



Program Progress Performance Report for University Transportation Centers

Prepared for the USDOT Office of the Assistant Secretary for Research and Technology (OST-R)

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Project title: **Pacific Northwest Transportation Consortium (PacTrans): Developing Data Driven Solutions and Decision-Making for Safe Transport in the Pacific Northwest**

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Reporting Period End Date: September 30, 2016

Report Term: Semi-Annual

Accomplishments

What are the major goals and objectives of the program?

Pacific Northwest Transportation Consortium (PacTrans) consists of institutions from all four states in our region with the University of Washington (UW) as the lead and Oregon State University (OSU), University of Alaska Fairbanks (UAF), University of Idaho (UI), and Washington State University (WSU) as partner institutions. PacTrans' theme centers on "Developing Data Driven, Sustainable Solutions for the Diverse Transportation Needs of the Pacific Northwest". PacTrans will serve as a focal point within Region 10 to develop initiatives and facilitate collaborative activities with regional partners to maximize the effectiveness of their collective services and programs toward the U.S. Department of Transportation (USDOT) strategic goal of safety. Major goals and objectives of PacTrans include:

Research – serving as Region 10's research engine, PacTrans is committed to funding research in both the categories of advanced and, more importantly, applied research.

Technology Transfer – PacTrans strives to be an applied technology showcase, providing additional funds to projects that are deemed as "Success Stories" to ensure dissemination of results to policy makers, educators, practitioners, other transportation professionals, and the general public.

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, mentoring, and scholarship opportunities for our students and future workforce trainees.

Workforce Development – PacTrans endeavors to be a workforce development base: hosting activities that focus on the development of transportation professionals, building strong partnerships with transportation agencies and companies in our region, and designing training programs to address the workforce development needs, while 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 and agency partners, attracting new research, and providing opportunities to share and learn about key outcomes and achievements that have been learned through research.

Collaboration – PacTrans desires to be a platform for participation and is always on the lookout for potential new partner and new opportunities with current partners to collaborate on transportation related endeavors.

What was accomplished under these goals?

During the period from April 1, 2016 – September 30, 2016, PacTrans was actively engaged in each goal and objective identified above. This was achieved through a breadth of activities that were conducted to ensure our transportation expertise contributes to the advancement of the region's transportation research, technology transfer, education, workforce development, outreach, and collaboration.

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.

PacTrans is currently collecting draft reports from year 3 (2015-2016) and year 4 (2016) funding cycles and is preparing to have those draft reports reviewed both for formatting consistency and for technical content. Once drafts have been reviewed, PIs will have one month to make revisions and resubmit final research project reports. These reports will then be promptly posted on the PacTrans website and upload to 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.

These projects have a diversity of topics under the purview of safety including: interactions between bikes and commercial delivery vehicles in commercial loading zones, development of low cost remote weather information systems, interdependency and real-time conditions assessment of critical lifelines in natural disasters, continued development of Bluetooth and WiFi mobile sensing technologies for safety data collection, aerodynamic effects on rural highways, and many more.

PacTrans has also recently selected, and is preparing to distribute funding for the year 5 (2016-2017) funding cycle. A total of six multi-institution projects (including a multi-institution education project and a multi-institution outreach project) have been select. Further, each individual institution has selected between three and five single-institution projects to fund during this cycle (for a total of 18 single-institution projects).

Technology Transfer

PacTrans is making its best effort to promote technology transfer through the early engagement of interested partners in its research projects. For each selected multi-institutional projects, PacTrans requires the research team to deliver a product for tech transfer. \$20,000 technology transfer funds are reserved for the potential technology transfer activities upon the successful completion of the proposed research for each multi-institutional project. Once a sufficient pool of projects have been completed, the center will solicit submissions for "success stories." Success stories are just that, research that merits the added funding and effort to make sure that the findings and conclusions of the project are disseminated to the appropriate entities. Thus PIs will submit proposals on how they would further disseminate and/or apply their findings in thoughtful and useful ways. Then PacTrans board of directors and advisory committees will select a handful of projects to receive sufficient funding to execute the proposed activity(s). With all of the year 3 (2015-2016) and year 4 (2016) research currently being submitted,

PacTrans is preparing to solicit such “success story” submissions.

During the reporting period, PacTrans PIs took many opportunities through conference, seminars, and workshops to showcase our accomplishments of the ongoing research projects. Several key examples of these events include:

Collaborate with transportation agencies and companies to facilitate the technology transfer process. On September 16, 2016, U.S. Transportation Secretary Anthony Foxx announced eighteen **Mayors’ Challenge Pedestrian and Bicycle Awards at the 2016 Safer People, Safer Streets Summit** in Washington, DC. Among the winners was our very own Bellevue, WA. There award was based on the collaboration effort of a City of Bellevue, PacTrans, and Microsoft project that is attempting creating a methodology for predicting bike accidents.

This past June, the 26 through the 29, 2016, the American Society of Civil Engineers (ASCE) held their 2016 annual International Conference on Transportation and Development. The four-day conference, co-sponsored by PacTrans, was held in Houston. **PacTrans director, Dr. Yinhai Wang along with Dr. Musharraf Zaman, professor at University of Oklahoma and director of the Southern Plains Transportation Center, hosted a session on Technology Transfer.** They were joined by Waseem Fazal, of the Federal Highway Administration. Dr. Wang shared about recent successes with our Center’s development of Bluetooth and WiFi mobile sensing technology. He also presented the challenges and obstacles that still stand in the way of these technologies being fully implemented to collect more robust data sets on peoples’ movements.

