



Program Progress Performance Report for University Transportation Centers

Prepared for the USDOT Research and Innovative Technology Administration (RITA)

RITA Sponsor Award Number: **DTRT12-G-UTC10**

Project title: **Pacific Northwest Transportation Consortium (PacTrans):
Using Technological Advances to Develop Data-driven, Sustainable Solutions for the Diverse
Transportation Needs of the Pacific Northwest**

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Report #8, PPPR reporting for six months (July 1, 2015 – December 31, 2015)

Project/Grant Period: January 01, 2012-June 30, 2016

Reporting Period End Date: December 31, 2015

Report Term: Semi-Annual

1. Accomplishments

- **What are the major goals and objectives of the program?**

PacTrans focuses on using technological advances to develop data-driven, sustainable solutions for the diverse transportation needs of the Pacific Northwest. Major goals and objectives of PacTrans include:

Research – serving as Region 10’s research engine, PacTrans is committed to funding cutting edge research as a collaboration platform with strong partners in both the public and private sectors in our industry.

Technology Transfer – PacTrans strives to be an applied technology showcase, providing necessary supports to projects that are deemed as “Success Stories” to ensure dissemination of results to policy makers, practitioners, educators, and others within the transportation community.

Education – As a consortium of five prestigious universities, PacTrans is devoted to being an education leader. This involves continued evaluation and evolution of our transportation engineering programs as well as providing state-of-the-art research laboratories, student conferences and seminars, and scholarship opportunities for our students and future workforce.

Workforce Development – PacTrans endeavors to be a workforce development base: hosting activities that focus on the development of people, building strong relationships with employers in our region, and connecting our students with quality jobs where they can implement the knowledge they gained through their education.

Outreach – Throughout all of these other goals and objectives, PacTrans seeks to be in a continual process of outreach: promoting and building the educational student base, making new industry partners, attracting new research, and providing opportunities to share and learn about key outcomes and achievements that have been learned through research.

- **What was accomplished under these goals?**

During the six month period from July 1, 2015 – December 31, 2015, PacTrans was actively engaged in each of the goals and objectives listed above. This was achieved through a multitude of activities that were conducted to ensure our transportation expertise contributes to the advancement of the nation and region’s transportation research, technology transfer, education, workforce development, and outreach.

Research

As Region 10’s research engine, PacTrans has been actively engaged in two broader categories of research projects. We engage in multi-institutional research projects that require participation from at least two consortium universities, typically have a larger budget. Such projects include multi-institutional general research projects (coded with MG), educational research projects (coded with ME), and multi-institutional outreach projects (coded with MO). We also engage in small research projects (referred to as single institutional projects) that only require participation from a single consortium

university and typically have smaller budgets. Such projects are coded with SR and university acronym). Both categories of research are geared towards the goal of advancing the region's transportation research. For those projects funded in 2013-2014, PacTrans has completed **seven** multi-institutional research projects and **twenty-four** small research projects, each has undergone review and is now completed. They have been posted to the PacTrans website and distributed to the different agency repositories.

List of completed multi-institutional projects using the 2013-2014 funding:

- MG-2013-1: Behavior of Drilled Shafts with High-Strength Reinforcement and Casing
- MG-2013-2: A Platform for Proactive Risk-based Slope Asset Management Phase II
- MG-2013-3: Data Collection and Spatial Interpolation of Bicycle and Pedestrian Data
- MG-2013-4: High Performance Bridge Systems for Lifeline Corridors in the Pacific Northwest
- MG-2013-5: Performance-Measure Based Asset Management Tool for Rural Freight Mobility in the Pacific Northwest
- ME-2013-1: Refinement and Dissemination of a Digital Platform for Sharing Transportation Education Materials
- MO-2013-1: Educating Teenage Drivers in the Pacific Northwest Regarding the Dangers of Distracted Driving Phase II

List of completed small research projects funded in 2013-2014:

- SR-OSU-2013-1: Geospatial Analysis of Bicycle Network "Level of Stress", Bicycle Crashes and the Geo-coded Pavement Conditions for Risk Factors Identification
- SR-OSU-2013-2: Assessing the Capacity of the Pacific Northwest as an Intermodal Freight Transportation Hub
- SR-OSU-2013-3: SSI Bridge 2: Evaluation of Soil Structure Interaction Effects on PNW Bridges
- SR-OSU-2013-4: Investigating the Feasibility of Using QR (Quick Response) Codes for Construction Document Control in Highway Construction
- SR-OSU-2013-5: Development of Improved Corrosion Inspection Procedures for Reinforced Concrete Bridges
- SR-OSU-2013-6: Alternative Information Signs: An Evaluation of Driver Comprehension and Visual Attention
- SR-OSU-2013-7: Improving Sustainability of Urban Streets via Rain Gardens – How Effective Are These Practices in the Pacific Northwest?
- SR-UAF-2013-1: Encouraging Young Civil Engineers: Support for the UAF College of Engineering and Mines Steel Bridge Team Competition Steel Bridge
- SR-UAF-2013-2: Roundabout Design Training for Alaska's Engineers
- SR-UAF-2013-3: Improving Performance, Knowledge, and Methods to Provide Quality Service and Products
- SR-UAF-2013-4: Evaluate Presawn Transverse Thermal Cracks for Asphalt Concrete Pavement
- SR-UAF-2013-5: The Value of Depressed Medians on Divided Highways in Alaska
- SR-UAF-2013-6: Evaluate H2RI Wicking Fabric for Pavement Applications

SR-UI-2013-1: Enhancing the Resilience of Idaho’s Transportation Network to Natural Hazards and Climate Change

SR-UI-2013-2: Modeling Passing Behavior on Two-Lane Rural Highways: Evaluating Crash Risk under Different Geometric Condition

SR-UI-2013-3: A Framework for Improved Safety and Accessibility through Pedestrian Guidance and Navigation

