including ramp metering, speed harmonization, and traveler information. This will require better infrastructure for data collection and fusion of data from multiple sources. Research and development of greater data quality is also needed. Incident management should be exploited to its maximum level of effectiveness. Basic principles such as better signing, striping and marking as well as enforcement, should also be pursued. Mechanisms for improving travel reliability should be the core of this work.

Integrated Corridor Management: Arterials handle about 42% of the VMT with about 11% of the nation's lane miles, and their operation should be optimized through better operations. This requires a national effort to exploit the existing infrastructure of controllers and surveillance systems to provide needed data for management purposes. Building on private sector innovation, investment in research and development for more open source capable traffic signal controller hardware and software should be considered. Communications systems and data quality management components supporting these systems will also be needed.

Advanced Transportation Information Systems: There is great value in accurate, timely and customized traveler information. There is still research needed to understand how people use traveler information and how it influences their decision making. For example, would providing travelers with detailed "green" traveler information that reports emissions, noise, and energy impacts, influence mode choice and affect traveler behavior? Navigation systems could be extended to include not only the shortest distance and shortest time routes, but the "greenest" route as well.

Multimodal Archived Data User Service: Transportation data will be more and more critical in the future so national attention should be paid to developing robust data collection, storage and

management systems. Building on Oregon's open data sharing philosophy, further research is needed to understand how to fuse data from multiple sources, including a mix of public and private sources in a way that encourages innovation in both the private and public sectors.

Electronic Freight Management: The unavailability of disaggregate freight data continues to be a problem decade after decade. Some strategy for creating a firewall between private sector needs in the freight sector and public sector needs should be developed, perhaps by a neutral third party. The need for data clearinghouses may be needed across the transportation system since the issues of fusing data from multiple sources with varying degrees of quality and sensitivity are becoming more important.

Several other issues that require further research and development include:

- Development of "green" performance measures that can be generated and compared across different geographic areas (state, county, urban/rural, city) and across all modes.
- Development of standard traveler information graphics to replace text-based dynamic message signs.
- Dealing with automated enforcement legal and institutional issues.
- Serious exploration of liability issues (following the lead of the European Union and Japan) related to technology deployment.

3. Innovative Technologies in Transportation Systems

The deployment of innovative technologies in the transportation system involves a complicated array of public and private organizations, viewpoints, interests, motivations, legacies, funding programs, and cross-disciplinary collaboration and communication. Historically, the transportation profession has included engineers and planners (as well as many others), but not necessarily requiring expertise in computing, data processing, programming, communications, system engineering and system integration. The development of the field of Intelligent Transportation Systems (ITS) has required the formation of new multi-disciplinary teams that require more careful communication and collaboration. Educational institutions, firms and government agencies, and professional organizations have begun to respond to this shift, but the response is not complete. Challenges remain that impede the use of innovative technologies in transportation, and there are roles for transportation agencies (local, state and federal) as well as academia and industry.

3.1 Challenges Impeding Use of Innovative Technologies

As noted, there are many challenges impeding the use of innovative technologies in transportation systems.

- **Shift to operations**: the needed shift in the transportation field toward an operations environment is partially complete, but still impedes the advancement of innovative technologies. Organizationally, there may not be incentives and rewards for operations personnel to advance in their career. Some agencies may not have sufficient operations staff.

Limited operations staff may not have time or expertise to oversee implementation of new technologies.

- **Finance and funding**: more flexible funding programs could expand the implementation of innovative technologies. Incentives that encourage transportation agencies to share resources across jurisdictional boundaries would remove barriers to implementation.
- **Human resources**: transportation professionals typically come from single-discipline educational backgrounds, and there may not be sufficient opportunities for professional development and continuing education. Many agencies and firms have travel restrictions that prevent employees from attending and participating in regional, national, and international conferences and symposia (even across state boundaries in some cases). There may not be programs for tuition reimbursement for pursuit of continuing education or advanced degrees, or rewards (e.g. promotion or salary increase) for attainment of graduate degrees.
- **Legacy systems**: there are numerous legacy systems throughout the transportation infrastructure that have not been maintained or upgraded. Funding for these kinds of upgrades should be expanded, along with performance incentives that allow for upgrades to new versions of hardware and software. Often the legacy systems do not allow flexible data transfers which impacts interoperability.
- **Communications**: historically transportation systems have been linked to communications, but transportation professionals may not have the necessary expertise to plan, design or implement robust communications networks. More attention should be paid to the establishment of communications infrastructure that supports the implementation of innovative technologies for the transportation system.
- **Data**: there is a need for high quality ubiquitous transportation surveillance data across all modes and all levels of the network. Systems for measuring, storing, and disseminating transportation data are complex and currently inconsistent.
- **System integration**: diverse systems that have been implemented piecemeal require integration. Data standards are moving targets and it is difficult to establish concrete standards for data formats and structures.
- **Collaboration**: the implementation of innovative technologies requires thinking beyond traditional jurisdictional boundaries. Users want to operate on a seamless transportation network, so traditional boundaries that divide finance, data, and other systems must be broken down. Boundaries between public and private entities along with associated liability issues also present challenges.
- **Need for objective and continuing evaluation**: often once a project has been implemented and possibly evaluated, continuing maintenance and performance evaluation is not provided.