Education

During this reporting period PacTrans consortium universities’ student competition teams were strong competitors both regionally and nationally:

- 1. UW Hyperloop team (which is sponsored directly by PacTrans) competed in the first-ever SpaceX Hyperloop Pod Competition. The UW team was one of only 26 teams who advanced to the building phase of the competition, and they were awarded the Safety Subsystem Technical Excellence Award for their pod design.**
2. UAF’s Steel Bridge team took 6th place overall at the 2016 National Student Steel Bridge Competition (NSSBC) hosted by Brigham Young University this past May 27 & 28. The event, hosted by the American Society of Civil Engineers (ASCE) and the American Institute of Steel Construction (AISC), features forty-eight-student teams from across the United States, Canada, Mexico and China, competing in areas of steel design, steel fabrication, and teamwork.
3. The University of Washington concrete canoe team competed at the National Concrete Canoe Competition at the University of Texas at Tyler, this past June 9 – 11. The Huskies claimed 10th place out of 21 teams from the United States, Canada, and Middle/ South America, in this ASCE hosted event. Teams competed in categories of design papers, oral presentations, and a series of races in their respective canoes.
4. The University of Idaho’s clean snowmobile team took 7th place overall in the Internal Combustion Class at the SAE International Clean Snowmobile Challenge this past March in Warrendale, PA. The UI team won in the areas of best fuel economy, most likely to be manufactured, most sportsmanlike

winners, CAN-DO-EControls, and most innovative emissions design.

5. Oregon State University's Big Beam team earned 3rd place among competitors throughout North America at the Precast/Prestressed Concrete Institute (PCI) Big Beam Contest. The contest objective is for student teams to fabricate and test a precast/prestressed concrete beam with the help of local PCI members. The beam must be made primarily of concrete without any trusses, arches, or other non-flexural members. Prizes are awarded to the top 20 performers in consideration of efficient design, highest load capacity, and other categories.

There were many other notable achievements in education at PacTrans consortium universities during this reporting period. Several key examples include:

This summer, a team of four officers from the OSU ITE student chapter placed second in the ITE Collegiate Traffic Bowl competition at the Institute of Transportation Engineers Western District annual meeting in Albuquerque, New Mexico. OSU has placed second for the last two years in a row. The OSU ITE Student Chapter was also selected for "Student Chapter Award Honorable Mention."

At the August 2016 Institute of Transportation Engineers (ITE) international annual meeting in Anaheim, California, PacTrans associate director and Oregon State University associate professor, **Dr. David Hurwitz, along with three other members of the ITE University Transportation Curriculum Project (UTCP), received the Transportation Education Council Innovation in Education award.** Hurwitz, along with the other project members, Kristen Sanford Bernhardt, Rod Turochy, and Rhonda Young, received the national honor in recognition of their innovative work over the last seven years on challenges related to undergraduate transportation engineering education.

This summer, Oregon State University's annual Summer Undergraduate Research Fellowship (SURF) program provided eleven fellowships to support hands-on research toward increasing community resilience in response to Cascadia Subduction Zone (CSZ) earthquakes and tsunamis. During the seven-week program, students participated in a specific project related to CSZ hazards, learned about engineering for natural hazards resilience, and developed research skills to increase graduate school opportunities.

Workforce Development

PacTrans had a number activities geared at workforce development during this reporting period. Notably, the center hosted four seminars, Oregon State University developed a new continuing education short course, and PacTrans director continued ongoing talks of establishing a continuing education, workforce development, and training platform for state and local agencies:

On September 23, 2016, PacTrans director, Dr. Yinhai Wang, had a meeting with WSDOT Statewide Workforce Development & Traffic Operations Engineer, Monica Harwood. This meeting pertained to **mutual interest in establishing a continuing education, workforce development, and training platform beginning with WSDOT** and then extending to other agencies. Ms. Harwood clearly expressed WSDOT's need in training and want PacTrans assistance.

On April 14, 2016, Dr. Daniel Sperling, Professor of Civil Engineer at University of California Davis and founding Director of the Institute of Transportation Studies, spoke to a packed lecture hall on the

University of Washington campus. His seminar covered car-centric monoculture and its expensive and resource-intensive nature. He then discussed several emerging revolutions such as energy efficient hybrids, and new propulsion technologies.

In June of this year, Dr. Tarek Sayed from the University of British Columbia gave a PacTrans sponsored seminar titled, *Advances in Proactive Road Safety Management*. Mr. Sayed spoke about two main transportation engineering approaches to improving road safety: reactive and proactive. The traditional reactive approach consists of implementing the necessary improvements to existing hazardous (black-spot) sites in order to improve safety at these sites. The proactive approach is a collision prevention approach that attempts to prevent unsafe road conditions from occurring in the first place.

This past August, Dr. Kelvin Wang, professor of civil engineering at Oklahoma State University (OSU) and Gilbert, Cooper, and W&W Steel chair, presented a PacTrans sponsored seminar on the University of Washington campus. His seminar was titled, *Challenges of Data Automation for Pavement Distress Survey in the 3D World*.

The Oregon State School of Civil and Construction Engineering offered a new short course this summer titled, "Cascadia Resilience." The purpose of the short course was to provide engineering practitioners and related professionals with an in-depth understanding of hazards posed by the Cascadia Subduction Zone and identify effective solution technologies to build more resilient communities.