SR-UW-2013-1: Smartphone-Based System for Automated Detection of Walking

SR-UW-2013-2: Field Validation of Recycled Concrete Fines Usage

SR-UW-2013-3: Testing of Cavity Attenuation Phase Shift Technology For Siting Near-Road NO2 Monitors

SR-UW-2013-4: Identifying and Analyzing the Relative Advantages and Disadvantages of Public-Private Partnerships and Traditional Delivery for Roadway Projects

SR-UW-2013-5: Changing Retail Business Models and the Impact on CO2 Emissions from Transport: E-commerce Deliveries in Urban and Rural Areas

SR-WSU-2013-1: Assessment of Lube Oil Management and Self-Cleaning Oil Filter Feasibility in WSF (WA State Ferries) Vessels

SR-WSU-2013-2: NDE System for Determining Wood Guardrail Post Integrity

SR-WSU-2013-3: Development of a Durable Asphalt Mix for Eastern Washington and Mountain Passes

Technology Transfer

In July and August of 2015, PacTrans made a call to its principal investigators (PIs) for “success stories.” The intent was to identify research projects that had significant results and made major findings, developments or conclusions. These PIs were asked to submit a proposal for additional PacTrans funds to execute a predetermined technology transfer plan. PacTrans then selected **seven** such activities and products. These technology transfer components are still ongoing but the following list outlines the funded tech transfer projects underway:

1. Multi-Institution Project (MG-2014-3) Title: **Unmanned Aircraft System Assessments of Landslide Safety for Transportation Corridors**. Over the last year this team has been using drones to collect optical imagery of several unstable slopes located in Alaska, using digital cameras to characterize and model slope stability and to forecast their dynamics. To this regard, a short promotional video of the research has been developed to showcase the effectiveness of drone imaging collection. This is currently being disseminated to the public via webinar and workshop meetings.
2. Single-Institutional Project (funded by a match funding source) Title: **Greenroads: A sustainability performance metric for roadway design and construction**. Out of this research came a green roadway design and construction certification system (much like Leadership in Energy and Environmental Design (or LEED) works for building) and also the Greenroads

Foundation, a 501(c)(3) that is meant to support and cultivate the mission and certification system. PacTrans is teaming up with the University of Washington's American Public Works Association (APWA) Student Chapter to fund a Technology Transfer opportunity called, "Greenroads Bootcamp." It is a full-day training event that involves: (1) a 1-hour general audience lecture about roadway sustainability and Greenroads, (2) a 2-hour in-depth training session on how to use the Greenroads Rating System to rate roadway projects, (3) a 1-hour information session with interested students, and (4) free passes for any in attendance wishing to take the Greenroads professional accreditation exam (STP Exam).

3. Single-Institutional Project (SR-WSU-2012-1) Title: **Laboratory evaluation of recycled concrete as aggregate in new concrete pavements.** This research has led the Washington State Legislature to recently pass Bill 1695 that calls for the use of recycled concrete in future building projects. Thus, PacTrans has allocated Dr. Wen additional funding for technology transfer which will include: meeting with Washington Department of Transportation, Washington Aggregate and Concrete Association, Concrete Suppliers, and local governments to present the findings on the use of recycled concrete; developing a brochure on how to use recycled concrete aggregate for concrete production; developing newsletter on the use of recycled concrete; and creating a social media video on how to use recycled concrete.

4. Single-Institutional Project (SR-OSU-2013-7) Title: **Improving Sustainability of Urban Streets via Rain Gardens – How Effective Are These Practices in the Pacific Northwest?** Using PacTrans funds, this project collaborated with the Benton County, City of Corvallis, Oregon Water Resources Department, and Oregon-BEST, and multiple other partners to construct, instrument, monitor, model, and evaluate the effectiveness of bioretention practices during their establishment phase. Thus, they constructed the OSU-Benton County Green Stormwater Infrastructure Research Facility. This facility is an instrumented, semi-controlled, and three celled testing facility for green infrastructure that captures runoff from the Benton County Public Works transportation yard. Each cell enables field-scale testing of a roadside stormwater (natural or artificial) technology, and provides opportunities for near real-time monitoring and comparison with other technologies. This unique facility provides excellent opportunities for education and outreach, which is why PacTrans has selected this work to receive additional funding for technology transfer. Multiple stakeholders have contacted administrators of the facility inquiring about whether it can be used for programs focused on K-12 and local community, and for field testing of new stormwater technologies. However, a well-developed long term plan is needed to address these opportunities. This additional funding will go to the following tasks:
 - Development of education materials, and collaborate with University of Washington to collect initial data and apply for the facility to be Technology Assessment Protocol - Ecology (TAPE) certified.

- Development of a web-based monitoring portal that will be made available to the community for monitoring these rain gardens in real-time and measure their performance via an embedded modeling framework.
 - Delivery of presentations to local stormwater utilities and water managers about the facility and research conducted at the facility.
5. Single-Institutional Project (SR-OSU-2013-6) Title: **Alternative Information Signs: An Evaluation of Driver Comprehension and Visual Attention**. This research studied the evaluation of traffic sign understandability. By using a variety of online survey question approaches and driving simulation tasks they have been assessing the understandability of alternative Tourist Information signs in Oregon. To communicate these exciting results to a broader range of traffic engineers, public agencies, and the general public at large, PacTrans has allocated additional funding to the research team for the development and dissemination of an interactive website. The aims of the website are to:
- provide a mechanism for sharing the literature review, experimental methods, results, and findings of the project
 - to provide an interactive interface that will enable users from around the world to populate a geospatial database with images and descriptions of information signs in different contexts.

The research team has already created the beginnings of such a database as a part of the original project. However, there is significant interest from organizations like the United Nations and Travel Oregon, to continue to consider how these signs can be standardized internationally as well as how international travelers comprehend these alternative sign designs. This Tech Transfer activity will contribute to that understanding.