3.2 Federal, State and Local Actions Needed

There are many actions that can be taken by federal, state, and local governments in order to break down barriers to the application of innovative technologies. Several examples of these roles include:

- **Encourage regional collaboration**: in the Portland metropolitan region, the TransPort ITS Advisory Committee has been meeting monthly on a voluntarily basis since 1994. TransPort includes representatives from federal, state, regional, local governments, the private sector and academia. The committee provides official ITS advising to the regional transportation

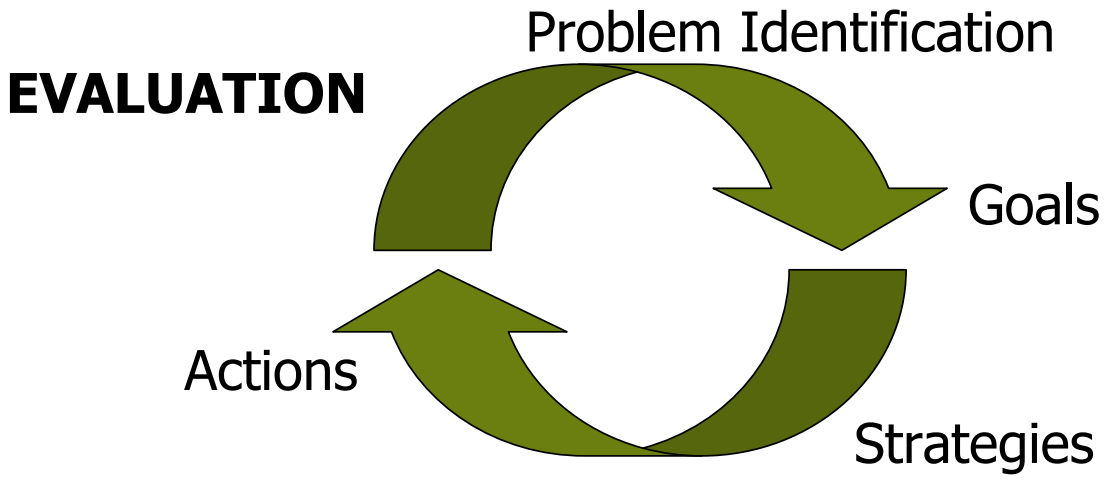
decision-making body and also provides a valuable forum for sharing project information, data, and resources. TransPort could be a model for regional coordination nationwide.

- **Public/private partnerships**: government agencies could encourage public/private partnerships particularly in the area of standards for data sharing and communications.
- **Funding and incentives for operations**: new strategies for funding operations activities within transportation agencies should be developed, particularly for those with small staffs. Operations funds should not compete with funding for capacity improvements and dealing with aging infrastructure.
- **Reward data sharing**: agencies that openly share data with other agencies and make it available for research and to the private sector (e.g. value added resellers) should be rewarded.
- **Continuing education and mentorship**: agencies should partner with education and training organizations to advance the multi-disciplinary educational level of employees, using specific performance targets. Increase level of experience within agencies to effectively implement, operate, integrate and maintain technology. Agency personnel can serve as valuable mentors and colleagues for students and faculty.
- **Performance measurement:** develop new strategies and incentives for "green" performance measurement and evaluation.
- **Rural infrastructure:** communications and utilities in rural locations can be unreliable and expensive to operate and maintain. Agencies should focus on improving rural infrastructure for technology.

3.3 Role for Industry and Academia

Industry and academia play important roles in the implementation of innovative technology solutions. At a fundamental level, it is important for both industry and academia to be at the table at the planning, design, and implementation stages. Often industry can assist government. For example, new vehicles are already equipped with advanced positioning and communications systems that could serve as a backbone for those vehicles to act as "probes" in the transportation system. However, serious privacy issues exist that prevent any aggregation of data generated from private vehicles to be used for management or information systems. Perhaps in the future, a collaboration of public, private and university organizations can work to develop a framework for integrating data from multiple sources in a mutually beneficial way.