Outreach

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

1. On April 22 and 23, 2016, the **University of Washington hosted its annual Engineering Discovery Days where thousands of local primary and middle school students, as well as teachers and parents, are invited to campus to learn about engineering programs**. PacTrans and the STAR Lab hosted both an informational booth outside and three separate demonstrations on technologies that have been developed.
2. On May 4, 2016, PacTrans Associate Director Billy Connor of University of Alaska Fairbanks delivered a talk title, Climate Change and Transportation: An Engineering Perspective, at the Sea-Level Rise conference at Florida Atlantic University.
3. On May 17, 2016, PacTrans Director, Dr. Yinhai Wang delivered a talk at the 2016 Gigabit City Summit in Kansas City to promote PacTrans research on smart cities.
4. On May 20, 2016, Oregon State University hosted an Undergraduate Engineering Student Expo where nearly 200 projects were on display for high school and middle school aged kids.
5. On May 30, 2016, PacTrans PI Dr. Haizhong Wang delivered a talk titled Emergent Human Mobility and Network Resilience: An Agent-based Modeling Approach, at the International workshop on Resilient and Sustainable Transportation (i-RESTRA) at Tongji University in Shanghai, China.
6. On June 15, 2016, PacTrans Assistant Director, Cole Kopca, attended the Knowledge Exchange on Undergraduate STEM Education in Alexandria, VA.

7. On June 16, 2016, PacTrans PI Dr. Haizhong Wang of Oregon State University hosted a USDOT Talking Technology Transportation webinar titled *Network-Wide Impacts of Connected Vehicles on Mobility: An Agent-Based Modeling Approach*.
8. On July 15, 2016, PacTrans Director, Dr. Yinhai Wang delivered a talk titled, *Toward Smart and Connected Communities: Challenges and Opportunities in Transportation*, at Hiroshima University in Hiroshima, Japan.
9. On September 12 through 15, 2016, PacTrans Director, Dr. Yinhai Wang, attended the 2nd annual 2016 IEEE Smart Cities Conference at the University of Trento in Trento, Italy. Dr. Wang chaired the inaugural conference last year and continues to sit on the steering committee.
- 10. PacTrans Director, Dr. Yinhai Wang has been elected to the prestigious role on the Transportation & Development Institute's Board of Governors as the Official Nominee for the 4-year position on the Board of Governors, commencing October 1, 2016, and will serve as President of T&DI in 2018.**
11. PacTrans PI, Joseph Wartman of the University of Washington won the prestigious 2016 Burwell Award for his participation in crucial research following the devastating Oso Landslide.
12. PacTrans Associate Director of Education, Dr. Anne Vernez Moudon of the University of Washington has been in the news lately for her work on the comprehensive health impacts of the automobile that will be featured in a three part series in the British medical journal called *The Lancet*.
13. Each year PacTrans funds one ongoing multi-institutional research project in education, and one in outreach. **During this reporting period the outreach project PIs developed and hosted a Safe Driving Public Service Announcement (PSA) Competition.** This competition sought submissions from both college age teams and high school age teams on the subject of roadway departure crashes. Competitors were asked to create a 20 to 30 second video, a series of five tweets or Instagram posts, and a 2x3 foot poster educating the general public about safe driving. Submissions are still coming and PacTrans is excited to share the creative submissions that will ensue.
14. Previously the communications manager and more recently promoted to the role of assistant director, Cole Kopca is about 80% completed with website overhaul that was outlined in the previous PPR.

Collaboration

During this reporting period, PacTrans was very active building new partnerships, strengthening current partnership, and discussing innovative way to better integrate companies and agencies outside of our institutions into our education, research, workforce development, and technology transfer efforts. Several key examples include:

1. On April 8, 2016, BMW Vice President for Government and External Affairs, Frank Breust (who is also PacTrans newest external advisory board member), met with PacTrans director Dr. Yinhai Wang. The meeting, also included Vikram Jandhyala, UW Vice Provost for Innovation, where they discusses future partnership and collaboration opportunities.
2. On April 8, 2016, Dr. Staci Hoff and her group of researchers and program managers from Washington Traffic Safety Commission (WTSC) visited the PacTrans STAR Lab to discuss ongoing collaboration in research efforts, workforce development, and technology transfer activities. Director Yinhai Wang and PacTrans graduate students introduced the Digital Roadway Interactive

Visualization and Evaluation Network (DRIVENet) which is an on-line transportation platform aimed at data sharing, integration, visualization and analysis.

3. On April 18, 2016, PACCAR engineers and managers met with PacTrans director, Dr. Yinhai Wang to discuss student internships and learn more about faculty research of interest to the company with the purpose of gaining more understanding on partnership opportunities.
4. On May 18 and 19, 2016, PacTrans director Dr. Yinhai Wang, along with PacTrans associate director, Mark Hallenbeck, attended a Microsoft hosted Trusted Big Data Sharing Platform workshop at the Impact Hub in the Pioneer Square neighborhood of Seattle. This was the second meeting on the subject and Microsoft is moving forward, with the collaboration of several other entities, including PacTrans and the STAR Lab.
5. On September 16, 2016, U.S. Transportation Secretary Anthony Foxx announced eighteen Mayors' Challenge Pedestrian and Bicycle Awards at the 2016 Safer People, Safer Streets Summit in Washington, DC. Among the winners was our very own Bellevue, WA. There award was based on the collaborative effort of a City of Bellevue, PacTrans, and Microsoft project that is attempting creating a methodology for predicting bike accidents.
6. On September 20, 2016, PacTrans Director Dr. Yinhai Wang and STAR Lab student researcher Ruimin Ke attended the WSDOT Public Transportation Conference in Wenatchee, WA to present collaborative research with the Washington State Transit Insurance Pool on collision avoidance systems for transit buses.