6. Multi-Institutional Project (MG-2013-3) Title: **Data Collection and Spatial Interpolation of Bicycle and Pedestrian Data**. Public transit and non-motorized travel modes represent convenient, affordable, and sustainable alternatives to personal motor vehicles for many travelers. However, understanding travel patterns and mode choice behavior is crucial to making well-informed planning and operations decisions that will optimize the allocation of limited resources and increase participation in these modes. Thus, PacTrans and the Washington State Department of Transportation jointly funded research focused on leveraging current data collection efforts to obtain more complete travel demand information, and introducing new methods that have the potential to reduce cost and improve the quality and coverage of transportation data. Methods developed in this work have a great deal of potential for practical application in non-motorized mode and transit data collection. However, the issue of public acceptance and cooperation was identified as a possible barrier to large-scale implementation of wireless MAC address sensing. Therefore PacTrans has allocated additional funding to an outreach project that will develop a short film explaining this unique data collection paradigm to the non-engineering public, with the aim of addressing common complaints regarding privacy and safety. The benefits offered by this method of data collection will be presented, including but not limited to the financial savings to transportation agencies and quality of service

improvements associated with more accurate and complete traveler OD and demand information. The film created in this project will be released publicly via popular video streaming services, and emphasis will be placed on clarity, simplicity, and entertainment value.

7. Multi-Institutional Project (ME-2013-1) Title: **Refinement and Dissemination of a digital platform for sharing transportation education materials.** There are approximately two hundred Introduction to Transportation Engineering courses taught annually in the United States but little evidence to suggest that teaching materials (other than textbooks) are being shared between the instructors of these courses. The National Science Foundation (NSF) spends millions of dollars annually through the Transforming Undergraduate Education in STEM (TUES) program on the development and testing of teaching methods and materials. Conversations with NSF program managers indicate that they are disappointed with the rate of return on this investment, and would like to see much less development and much more sharing and dissemination of best practices. New NSF programs are emerging specifically on utilizing best practices and understanding the adoption process. PacTrans funded a two-year, Multi-Institutional project, bringing together researchers from each of the five Universities in the PacTrans Consortium to address this issue. During the initial phase of this project, the research team developed a framework for a prototype website, the PacTrans Transportation Education Resource Center (pTERC), for sharing transportation curriculum and best practices. PacTrans has since awarded additional funds to this group of researchers to complete the technology transfer process. This process will include the creation of the website explored in the research.

Education

During this reporting period PacTrans Universities continued to utilize the student researchers, data, instruments, and equipment from the transportation labs at each of the five participating consortium universities. These labs include:

University of Alaska at Fairbanks

- Alaska Center for Energy and Power
- Alaska University Transportation Center

Oregon State University

- Driving and Bicycling Simulator
- National Center for Accessible Transportation

University of Idaho

- National Institute for Advanced Transportation Technology

University of Washington

- Human Factors and Statistical Modeling Lab
- STAR Lab
- Urban Form Lab
- Washington State Transportation Center (UW)

Washington State University

- Center for Environmentally Sustainable Transportation in Cold Climates
- Freight Policy Transportation Institute
- Washington Center for Asphalt Technology
- Washington State Transportation Center (WSU)

PacTrans set up external tours for students that included a visit to the Washington State Patrol headquarters (July 22, 2016) in Olympia and the Washington State Department of Transportation's Traffic Management Center (December 7, 2016). PacTrans universities' students also had the opportunity to participate in a number of regional and nationwide competitions. The University of Washington Institute of Transportation Engineers Student Chapter team won the gold medal at the 24th Annual Bill Kloos Traffic Bowl in Portland, Oregon (November 19, 2016), and a team of students from the University of Alaska Fairbanks garnered first place in all categories of their ASCE Steel Bridge Competition for the Pacific Northwest Conference (May 22-23, 2016).

As part of the 2015 PacTrans Regional Transportation Conference, which will be discussed in the following subsection, PacTrans hosted its annual Region 10 Student Transportation Conference (October 17, 2015). This event brought together fifty students from the five consortium universities for a panel discussion with young transportation professionals, speakers from the industry, and research poster competitions.

Finally the University of Washington, PacTrans lead university, is excited to announce a new educational opportunity for transportation interested students. The Master of Science in Construction Management degree will now be offering a Construction Management Occupational Safety and Health track. PacTrans universities make continued efforts to create more robust opportunities for learning and researching in transportation and transportation related fields.

Workforce Development

PacTrans had three activities geared at workforce development during this reporting period: the 2015 PacTrans Regional Transportation Conference, and two PacTrans Seminar Series guest lecturers.

On October 16, 2015 PacTrans hosted its third annual Regional Transportation Conference. One hundred eighty nine students, researchers, educators, practitioners, policy makers, and officials from all four states in Region 10 gathered at the University of Washington's Seattle Campus for a day of networking, education, collaboration, research sharing, research funding, and updates on cutting edge technologies.

PacTrans also hosted two guest lecturers who participated in our Seminar Series. Dr. Simon Washington from Queensland University of Technology in Brisbane, Australia joined students, researchers, and industry professionals on August 4, 2015, to discuss the effect of government policy on the promotion of energy efficient vehicles. On November 4, 2015, Dr. Pitu Mirchandani from Arizona State University came and discussed the possible future of proactive traffic management systems.