The figure below illustrates one way that academia can play a significant role in the development of new technology. Most transportation agencies have systems in place to identify problems, set specific goals for their region or state, select and assess multiple alternative strategies, and ultimately take particular actions. The feedback loop is complete when the evaluation step is completed, which provides feedback into the next stage of problem identification. Many times, the evaluation step is left out and this is where academia can play an important role. Through collaboration, universities can work with transportation agencies and industry to provide unbiased, rigorous evaluations that complete the feedback loop.



In the ITS field, often academia can play an important role in the collection, storage and maintenance of data archives. It has been shown that having a group of researchers who are interested in using data can ensure its quality. Academia also plays a crucial role in providing unbiased, rigorous evaluations of ITS projects and programs, which serves as a training ground for future and current professionals.

4. Technology Transfer

4.1 OTREC Technology Transfer

OTREC's technology transfer efforts are contributing toward an expanded and coordinated statewide program of transportation outreach involving accessible communication of research results, continuing education and training courses for transportation professionals at all levels and at all stages of their careers, in a variety of formats. These programs are being developed in coordination with a statewide needs assessment, transportation agency, industry, and community needs, and may also appeal to a larger national and international audience. In addition, all OTREC projects have an explicit component of transferring ideas, skills, and results as part of the research process. OTREC is also working with individual campus commercialization officers to efficiently move intellectual property into the marketplace as relevant.

There is a need to improve our transportation systems to make them more sustainable through research and education. There is also a workforce crisis in the transportation sector in that half of our nation's transportation system employees will be eligible for retirement in the next ten years. Many rural city managers and transportation planning staff are expected to retire within the next decade, yet many rural towns in Oregon are experiencing either rapid growth or decline where transportation issues become central issues. OTREC is supporting efforts to link student service learning projects with improving rural community planning, and will bring this approach to developing transportation training modules for new city managers, planners, planning commissioners, and legislators throughout rural Oregon. OTREC is encouraging and funding investigator-based technology transfer initiatives and encourage development of ways to share knowledge nationally and internationally. An example of such an initiative is the free web-based

Friday seminar program already underway at PSU. Each research/education project proposal requires a technology transfer plan that is evaluated as part of our peer review process. OTREC will encourage dissemination of research results via journal publications and presentations at recognized conferences.

There is a comprehensive OTREC website with links to all reports and publications. Project descriptions are posted on the OTREC website and submitted to TRB's RiP database one month after project selection. The OTREC newsletter is a key communication tool, and has been published twice a year and posted on the OTREC website. We also use electronic communication by email as a key outreach tool for faculty, students, professionals and stakeholders. OTREC provides the Uniform Resource Locator (URL) of all full text reports to TRIS, transmits it to NTL and sends five printed copies to the Northwestern University Transportation Library, Volpe National Transportation Systems Center the Institute of Transportation Studies Library at the University of California at Berkeley, the TRB Library and NTIS within two months of project completion.

In addition to national conferences such as the Transportation Research Board Annual Meeting and others, OTREC faculty and students actively participate and present at local conferences including:

- Annual Region X (TransNow) student conference
- Oregon Planning Institute (OPI) Conference
- Northwest Transportation Conference currently sponsored by ODOT in even-numbered years
- Oregon Transportation Safety Conference
- Institute of Transportation Engineers District 6 Annual Meeting (13 Western states)

Research PIs will be encouraged to produce posters and "project capsules," one page summaries of project results with graphics. These are posted on the website and are also used in hardcopy to provide a convenient format to distribute to transportation professionals. The OTREC newsletter also features abstracts from recently published results. A series of seminars/lectures/symposia/panels will be continued and/or expanded at all campuses.

OTREC is supporting and expanding existing short courses and training programs (e.g. Kiewit Center Safety Courses, PSU's Urban Rail series, NCAT training, etc.). OTREC hopes to develop programs for the Pacific Rim (e.g. China and Vietnam). In addition, we try to work with other organizations to be a clearinghouse for a broad array of training programs (ODOT's Road Scholars, the University of Washington's Transpeed programs, WTS leadership programs, OSU's Kiewit Center courses, FHWA sponsored courses through the National Highway Institute (NHI), the National Transit Institute (NTI) and ITS Oregon sponsored courses.)