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

Many of the specific details of these opportunities have been discussed above. More generally, PacTrans provides training and professional development opportunities through multiple channels:

Research: Through the lifespan of this grant, PacTrans annually selected research projects that offered faculty and student researchers funding to conduct cutting edge research in a variety of areas directly tied to the USDOT strategic goals.

Education: PacTrans consortium partners offer a variety of other on-campus and online courses designed for professional development in addition to the regular degree programs. 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.

Outreach: PacTrans offers training and educational opportunities to K-12 students through its outreach activities. Examples include: UW engineering discovery days, OSU undergraduate engineering expo, and Alaska Summer Research Academy (ASRA), where high school students enrolled in the ASRA Civil Engineering Module applied basic design principles of statistics and structural analysis showing how engineering principles are used to solve problems.

Funding assistance: PacTrans has supported 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 competitions, conferences, and seminars such as the Hyperloop competition, IEEE

Smart Cities Conference, the Oregon State University hosted Northwest Transportation Conference, and the Transportation Research Board Annual Meeting. 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 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.

Internships: PacTrans internship program offers students training opportunities by partnering with local agencies and private industries. We have internship programs with WSDOT, Seattle DOT, Bellevue Transportation Department, Transpo Group, FEHR & PEERS, Parsons Brinckerhoff, Puget Sound Regional Council, ODOT, etc. Additionally, PacTrans also offers intern opportunities for both graduate and undergraduate students to work in 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.

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, where 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. While the Fall and Winter (the other six-month reporting period) contain most of the large scale dissemination opportunities (such as the annual TRB meeting and the PacTrans Regional Transportation Conference), PacTrans PIs and student researchers take many contributory opportunities to highlight research findings. Examples of these can be found above in the “Outreach” section and below in the “Example of lectures/seminars/workshops/invited talks” and “Examples of Conference Papers and Presentation” sections.

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?

PacTrans is excited for the busy season ahead. Below are the center’s identified plans and strategies for accomplishing its goals and objectives over the next reporting period.

Research

As detail above, PacTrans is going to have a very busy six months ahead in the research department. Two different funding cycles of research will be coming in that needs to be peer reviewed, finalized, and disseminated. Further, six new multi-institution and eighteen new small projects need to be funded to that PIs can begin work. Finally, **PacTrans will implement a new research project feature called the hot sheet.** This idea came from several other UTCs at the summer CUTC meeting in Los Angeles. Hot sheets are an efficient and approachable way to share current and ongoing research projects with a broader audience. These hot sheets will be made available through the PacTrans website.

Technology Transfer

The first and second round of research funding projects under this grant are currently being submitted by PacTrans PIs. Subsequently, this next reporting period will be an exciting time for technology transfer activities.

PacTrans will encourage and cultivate the importance of technology transfer among PIs in the following ways:

1. PacTrans will solicit submissions for “success stories.” Once selected, a handful of projects will receive additional funding to engage in innovative technology transfer techniques.
2. PacTrans will continue supporting PIs and student researchers to conferences, seminars, and workshops where these findings can be presented to a broader audience.

Further, during this next reporting period PacTrans will host its annual Regional Transportation Conference, the subsequent student conference, and send many PIs and student researchers to the annual TRB meeting in Washington DC to present PacTrans work.

Education

There will be a lot going on in the education subject during this upcoming reporting period.

1. **PacTrans will host the 2016 Region X Student Conference in Seattle, Washington on October 15, 2016.**
2. University of Washington PacTrans student researchers will visit the Washington State Traffic Management Control Center on December 5, 2016.
3. PacTrans will provide financial support to qualifying graduate students to attend the annual TRB meeting in Washington DC in January.
4. The ITE Bill Kloos Traffic Bowl will be held on November 17, 2016.
5. **The University of Washington’s Supply Chain and Transportation Logistics Center will be opening its new Urban Freight Lab.**

Workforce Development

The center has three main focuses for on workforce development over this next reporting period:

1. **PacTrans will host the Regional Transportation Conference, which will feature two keynotes, four topic sessions (which will include a total of twelve presenters), a poster session, and a networking hour. This conference is projected to have well over 200 individuals from private companies,**

public agencies, and academic institutions.

2. The center has a number of meetings on the books with WSDOT to continue discussing state and local DOT needs with regard to the development of the continuing education, workforce development, and training platform outlined above for state and local DOTs.
3. PacTrans will host Dr. James Tsai, a professor of School of Civil and Environmental Engineering at Georgia Tech and an adjunct professor of School of Electrical and Computer Engineering at Georgia Tech, for the quarterly PacTrans Regional Transportation Seminar. Further, the Center is currently in the process of identifying and scheduling winter and spring guest lecturers.

Outreach

The center will continue sending faculty and student researchers to seminars, workshops, and conferences to further goal of making PacTrans and its research more visible to practitioners, decisions makers, students, educators and others in the transportation sector. For example, **PacTrans director Dr. Yinhai Wang has been invited to give the keynote address at the 15th Global Spatial Data Infrastructure World Conference on November 29 through December 2, 2016, in Taipei, Taiwan.**

Collaboration

PacTrans has a number of exciting opportunities in the works for collaboration. For example, Washington State Senator Joe Fain (of the 47th Legislative District) has scheduled a meeting with PacTrans Director Dr. Yinhai Wang to discuss PacTrans and STAR Lab research efforts. Senator Fain also sits on the Transportation (Budget Leadership) Committee. Dr. Wang is hopeful that a stronger partnership between state government and the Center will lead to great opportunities for collaboration.