Outreach

During this reporting period PacTrans made great use of the ample opportunities to participate in external functions that make the center more visible, show off our research, add expertise and influence, advertise to potential student, and build strong partnerships within the industry. The following is a brief list of these functions:

1. PacTrans Dr. David Hurwitz and Dr. Haizhong Wang participated in the 15th COTA International Conference of Transportation Professionals which took place on July 25-27, 2015 in Beijing, China wherein Dr. Hurwitz presented a PacTrans sponsored research entitled, "Driving Simulator Evaluation of Alternative Information Signs in Oregon. Dr. Wang on the other hand chaired an international forum of young scholars and presented a research entitled, "Understanding Interdependencies between Networks: Toward Resilient Lifeline Infrastructure Systems for Smart Cities". The presentations have generated a lot of interest from conference participants.
2. Director Yin Hai Wang presented at the Washington Traffic Safety Commission (WTSC) Meeting on July 16, 2015 at their office in Olympia, WA and talked about PacTrans goals and mission. He also discussed ways and means we will be able to collaborate with WTSC and form a partnership to jointly address critical transportation issues for Region 10.
3. PacTrans Associate Director for Outreach Mark Hallenbeck of the University of Washington delivered a presentation on the rise of new transportation alternatives and an ORCA data analysis project at the ASCE/ITE/WTS joint meeting on October 14, 2015
4. On October 29, 2015 Dr. Hallenbeck presented on Transportation, Growth, and Equity at the Urban@UW Fall Workshop
5. Intelligent Transportation Society of America Symposium and STAR Lab Tour, July 16 and 17, 2015, tackled dramatic urban changes and cost with tremendous impact on transportation, mobility, and demographic shifts. Dr. Wang, director of PacTrans, also introduced PacTrans research at this Symposium.
6. Meeting with the Honorable Anthony Foxx on Beyond Traffic Forum with the City of Seattle and Local Agencies on October 6, 2015 at the Seattle City Hall. PacTrans participated in this opportunity to provide direct insights on the draft "Beyond Traffic" framework, intended to ignite a national conversation on how new technologies and public policy will shape U.S. transportation systems to enable new safety, mobility, growth, and economic benefits over the next 30 years.
7. Dr. Wang presented at the Workshop of Innovative Technologies and Methods to Improve Transportation Systems in Southwest Jiaotong University, China, on July 29, 2015. He spoke on mobile sensing for pedestrian and bicyclist data.
8. Dr. Wang was invited to speak at the 2015 Oklahoma Transportation Research Day on October 20, 2015. He talked about PacTrans research on data-driven solutions and the DRIVE Net system being developed at the STAR Lab.
9. At Georgia Tech's National Center for Transportation Systems Productivity and Management (NCTSPM), on August 27, 2015, Dr. Wang spoke on transportation big data analytics for smart cities applications.
10. In July 2015, PacTrans representative Maria Bayya attended the 2015 AASHTO Research Advisory Committee/Transportation Research Board State Representative Meeting in Portland, Oregon.
11. In October 2015 PacTrans PIs, researchers, and students attended/presented at the inaugural Institute of Electrical and Electronics Engineers (IEEE) International Smart Cities Conference in Guadalajara, Mexico. Participating students also hosted a PacTrans informational booth throughout the conference. Dr. Yin Hai Wang served as a co-chair of this conference.

- **What opportunities for training and professional development have the program provided?**

Many of these opportunities have been discussed above. PacTrans provides training and professional development opportunities through multiple channels:

Research: All the selected and PacTrans funded research projects have and will continue to involve graduate students, which also provides many opportunities to work with state and local transportation agencies. By involving students, PacTrans provides students an invaluable opportunity to develop skills they need to be successful in their future careers in academia, industry, and government.

Education: Beyond the new online construction management track discussed in the above subsection, PacTrans consortium partners offer a variety of other on-campus and online courses designed for professional development. The online programs, such as the online master's program of sustainable transportation, are particularly good for working professionals because of the flexibility in schedule and location. Also, PacTrans offered PacTrans fellowships to attract outstanding students to join its transportation graduate programs. The new PacTrans fellows started their masters' studies include: Jeffrey Conor, Thomas Steckel, Riley Kimball, Luke Peters, and Rich Lee. PacTrans covers these fellow students' tuitions and links them to the intern jobs open at collaboration agencies and companies.

Outreach: PacTrans offers training and educational opportunities to K-12 students through its outreach activities. For example, PacTrans STAR Lab hosted visitors from K-12 schools including both students and teachers, showcased PacTrans research results to working professionals through technical tours, such as the ITS America Seattle Symposium, and demonstrated its technologies to world-wide audience through international events, such as the 2015 IEEE International Smart Cities Conference.

Funding assistance: PacTrans continues to support student education and research activities. Beyond our PacTrans fellows, for whom we fund tuition, we also give a significant amount of assistance to students to participate in conferences and seminars such as the ITE conferences and student events. This aides them with funds for presentation materials, travel expenses, and registration fees.

Seminars, workshops, and conferences: As outlined above, PacTrans offers many opportunities for training and professional development through its seminar series, annual regional transportation conference, and various workshops. Furthermore, PacTrans also uses its Region 10 Transportation Conference and Region 10 Student Conference as important opportunities for training and professional development. The 2016 PacTrans Region 10 Transportation Conference attracted 189 registered participants and covered a variety of topics including research, education, tech transfer, outreach, and workforce development.

Internships: PacTrans internship program continues to offer students great training opportunities by partnering not only with local agencies but also private industries. We have an internship program with WSDOT, Seattle DOT, Bellevue Transportation Department, Transpo Group, FEHR & PEERS, Parsons Brinckerhoff, Puget Sound Regional Council, DKS, ODOT, etc. Additionally, PacTrans itself also offers intern opportunities for both graduate and undergraduate students to work in the PacTrans consortium university labs to gain hands on experience in transportation.

Partnerships: PacTrans has a partnership program with Institute of Transportation Engineers (ITE). PacTrans has developed strong partnerships with local ITE chapters in student mentoring and training. ITE Washington has a mentor program for university students. They offer student fellowships and also host events for student training.

Retreats: During the current reporting period PacTrans offered staff and faculty two retreat opportunities. On September 9-10, 2015 PacTrans hosted a staff retreat and board of directors meeting in Cle Elum, WA. On September 16-17, 2015 at the Sun Mountain Lodge in Winthrop, WA, PacTrans attended a transportation faculty retreat.

- **How have the results been disseminated? If so, in what way/s?**

PacTrans has a strong outreach program to local and state transportation agencies and private partners in the region, through which PacTrans research outcomes are presented and demonstrated. Research outcomes are posted on the PacTrans website, distributed through our *quarterly newsletter* and *annual reports*, and promoted through social media such as *Facebook* and *Twitter* and the University of Washington *press media*. We also disseminate news, events and results via our website at www.pactrans.org.