OTREC has been in operation for about 18 months, and so far we believe that our technology transfer efforts have been successful. By funding 85 projects, there are now about 60 different faculty involved in OTREC projects with roughly 95 students involved as research assistants. Each project has an external matching partner who is interested in the research undertaken. External partners also assist with peer review of the final report, which also requires review by a federal agency staff member. These efforts, along with direct access to the products of each

project, will help get the results into the hands of those who can implement the technology. Our projects have about 30 external partners. We have 17 undergraduate and graduate degree programs that are preparing future transportation professionals and providing opportunities for working professionals to seek additional education and training. OTREC faculty and students are quite active publishing and presenting their research results and providing opportunities for students to gain experience presenting the results of their work. Finally, during our first year of operation our 31 professional development courses and symposia have reached about 585 transportation professionals.

4.2 OTREC Industry Partners

Industry partners play a significant role in technology transfer in several ways. First, each project has an external matching partner to help ensure success, and some of these come from industry. Second, OTREC's External Advisory Board includes four members from private industry, who help identify research topics and ensure technology transfer.

4.3 OTREC Demonstration Projects

OTREC has not been involved in any official federally-funded demonstration projects for new technologies.

5. Conclusion

Our themes—healthy communities, integration of land use and transportation and advanced technologies—are guiding us, along with our transportation agency and industry partners across the state, to develop research and education programs aimed at solving transportation problems and strengthening the transportation workforce. Our research is being developed through a collaborative process and all products will be peer-reviewed. Thank you for this opportunity to provide testimony at this important hearing. With your continuing support, we are looking forward to making important contributions toward a more intelligent and sustainable future.

Dr. Robert L. Bertini, P.E. Biography

Dr. Robert L. Bertini is an Associate Professor of Civil & Environmental Engineering and Urban Studies & Planning at Portland State University in Portland, Oregon. A registered professional engineer in Oregon and California, he is also the Director of the Oregon Transportation Research and Education Consortium (OTREC), a statewide collaborative national university transportation center that is a partnership between Portland State University, the University of Oregon, Oregon State University and the Oregon Institute of Technology. OTREC is advancing new research, education and technology transfer initiatives throughout the state of Oregon with a multidisciplinary theme of advanced technology, integration of land use and transportation and healthy communities. With 20 years of experience in transportation, Bertini is a recipient of the National Science Foundation CAREER award entitled *Mining Archived Intelligent Transportation Systems Data: A Validation Framework for Improved Performance Assessment and Modeling.*

Since joining the Portland State faculty in 2000, Bertini has developed an Intelligent Transportation Systems Lab, unique in the Northwest, where he and his students and colleagues are developing ways of archiving and mining transportation data to improve the operation of our transportation system, reduce congestion and fuel consumption and improve quality of life. Bertini's goals at Portland State University have been to create rich classroom and laboratory environments to prepare leaders in transportation field; to conduct relevant research toward more efficient, equitable, effective and sustainable transportation system; and to develop new partnerships at Portland State, within the Oregon University System, with transportation agencies, consultants and industry. During this time Bertini has developed new courses, curricula and seminars; published over 200 papers and articles (81 peer reviewed), most with student co-authors; his published work has been cited 139 times; he has presented 163 invited lectures and presentations; he has been principal investigator or co-principal investigator on 53 research projects; and has supervised 87 undergraduate and graduate students. He is the recipient of several best paper awards from the Institute of Transportation Engineers, a diversity achievement award from the Women's Transportation Seminar and the Distinguished Faculty Achievement Award from the Portland State University Alumni Association.

Bertini works to bring a community-based learning component into the classroom and serves as the advisor for the Portland State University student chapter of the Engineers Without Borders. He is the Secretary of the Transportation Research Board's Committee on Traffic Flow Theory and Characteristics. He received a Ph.D. in Civil Engineering from the University of California at Berkeley, an M.S. in Civil Engineering from San Jose State University, and a B.S. in Civil Engineering from California Polytechnic State University San Luis Obispo. His government and industry experience includes positions with the San Mateo County California Department of Public Works, DeLeuw, Cather & Company, Parsons Brinckerhoff Quade & Douglas, Inc., and DaimlerChrysler Research and Technology North America, Inc. As a transportation engineer he has worked on public works, highway, light rail and airport projects, including planning, design and construction. Bertini and OTREC are members of ITS America, ITS Oregon, the Institute of Transportation and the American Road and Transportation Builders Association.