Products (reporting period: April 1, 2016 – September 30, 2016)

	Total	UW	WSU	UI	OSU	UAF
Publications: peer reviewed journal articles	159	87	1	19	48	4
Publications: Book chapters and other edited manuscripts	14	9	0	2	2	1
Conference papers	107	40	5	13	41	8
Conference presentations	141	59	5	23	44	10
Lectures/Seminars /Workshops/ Invited Talks	109	49	12	10	35	3
Technologies or Techniques	12	1	3	2	3	3
Inventions, patent applications, and/or licenses	1	1	0	0	0	0
Websites or Other Internet Sites	9	3	0	2	3	1
Other products: data or databases, physical collections, audio or video products, software or NetWare, models, educational aids or curricula, instruments, or equipment	9	3	2	1	1	2

Examples of peer reviewed journal articles

- Wang*, Z., Wu, B., and Wang, Y. (2016) "Comparison of Delay Estimation Models for Signalized Intersections Using Field Observations in Shanghai." IET Journal of Intelligent Transportation Systems. 10(3), 165-174, 2016. <http://dx.doi.org/10.1049/iet-its.2014.0280>
- Barbosa, A.R., Trejo, D., and Nielson, D. (2016). "Effect of High Strength Steel on Shear Friction Behavior." ASCE Journal of Bridge Engineering, In Press
- Hurwitz, D., Miller, E., Jannat, M.*, Boyle, L., Brown, S., Abdel-Rahim, A., and Wang, H. (2016) "Improving Teenage Driver Perceptions Regarding the Impact of Distracted Driving in the Pacific Northwest," Journal of Transportation Safety & Security, Volume 8, Issue 2, 148-163. <http://www.tandfonline.com/doi/full/10.1080/19439962.2014.997329>
- Barbosa, A., Trejo, D., and *Nielson, D. R., (2016) "Performance of Shear Specimens Reinforced with High Strength Reinforcing Bars," Accepted for Publication, ACI Structural Journal, April 2016.
- Bacon, C., Abdel-Rahim, A., Chang, K., and Patel, K. (2016) "Intersection Treatment Alternatives to Address Holiday Traffic Congestion and Delays", CD-ROM, Proceedings of the TRB 95th Annual Meeting, Transportation Research Board, National Research Council, Washington, D.C., January 2016, Paper # 16- 2812.
- Lowry, M., *McGrath, R., Scruggs, P., and Paul, D. (2016) "Practitioner survey and measurement error in manual bicycle and pedestrian count programs" International Journal of Sustainable Transportation.
- Howard, E.J., Hurwitz, P.M., Seto, E., Moudon, A.V., and Saelens, B.E. (2016) "Associations between the built environment and traffic-related air pollution exposure while walking: a multi-level analysis." Transportation Research Board D.
- Hughes, R. and MacKenzie, D. (2016) "Transportation network company wait times in Greater Seattle, and relationship to socioeconomic indicators." Journal of Transport Geography 56, pp. 36-44.
- Islam, S.* and Hajbabaie, A. (2016) "Distributed – Coordinated Signal Timing Optimization in Connected Transportation Networks." Transportation Research Part C: Emerging Technologies, August 2016.
- Bertini, R., Wang, H., Knudson, T., and Cartesen, K. (2016) "Toward Assessing State Department of Transportation Readiness for Connected Vehicle/Cooperative Systems Deployment Scenarios: An Oregon Case Study." Journal of Transportation Research Record, Vol. 2559, 2016. DOI: 10.3141/2559-04. (<http://dx.doi.org/10.3141/2559-04>)

Example of book chapters and other edited manuscripts

- Olsen, M.J. Terrestrial laser scanning, ASCE Surveying Engineering Manual.
- Anderson, J. and Hernandez, S. (2016) "Heavy Vehicle Crash Rate Analysis: A Comparison of Heterogeneity Methods Using Idaho Crash Data." Transportation Research Record: Journal of the Transportation Research Board.
- Jafarnejad, A., Gambatese, J., and Hernandez, S. (2016) "Influence of Truck-Mounted Radar Speed Signs in Controlling Vehicle Speed for Mobil Maintenance Operations: An Oregon Case Study." Transportation Research Record: Journal of the Transportation Research Board.
- Wartman, J., Dunham, L., Olsen, M., O'Bannion, M., and Cunningham, K. (2016) "Rockfall Activity Index (RAI): A Lidar-Derived, Morphology-Based Method for Hazard Assessment." Engineering Geology
- Shen, Q. (2015) "Transportation Planning." International Encyclopedia of the Social and Behavioral Sciences. Second Edition, Oxford, UK: Elsevier, Vol. 24, pp. 616-622.
- Wang, Y., Zhang, W., Henrickson, K., Ke, R., and Cui, Z. (2016) "Digital Roadway Interactive Visualization and Evaluation Network Applications to WSDOT Operational Data Usage." Technical report for Agreement T1461, Task 05 of Washington State Department of Transportation. April 2016.