The second large component of our dissemination efforts surround facilitating and attending various seminars, workshops and conferences. Many of these have been outline and discussed in previous sections: Regional Transportation Conference (October 16, 2015), Student Transportation Conference (October 17, 2015), IEEE Smart Cities Conference (October 2015), Seminar Series guest lecturers (August 4, 2015 and November 4, 2015).

Finally, per our obligation as a UTC, research results are posted on our website and are disseminated to all of the required repositories that include, TRID, USDOT, Transportation Library, Volpe National Transportation Systems Center, Federal Highway Administration Research Library and the US Department of Commerce National Technical Information Service.

- **What do you plan to do during the next reporting period to accomplish the goals and objectives?**

This center was set to close on January 30, 2016. PacTrans however, has requested, and been approved for, a six-month no-cost extension. This effectively makes our close date July 31, 2016. During these six

months, the Center will continue to work on technology transfer activities making sure that each of the research technology products and activities that we have funded are completed and disseminated to a broad audience. One important event worth mentioning is the Technology Transfer Workshop, jointly organized by PacTrans and the Region 6 UTC, at the 2016 ASCE International Conference on Transportation and Development. We will continue to track progress and document impact to the community by sending out evaluation forms and following responses through social media.

2. Products (for the reporting period of July 1 – December 31, 2015)

	PacTrans Total	UW	WSU	UI	OSU	UAF
Publications: peer reviewed journal articles	73	58	5	1	6	3
Publications: Book chapters and other edited manuscripts	12	12	0	0	0	0
Conference papers	56	26	5	1	20	4
Conference presentations	90	41	10	10	23	6
Lectures/Seminars /Workshops/ Invited Talks	68	49	2	3	12	2
Inventions, patent applications, and/or licenses	2	1	0	0	0	1
Other products: data or databases, physical collections, audio or video products, software or NetWare, models, educational aids or curricula, instruments, or equipment	19	4	2	3	9	1

- **Examples of peer reviewed journal articles**

- 1) Hurwitz, D., Miller, E., Jannat, M., Boyle, L., Brown, S., Abdel-Rahim, A., & Wang, H. (in press) Improving Teenage Driver Perceptions Regarding the Impact of Distracted Driving in the Pacific Northwest. *Journal of Transportation Safety & Security*.
- 2) Neill, J., Hurwitz, D., & Olsen, M. (Accepted 4/10/2015) Alternative Information Signs: An Evaluation of Driver Comprehension and Visual Attention. *ASCE: Journal of Transportation Engineering*.
- 3) Dong, S., Wang, H., Hurwitz, D., Zhang, G., & Shi, J. (Accepted 4/10/15) Nonparametric Modeling of Vehicle-type Specific Headway Distribution in Freeway Work Zones. *ASCE: Journal of Transportation Engineering*.
- 4) Michael Olsen, Joseph Wartman, Martha McAlister, Hamid Mahmoudabadi, Matt O'Banion, Lisa Dunham, Keith Cunningham (in review) Point cloud surface modeling and volumetric analysis for rockfall magnitude-frequency relationship, *Journal of Remote Sensing*

- 5) Moss, R. E. S., Thompson, E. M., Kiefer, D. S., Tiwari, B., Hashash, Y. M. A., Acharya, I., Adhikari, B., Asimaki, D., Clahan, K. B., Collins, B. D., Dahal, S., Jibson, R. W., Khadka, D., MacDonald, A., Madugo, C. L. M., Mason, H. B., Pehlivan, M., Rayamajhi, D. and Uprety, S. (2015). Geotechnical effects of the 2015 magnitude 7.8 Gorkha, Nepal earthquake and aftershocks, *Seismological Research Letters* 86(6). 10.1785/0220150158
- 6) Bham, G., Manepalli, U., Lavvadi, B. (2015 Published CD Rom) Crash Prediction Modelling of State Highways in Arkansas, 5th International Conference, Conference on Road Safety and Simulation, Journal of Road Safety and Simulation Conference
- 7) Bham, G., Minturn, J., Hafele, B., (2015 Published CD Rom) Preliminary Crash Causality Study of Divided Highways with Depressed Medians in Alaska, Journal of Road Safety Conference
- 8) Olsen, M., Wartman, J. McAlister, M., Mahmoudabadi, H., O'Bannon, M., Dunham, L., Cunningham, K., To fill or not to fill: Sensitivity Analysis of the Influence of Resolution and Hole Filling on Point Cloud Surface Modelling and Individual Rockfall Detection, *Journal Remote Sensing*, 2015, 7(9), 12103-12134;doi:10.3390/rs70912103
- 9) Fox J.R., Cox D.P., Drury B.E. , Gould T.R., Kavanagh T.J., Paulsen M.H., Sheppard L., Simpson C.D., Stewart J.A., Larson T.V. and Kaufman J.D. (2015) Chemical characterization and in vitro toxicity of diesel exhaust particulate matter generated under varying conditions. *Air Quality, Atmosphere & Health* DOI: 10.1007/s11869-014-0301-8.
- 10) Adar S.D., D'Souza J., Mendelsohn-Victor K., Jacobs D.R., Cushman M., Thorne P.S., Sheppard L., Burke G.L., Daviglius M., Szpiro A., Diez Roux A.V., Kaufman J.D., Larson T.V. (2015) Long-Term Exposure to Coarse Particulate Matter, Inflammation, and Coagulation: A Cross-Sectional Analysis from the Multi-Ethnic Study of Atherosclerosis. *Environmental Health Perspectives* DOI:10.1289/ehp.1308069.
- 11) Kim S-Y, Sheppard L., Larson T.V., Kaufman J.K., Vedal S. (2015) Combining PM2.5 Component Data from Multiple Sources: Data Consistency and Characteristics Relevant to Epidemiological Analyses of Predicted Long-Term Exposures *Environmental Health Perspectives*. DOI:10.1289/ehp.1307744.
- 12) Alexander D., Larson T.V., Vedal S. and Bolton S. (2015) Associations between a cookstove intervention and lung function in indigenous Bolivian women: a small intervention study. *Global Public Health* (accepted).