Examples of conference papers and presentations

- Zhu*, W., Li, Z., and Wang, Y. (2016) "Capacity Modeling and Control Optimization for Two-lane Highway Lance Closure Work Zones." Presented by Wenbo Zhu at the International Symposium on Enhancing Highway Performance (ISEHP). June 14-16, 2016.
- Cunningham, K. (2016) Invited presentation, "Unmanned Aircraft System Photogrammetry." California Land Surveyors Annual Conference, March 21 2016, Sonoma, CA.
- Hurwitz, D., Monsere, C., Jannat, M.*, Jennifer, W.* & Razmpa, A. (2016) "An Explanatory Mechanism for Right-hook Crashes at Signalized Intersections." 17th Road Safety on Five Continents, Rio de Janeiro, Brazil, May 17-19. <http://vti.diva-portal.org/smash/get/diva2:927794/FULLTEXT01.pdf>
- Wang, H., Dong, S., and Mostafizi, A. (2016) "Understanding Interdependencies between Systems towards Resilient Critical Lifeline Infrastructures." EMI/PMC2016, May 22 – 25, 2016 Nashville, TN.
- Olson, M. (2016) International Conference on Sustainability in Design, Engineering, and Construction (ISCDEC), Phoenix, AZ, May 2016.
- Chang, K. (2016) American Society of Engineering Education Pacific Northwest Section Meeting; Boise, ID.
- Lowry, M., (with Furth, P., and Hadden-Loh, T.) (2016) "Low-Stress Neighborhood Bikeability Assessment to Prioritize Bicycle Infrastructure" Presented at the 95th Annual Meeting of the Transportation Research Board, National Research Council, Washington, D.C.
- Goodchild, A., McCormack, E., and Butrina. (2016) "An Exploration of Bicycle Safety Impacts from Seattle's Commercial Vehicle Activity" VREF Urban Freight Conference, Gothenburg, Sweden (October 2016)
- MacKenzie, D. (2016) Tsukuba Global Science Week. Tsukuba, Japan. September 19, 2016.

Example of lectures/seminars/workshops/invited talks

- Wang, Y. (2016) Tongji University Bigdata Workshop. "Mining Big Data for Big Transportation Decisions and Discoveries: E-Science of Transportation Approach and Its Supporting Platform." Shanghai, China, July 16, 2016.
- Hernandez, S. (2016) "Inaugural Cascadia Resilience Short Course" (<http://cce.oregonstate.edu/cszresilience>)
- Olson, M. (2016) "Assessing, Coding, and Marking of Highway Structures in Emergency Situations." AASHTO Subcommittee on Maintenance (SCOM) Annual Meeting, Las Vegas, Nevada (July 20, 2016).
- Lowry, M., (2016). "Tools and Strategies for Improving Citywide Bicycle Travel", Distinguished Seminar Series, Northeastern University, Boston, Massachusetts.
- Goodchild, A. (2016) Nectar Joint Cluster 2 and Cluster 3 International Workshop Keynote Address "The role of planning towards sustainable urban mobility" Land use Patterns, Logistics, and Emissions, Brno, Czech Republic (May 2016)
- Shen, Qing. (2016) "Impact of Spatial Development Pattern & Transportation Accessibility on Labor Market: Research Methodology & Evidence", lecture given at World Bank Office in Beijing. May 18, 2016.

Examples of technologies or techniques

- pTERC - Digital Platform for Sharing Transportation Education Materials
- Raspberry Pi version of mobile sensor: used for collecting data through media access control address detection and matching

Examples of Websites

<http://www.sciencedirect.com/science/article/pii/S0966692316304616>

<http://touristinfosign.com/>

<https://youtu.be/4LrmLbwbK7Y>

Participant and Collaborating Organizations: Who has been involved?

What individuals have worked on the program?

- PacTrans Director, **Yinhai Wang**, Ph.D., Professor of Civil and Environmental Engineering at the UW, devotes 50 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 of Transportation Engineering 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, 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 and spends 5 percent of his time in organizing student seminars, internships, and fellowship programs.
- PacTrans Associate Director in Oregon State University (OSU), **David Hurwitz**, 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.
- Assistant Director, **Cole Kopca**, devoted 90 percent of his time to the day-to-day operations in support of the PacTrans mission. His responsibilities include project management, grant management, events coordination and outreach, and managing the PacTrans operations team.
- PacTrans full-time Program Coordinator, **Melanie Paredes**, devoted 90 percent of her time to the Center’s fiscal matters, support with events coordination and outreach and day to day administration.
- **Weibin Zhang**, Ph.D., Research Associate in the PacTrans STAR Lab at the University of Washington, devotes 30 percent of his time in providing research support and oversight.
- 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 such as the Region 10 Student Conference.
- PacTrans has 28 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 table below highlights the many partnerships that PacTrans has built over the duration of this grant:

Partner	Type	Fund Match		Serve on EAB	Project Collaborator	Event Collaborator
		Financial	In Kind			
Alaska State Department of Transportation	Government	X		X		
Idaho Transportation Department	Government	X		X		
Oregon State Department of Transportation	Government	X		X		
Washington State Department of Transportation	Government	X		X		
City of Bellingham	Government					
City of Seattle	Government	X				
City of Lynnwood	Government				X	X
City of Bellevue	Government				X	X
City of Everett	Government					X
King County	Government				X	X
Snohomish County	Government					
Pierce County	Government				X	
Washington Traffic Safety Commission	Government Agency					X

Washington State Transportation Insurance Pool	Government Agency	X				X
University of Alaska, Anchorage	Educational Institution		X		X	X
Washington State Department of Ecology	Government	X				
Puget Sound Regional Council	Government			X		
Washington State Transportation Investment Board	Government Agency					X
American Society of Civil Engineers	Professional Association					X
Institute of Electrical and Electronics Engineers	Professional Association					X
Institute of Transportation Engineers	Professional Association					X
Port of Portland	Government			X		
BMW Group	Private Industry			X		
Western Trailers	Private Industry			X		
Coral Sales Co.	Private Industry	X				
National Institute for Transportation and Communities	University Transportation Center				X	X
Transportation for Livability by Integrating Vehicles and the Environment	University Transportation Center				X	X
Center for Environmentally Sustainable Transportation in Cold Climates	University Transportation Center				X	X
Aichele and Associates	Private Industry				X	
Alstom Grid Inc.	Private Industry				X	
Alta Planning and Design	Private Industry				X	
Battelle	Private Industry				X	X
Cascade Bicycle Club	Non-profit/Foundation				X	X
Feet First	Non-profit/Foundation					X
DKS Associates	Private Industry	X				X
Fehr and Peers	Private Industry				X	X
Inrix Inc.	Private Industry				X	
Transpo Group	Private Industry	X				X
Intelligent Transportation Systems of Washington	Professional Association					X
Luum	Private Industry				X	X
Kittelson and Associates	Private Industry			X		X
Microsoft	Private Industry				X	X
West Salem High School	Educational Institution				X	X

Impact

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

Impacts from PacTrans-funded activities on the development of the principal disciplines to our transportation program has been observed:

1) *Implementation of new technologies to increase efficiency, accuracy, and safety:* With the rapid and exponential growth of America's IT sector, new technologies are under a constant state of evolution. New version and upgrade come out regularly, making the technologies more accessible and less expensive. These characteristics have made such technologies ripe for implementation into current procedure within the transportation industry. PacTrans has had several recent research projects aimed at just such implementation:

- Project 2015-M-UAF-64 entitled, “Unmanned Aircraft System Assessments of Landslide Safety for Transportation Corridors,” explored landslide safety assessment for transportation corridors by capitalizing on recent advances in unmanned aircraft systems (UAS) and new low-cost Structure from Motion (SfM) photogrammetry techniques. The resulting improved hazard assessment techniques will facilitate cost-effective evaluation of landslide safety across the broadly distributed transportation networks of the Pacific Northwest. For interrelated work, UW Professor Joe Wartman, co-PI of this project, was honored the E.B. Burwell, Jr. Award among the seven authors for their study of the March 2014 landslide in Oso, Washington where 43 people were killed. The Burwell Award is given each year by the Geological Society of America. It is the society's most esteemed honor for engineering geology. This news was reported by UW Today and several association websites.
- Project 2015-S-OSU-82 entitled, “Cost-effective bridge safety inspections using unmanned aerial vehicles (UAVs),” evaluated how well UAV technology can be used to perform visual bridge inspections. Since the FHWA requires biennial bridge inspections, evaluating this exciting and emerging technology will provide helpful information to every region in the United States. Results showed that the technology and methods research appeared to be a particularly useful tool for performing initial and routine bridge inspections which are primarily done visually as per AASHTO's Bridge Inspection Manual (AASHTO, 2011). However, for in-depth bridge inspections, the AASHTO Manual requires the inspector to be at arm's length from the bridge. UAS cannot satisfy this requirement; however, imagery collected with a UAS can be highly resolute and somewhat close to the same resolution as the human eye at arm's length. UAS also cannot be used to probe and scrape the bridge as required for some types of in-depth inspections.
- Project 2015-S-OSU-83 entitled, “Development of Low-Cost Wireless Sensors for Real-Time Lifeline Condition Assessment,” proposed to develop a low-cost wireless sensor to assess the condition of the lifeline bridges following a natural hazard. The primary goal of the sensor will be to minimize cost and increase the ease of installation. Off-the-shelf hardware will be adopted to meet the design criteria, emphasizing multiple year autonomous operation. The sensors were be paired with a wide-area network, allowing real-time analysis of the entire transportation system following an event.

Therefore, this project has delivered a low-cost sensor that can be widely deployed throughout the Pacific Northwest transportation network to provide first responders with an overview of the current state, and route appropriately.

2) *Investigation of emerging modal conflict with the rise in healthy transportation options:* In recent years, the U.S. has seen an urban renaissance. People with means are moving back into urban areas looking for more vibrant lifestyles. On the transportation side, these migrants seek accessibility, options, and more interaction. One consequence is an increase in mode split for pedestrians, and more specifically cyclists in our urban areas. With increased competition for precious right-of-way space, conflict has increased accordingly. Several PacTrans PIs have recently investigated several key aspects of this phenomenon:

- Project 2015-S-UW-77 entitled, “An Evaluation of Bicycle Safety Impacts of Seattle’s Commercial Vehicle Load Zones,” identified the correlations between collision rates and commercial vehicle on-street parking activity. This project made several significant observations that has informed Seattle DOT’s revised strategies for Commercial Vehicle Load Zone location, pricing, and design, supporting the design of a safe and commercially accessible urban core.
- Project 2015-S-UW-76 entitled, “Safe Main Street Highways (SMSH),” sought to build tools to identify locations with a high risk of collisions between motor-vehicles and pedestrians or bicyclists. These tools are essential to insure that gains in mobility, air quality, and health are not accompanied by higher rates of injuries and fatalities in vulnerable road users. The overall goal of this project was to assist in complying with Washington State Strategic Highway Safety Plan of zero fatality and serious injury by 2030, and in reducing the number of pedestrian and bicyclists involved in motor-vehicle collisions on state highways.

What is the impact on other disciplines?