- **Example of lectures/seminars/workshops/invited talks**

- 1) Georgia Tech's National Center for Transportation Systems Productivity and Management (NCTSPM). *Transportation Big Data Analytics for Smart Cities Applications*. Aug. 27, 2015.
- 2) Workshop of Innovative Technologies and Methods to Improve Transportation Systems. *Mobile Sensing for Pedestrian and Bicyclist Data*. Southwest Jiaotong University, China, July 29, 2015.
- 3) Oklahoma Transportation Research Day. "DRIVE Net: A Large-Scale Online Data Platform for Performance Analysis and Decision Support." Oklahoma City, Oklahoma, Oct. 20, 2015.

- 4) ITS Washington Annual Meeting. “PacTrans and Its Data-driven Safety Research.” Seattle, Washington, Nov. 3, 2015.

3. Participant and Collaborating Organizations: Who has been involved?

- **What individuals have worked on the program?**

- PacTrans Director, Yin Hai Wang, Ph.D., Professor of Civil and Environmental Engineering at the University of Washington (UW), devotes 10 percent of his time directing PacTrans. Dr. Wang has overall responsibility for program management, oversight of PacTrans operations, including the Research Committee, the Education and Workforce Development Committee, and the Outreach and Technology Transfer Committee, and Student Leadership Council. He is the regional and national leadership for PacTrans, and the contact person for management relationships with USDOT Research and Innovative Administration (RITA) and other USDOT organizations.
- PacTrans Associate Director in Research, Linda Ng Boyle, Ph.D., Professor with joint appointments in Industrial and Systems Engineering and Civil and Environmental Engineering at the UW spends 5 percent of her time managing the research program for PacTrans and coordinates the research collaboration across the five partner institutions.
- PacTrans Associate Director in Education and Workforce Development, Anne Vernez-Moudon, Dr. es SC, Professor of Architecture, Landscape Architecture, and Urban Design and Planning, Adjunct Professor of Epidemiology and in Civil and Environmental Engineering, devotes 5 percent of her time leading the Education and Workforce Development Committee. She is involved in curriculum changes, professional training program development, and educational enhancements among the partner institutions.
- PacTrans Associate Director in Outreach, Mark Hallenbeck is also the Director of the Washington State Transportation Center (TRAC) office located at the UW. Mr. Hallenbeck works closely with Associate Director Anne Vernez-Moudon in organizing student seminars, internships and fellowship programs.
- PacTrans Associate Director in Oregon State University (OSU), Chris Bell, Ph.D., Professor of Civil and Construction Engineering at OSU, devotes 5 percent of his time to managing and organizing the education, outreach, and research activities within OSU. He coordinates all results and outcomes with the UW on a regular basis.
- PacTrans Associate Director in the University of Alaska Fairbanks (UAF), Billy Connor, Director of the Alaska University Transportation Center (AUTC), devotes 5 percent of his time to managing and organizing the education, outreach, and research activities within UAF. He coordinates all results and outcomes with the UW on a regular basis.

- PacTrans Associate Director in University of Idaho (UI), Ahmed Abdel-Rahim, Ph.D., Associate Professor of Civil Engineering at UI, devotes 5 percent of his time to managing and organizing the education, outreach, and research activities within UI. He coordinates all results and outcomes with the UW on a regular basis.
- PacTrans Associate Director in Washington State University (WSU), Ken Casavant, Ph.D., Professor and Transportation Economist in the School of Economic Sciences at Washington State University (WSU) and Director of WSU's Freight Policy Transportation Institute, devotes 5 percent of his time to managing and organizing the education, outreach, and research activities within WSU. He coordinates all results and outcomes with the UW on a regular basis.
- From July to December 2015, Assistant Director, Ms. Maria Bayya, devoted 10 percent of her time to the day-to-day operations in support of the PacTrans mission. Her responsibilities include project management, grant management, events coordination and outreach, and managing the PacTrans operations team.
- Ms. Elysse Reyna is PacTrans Communications Manager through September 2015. Ten percent of her time is devoted in managing and coordinating all aspects of PacTrans publications which include newsletters, website content and annual reports.
- PacTrans full-time Program Coordinator, Ms. Melanie Paredes, devoted 10 percent of her time to the Center's fiscal matters, support with events coordination and outreach and day to day administrative tasks.
- Weibin Zhang, Ph.D., Research Associate in the PacTrans STAR Lab at the University of Washington, devotes 30% of his time in providing research support and oversight of PacTrans consortium and center projects which include multi institution and small center projects.
- Graduate Student Assistant devotes 10 percent to assist with facilitating and coordinating seminars, workshops and events.
- The Student Leadership Council, composed of graduate students at all Consortium partner universities, is an active part of the PacTrans management structure. The Student Leadership Council facilitates student and center communications and plans their own activities.
- Additionally, PacTrans has 27 fulltime faculty at the UW engaged in transportation research. Our consortium partners (OSU, UI, WSU, UAF) have 41 fulltime faculty directly involved in PacTrans research.

- **What other organizations have been involved as partners?**

The state transportation agencies in Alaska, Idaho, Oregon, and Washington have all been extensively involved in PacTrans in terms of research, outreach, and technology transfer activities. Their research office directors are members of our PacTrans External Advisory Board (EAB), which provides strategic oversight to the PacTrans Board of Directors. In addition to the state DOTs, many other public transportation agencies and private companies are also actively involved in PacTrans activities. We have interactions and have partnered with City of Bellingham, City of Seattle, City of Lynnwood, City of Bellevue, City of Everett, King County, Snohomish County, Pierce County, Washington Traffic Safety Commission, Puget Sound Regional Council (PSRC), Washington Transportation Investment Board, American Society of Civil Engineers (ASCE), Institute of Electrical and Electronics Engineers (IEEE), and Institute of Transportation Engineers.

The PacTrans EAB provides strategic guidance to the PacTrans Board of Directors. In addition to state DOT members on the PacTrans EAB, membership includes a representative from BMW, Inc., Port of Portland, PSRC, as well as a representative from Idaho industry, Western Trailers.

PacTrans also collaborates with Portland State University's UTC (NITC), University of Idaho's TranLIVE, and UAF's CESTiCC on various Region 10 events.

We have partnered with private companies and non-profit organizations such as, Aichele and Associates, Alstom Grid Inc., Alta Planning and Design, Battelle, Cascade Bicycle Club, Feet First, DKS, Fehr and Peers, Inrix Inc. Transpo Group, ITS America, Luum, Kittelson and Associates, Inc. to name a few.

4. Impact

- **What is the impact on the development of the principal discipline(s) of the program?**

PacTrans has been dedicated to developing data-driven safe and sustainable solutions to the diverse transportation needs of the Pacific Northwest. Specific impacts are from all PacTrans activities, including those for research, education, outreach, workforce development, and technology transfer.

Specifically, the following impact has been observed:

- Washington legislators passed Bill 1695 based on PacTrans researcher findings from Project SR-WSU-2012-1 (Laboratory evaluation of recycled concrete as aggregate in new concrete pavements). Professors Haifang Wen and David McLean, co-PIs of this project, found that recycled concrete aggregates (RCA) have no significant effects on the compressive strength, modulus of rupture, coefficient of thermal expansion, drying shrinkage, or freeze-thaw durability of hardened concrete for up to a 45% replacement of coarse RCA for natural coarse aggregate. The concrete industry, which was very interested in Wen's research, took this research to the legislature this past year. By January 2016, the Bill mandates a minimum use of 25% recycled concrete and a higher percentage

in the future, with usage steadily increasing in the subsequent years. Project SR-WSU-2012-1 was selected by AASHTO as a 2014 Sweet Sixteen High Value Research Project.

- PacTrans and Washington State Transit Insurance Pool (WSTIP) jointly investigate collision avoidance technology. This research effort received funding support from the TRB Transit IDEA program, WSTIP, and PacTrans. Bus collisions with pedestrians or cyclists are very costly and difficult to prevent because pedestrians or bicyclists may be hidden in a blind spot unvisitable from the bus driver when the bus is turning or merging into or out of traffic. Collision avoidance systems help detect nearby pedestrians or bicyclists are highly desirable to improve transit vehicle safety. This research work will install the Mobileye system produced by ROSCO Vision Systems on 36 busses to test the effectiveness of the Mobileye system. Even though this research project is just started, there are already impacts on transit operators and users. More details of this story can be found in an article published in Mass Transit at <http://www.masstransitmag.com/article/12127151/wstip-awarded-trb-idea-grant-to-study-and-evaluate-collision-avoidance-technology>.
- PacTrans researchers studied “Recycling Scrap Fiber into Permeable Pavements.” Funded by Boeing and PacTrans, Professors Haifang Wen, Liv Haselbach, and Somayeh Nassiri of WSU made an investigation on whether recycling Boeing’s scrap carbon fiber to strengthen the permeable pavement is feasible. If successful, scrap carbon fiber materials will find their places for permeable pavement applications and therefore avoid the cost and potential environmental problems in disposing them. More details of this project can be found at <http://depts.washington.edu/pactrans/pactrans-researchers-works-on-recycling-scrap-fiber-into-permeable-pavements-sponsored-by-boeing/>.
- The Greenroads Foundation, resulted from a previous Region 10 UTC research project, is continuing its success by enhance sustainable roadway design and construction standard. PacTrans is teaming up with the University of Washington’s American Public Works Association (APWA) Student Chapter to fund a Technology Transfer effort called, “Greenroads Bootcamp.” It is a full-day training event that involves: (1) a 1-hour general audience lecture about roadway sustainability and Greenroads, (2) a 2-hour in-depth training session on how to use the Greenroads Rating System to rate roadway projects, (3) a 1-hour information session with interested students, and (4) free passes for any in attendance wishing to take the Greenroads professional accreditation exam (STP Exam). Professor Steve Muench is the PI for this project. A list of projects using the Greenroads rating system can be found at <https://www.greenroads.org/307/projects.html>.
- Project MG-2013-3 (Data Collection and Spatial Interpolation of Bicycle and Pedestrian Data) resulted in several new tools and methods for cost-effective collection of pedestrian and bicyclist data. This project is led by Professor Michael Lowry of UI and Professor Yin Hai Wang of UW. In particular, the mobile sensing technology that collects people movement data via matching the Media Access Control (MAC) addresses detected in Bluetooth and/or Wifi signals offers a much cheaper way to collect pedestrian and bicyclist data. This technology was tested on transit vehicles operated by the UW and the results were encouraging. More details of the test can be found in a story published by GeekWire at <http://www.geekwire.com/2016/signals-bus-riders-smartphones-giving-researchers-new-insights-transit-use/>.

- **What is the impact on other disciplines?**

Faculty of multiple other disciplines worked directly or collaboratively with transportation faculty in our consortium. During this reporting period, we communicated and collaborated with professionals in environmental engineering, electrical engineering, computer science and engineering, public health, public policy, and mathematics for various PacTrans activities. Our regional transportation needs are clearly delivered to people from these relevant disciplines. They will join our effort in development of data-driven, sustainable solutions for the diverse transportation needs of the Pacific Northwest. One great example is Project SR-OSU-2013-7 (Improving Sustainability of Urban Streets via Rain Gardens – How Effective Are These Practices in the Pacific Northwest) that resulted in the OSU-Benton County Green Stormwater Infrastructure Research (OGSIR) Facility, an Oregon BEST Lab. It is a field research facility for testing green stormwater infrastructure (also called Low Impact Development technologies). It is located at 360 SW Avery Ave., in Corvallis, Oregon. This facility will be greatly important for studying transportation sustainability and water environment. For more information, please read a story published by Gazette-Times at http://www.gazettetimes.com/news/local/county-unveils-outdoor-stormwater-lab/article_b723c43a-53f1-11e4-825a-23d01d8a24d9.html. Additionally, contacts have been received by Dr. Yin Hai Wang about applying the mobile sensing technology to other fields, such as smart building and residence occupancy research.