Our center theme focuses on data-driven, sustainable solutions for the diverse transportation needs of the Pacific Northwest. PacTrans activities tie naturally to sustainability and data science domains. Researchers from structure engineering, environmental engineering, electrical engineering, computer science and engineering, public health, public policy, and mathematics are attracted to collaborate with our transportation researchers for a variety of PacTrans activities. The interdisciplinary University of Washington Hyperloop student team is a great example, with approximately 70 students from engineering, computer science, economics, business, etc.

Project 2012-ME-OSU-6 entitled, “Digital Dissemination Platform of Transportation Engineering Education Materials,” developed an education platform for transportation engineering materials. National interest abounds in improving engineering education in the US. This interest stems from low performance on concept inventories concerns over the role of the US as a national economic leader, evidence of best practices in curriculum development and pedagogy, and a sense that we can just do things better. These concerns have led to the development of an abundance of materials and methods that are based on effective methods of development and/or been shown to be effective on student learning and other important educational outcomes.

What is the impact on transportation workforce development?

PacTrans continues its intern programs with transportation agencies and companies. For example, the PacTrans-WSDOT intern program involves nine undergraduate student interns to help operate ramp meter controls and other traffic management functions. These intern positions are important for students to understand real-world problems and how the knowledge learned in the universities may be applied to solve problems. PacTrans and WSDOT are also in continued conversations to establish a continuing education, workforce development, and training platform. Once this platform is running, it will then be broadened and expanded to allow other transportation agencies to utilize the same resources.

Consortium universities are constantly implementing new and innovative programs for educating and training the next generation of transportation experts and professions. This summer for example, Oregon State University began a Summer Undergraduate Research Fellowship (SURF) program, providing eleven fellowships to support hands-on research toward increasing community resilience in response to Cascadia Subduction Zone (CSZ) earthquakes and tsunamis. During the seven-week program, students participated in a specific project related to CSZ hazards, learned about engineering for natural hazards resilience, and developed research skills to increase graduate school opportunities.

PacTrans researchers were invited to present at several national workshop and webinars that directly contributed to workforce development. For example, Professor Haizhong Wang of OSU presented at an ITS Professional Capacity Building Program/Advancing ITS Education webinar. His presentation focused on network-wide impacts of connected vehicles on mobility: an agent-based modeling approach.

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

PacTrans has funded 16 regional projects and 43 small projects in using 2014-2017 funds of this center grant. These projects add new physical, institutional, and information resources and facilitate cross sharing of existing resources among consortium partners. For example, Professor Yin Hai Wang is developing a connected vehicle test-bed for testing new sensors, connected vehicle devices, and data analysis methods. This effort is jointly sponsored by PacTrans, WSDOT, and the UW. The testbed offers a great test platform for a variety of transportation safety solutions.

PacTrans associate director and Oregon State University associate professor, Dr. David Hurwitz, along with three other members of the ITE University Transportation Curriculum Project (UTCP), received the Transportation Education Council Innovation in Education award at the Institute of Transportation Engineers (ITE) international annual meeting in Anaheim, California in August. Dr. Hurwitz, along with the other project members, Kristen Sanford Bernhardt, Rod Turochy, and Rhonda Young, received the national honor in recognition of their innovative work over the last seven years on challenges related to undergraduate transportation engineering education. Also worthy of note, PacTrans PI and University of Idaho assistant professor, Kevin Chang, chairs the ITE Transportation Education Council.

What is the impact on technology transfer?

In June, the 2016 American Society of Civil Engineers (ASCE) International Conference on Transportation

and Development was held in Houston, Texas. PacTrans director, Dr. Yinhai Wang along with Dr. Musharraf Zaman, professor at University of Oklahoma and director of the Southern Plains Transportation Center, hosted a session on Technology Transfer for the purpose of promoting UTC research to working professionals. Dr. Wang shared about recent successes with PacTrans research, particularly our Center's development of Bluetooth and WiFi mobile sensing technology.

This same research, on Bluetooth and WiFi mobile sensing technology, was in the news again several times this reporting period as the first of several patents was finalized and a new technology transfer short video was produced to better articulate its capabilities. It has been recently tested on the UW busses as well as on local streets. Several agencies showed strong interest to employ this technology in their daily practice. Please view the video here: <https://www.youtube.com/watch?v=Fi07GCRvRM0>

What is the impact on society beyond science and technology?

This Center's theme focuses on developing data driven solutions and decision-making for safe transport. While all of our data and decision-making solutions are firmly rooted in science and technology, our ultimate goal is toward the end user. More specifically, PacTrans efforts emphasize the education and workforce development of the next generation of transportation professionals and experts, and research and technology transfer regarding the safe transport of people.

The UAV research projects highlighted above seek to one day remove the danger to human in life in the jobs of surveying bridges and critical slopes and instead give them to technology. Simultaneously, these new technologies have the potential to remove human error and increase accuracy in evaluating the state of our crumbling transportation infrastructure and critical slope that have disastrous effects when they fail.

The research highlighted above, and many other PacTrans funded projects, on emerging conflict concerns regarding an increasingly diverse mode split seek to increase accessibility through transportation choices that are safe and reliable. On the flip side, in rural communities, transportation options can be equally dire. PacTrans also has researchers exploring mixed use safety on rural facilities in the Pacific Northwest. The current federal administration has recently coined the phrase, "ladders of opportunity." We feel that these research projects, in particular, are geared toward the very ends that that phrase is referring to.

PacTrans has dozens of other research projects that may be based on science and technology but they each is in some way geared toward making our comprehensive transportation system safer for all.

Changes/Problems

NONE

Special Reporting Requirements

NONE