- **What is the impact on transportation workforce development?**

PacTrans continues its dedication to transportation workforce development. In addition to the award-winning intern program with WSDOT and several other new intern programs recently established, PacTrans is making great efforts to merge the gap between practice and university education. In the *Transportation Workforce Challenge Recruiting, Training, and Retaining Qualified Workers for Transportation and Transit Agencies* published by Transportation Research Board as Special Report 275 (<http://www.trb.org/Publications/Blurbs/152777.aspx>), technology options, system integration, data management and analysis skills, etc. are considered top 10 key competencies for future ITS professionals. PacTrans research and educational efforts directly contribute to the training materials needed for transportation workforce development. Our four online transportation degree granting programs continue to play an important role in workforce development, serving over 160 continuing education students during the reporting period. Furthermore, PacTrans is making progress to re-establish the fellowship program with WSDOT, which has been proven successful over the past decades but interrupted because of the financial crises occurred in 2009.

- **What is the impact on physical, institutional, and information resources at the university or other partner institutions?**

PacTrans completed fourteen regional projects and 39 small projects funded by this UTC grant. All these projects have produced many useful research findings. They have added new physical, institutional, and information resources and facilitate cross sharing of existing resources among consortium partners. Research laboratories of PacTrans consortium partners working on PacTrans projects added new research equipment, software tools, and other academic resources as part of their research efforts. For

example, the UW STAR Lab is sharing its big data analytics system, DRIVE Net (<http://uwdrive.net/STARLab>) with researcher partners at Washington State University, the University of Idaho, and Oregon State University for multiple research efforts. DRIVE Net will also be used to host the interstate highway network elevation data for access of the general public.

Also, there are approximately two hundred Introduction to Transportation Engineering courses taught annually in the United States but little evidence to suggest that teaching materials (other than textbooks) are being shared between the instructors of these courses. In 2012, PacTrans funded a two-year, multi-Institutional project (ME-2012-1), bringing together researchers from each of the five Universities in the PacTrans Consortium to address this issue. Upon completion of this project, the research team developed a framework for a prototype website, the PacTrans Transportation Education Resource Center (pTERC), for sharing transportation curriculum and best practices. Tech transfer funding is provided to the research team to make the website available for instructors to use. pTERC is expected to provide great support to introduction level courses of transportation engineering.

- **What is the impact on technology transfer?**

PacTrans emphasizes technology transfer and involves relevant parties early in those funded projects with a technology development component. In the 2015 PacTrans Region 10 Transportation Conference, technology transfer was a main focus and a session dedicated to technology transfer was organized. Mr. Santiago Navarro, Technology Transfer Program Manager at the Office of the USDOT Assistant Secretary for Research & Technology, delivered a presentation on this important issue. Vikram Jandhayala, Vice Provost for Innovation at the UW, also delivered a speech on technology transfer. The conference offers a great platform for researchers, practitioners, and investors to come and talk about research products for possible technology transfer.

Following the PacTrans BOD decision made in 2014, a deliverable for technology transfer is required in every PacTrans funded research project. Such a deliverable could be a video clip, a presentation file, or a website. The classical research report cannot satisfy this requirement. Also, PacTrans awarded seven research projects technology transfer funds to facilitate the technology transfer process. An example of these project is SR-WSU-2012-1 (Laboratory evaluation of recycled concrete as aggregate in new concrete pavements) that led the Washington State Legislature to recently pass Bill 1695 that calls for the use of recycled concrete in future building projects.

- **What is the impact on society beyond science and technology?**

Because transportation is related to everyone's daily life, our study research certainly has an important impact on everyone's life. Through regular open day events and other international exchanges, PacTrans Research Laboratory has received thousands of visitors, and exhibits our research products to the general public. For example, the STAR Lab hosted a delegation from Sichuan Province in China and contributed to the establishment of the 2+2 (two governments and two universities) collaboration agreement between Washington State and Sichuan Province (two governments) and the UW and Tsinghua University (two universities).

Approximately 60% of fatalities on our nation's roadways are the result of lane departure (e.g., crossing of centerline or run-off-the-road) crashes. A variety of transportation engineering solutions have been proposed to mitigate the occurrence of lane departure crashes, including but not limited to: the safety edge, nighttime visibility, rumble strips, retroreflectivity, and pavement lane markings. While these strategies have shown varying degrees of promise in particular contexts, they do not immediately address all of the causal factors inherent in road users (motor vehicle and all-terrain vehicle operators), such as fatigue, operating under the influence, distraction driving, etc. There is a critical need to raise the awareness of the traveling public in the Pacific Northwest about the risks regarding lane departure crashes and how behaviors can mitigate their occurrence.

PacTrans' outreach research project (MO-2013-1) helps raise the awareness of the traveling public about the risks regarding lane departure crashes. Efforts made in this project include a student video/media competition to encourage safer driving practices in the Pacific Northwest region, lectures at participating high schools, etc. They target schools and universities in the Pacific Northwest region to engage students on the importance of attentive and safe driving habits that can serve to minimize lane departures while driving. School-based initiatives have been proven to be an effective means of changing behaviors at the household level, including environmental awareness, eating habits, and other healthy lifestyle choices. It is anticipated that by engaging high school and college students across the Pacific Northwest, a larger audience can be made aware of the risks regarding lane departure crashes and how certain behaviors can mitigate their occurrence.

5. Changes/Problems

Nothing to report.

6. Special Reporting Requirements

Nothing to report.