



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**

Program Director:

Yinhai Wang, PhD
Professor and Director
E-mail: yinhai@uw.edu
Tel: 206.616.2696

Submitting Official:

Cole Kopca
Assistant Director
E-mail: ckopca@uw.edu
Tel: 206.685.6648

Organization Name:

University of Washington
Pacific Northwest Transportation Consortium (PacTrans)
University of Washington
Civil and Environmental Engineering Department
More Hall 112
Seattle, WA 98195

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Reporting Period End Date: September 30, 2017

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, 2017 – September 30, 2017, 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, and typically have a larger budget. Such projects include multi-institutional general research projects (coded with MG), multi-institutional educational projects (coded with ME), and multi-institutional outreach projects (coded with MO). We also engage in single institutional projects (referred to as small research 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.

In the last six months, while PacTrans has been finishing up the external reviewer process for year 3 (2015-2016) and year 4 (2016) funding-cycle research project reports, year 5 (2016-2017) investigators have been working hard on their projects. Draft reports of those projects are due at the end of November. The year 3 and 4 projects will soon be finalized and then disseminated to the proper repositories. 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.

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 will solicit such "success story" submissions soon.

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:

Two different PIs from consortium partner Washington State University presented PacTrans outcomes at freight conferences. In late April, PacTrans Associate director, Eric Jessup, presented *Uncovering Confounding Factors of Large Truck Crashes and Safety Critical Events: An Exploratory Analysis of a Northwest Truck Driver Survey*, at the Transportation Research Forum Conference in Chicago, Illinois. In late May PacTrans PI Ali Hajbabaie presented *A Two-Stage Model for Predicting Crash Frequency by*

Severity Type, at the Pacific Northwest Regional Economic Conference in Bend, Oregon.

In May, PacTrans assistant director, Cole Kopca, traveled to Washington DC along with Student Researcher Ruimin Ke, to the Carnegie Mellon Summit of University Transportation Centers for Safety. Mr. Kopca presented outcomes from the ongoing Outreach project and Ruimin Ke presented PacTrans work on bus-pedestrian collision avoidance technology.

In June, PacTrans assistant director, Cole Kopca, participated in a press conference, hosted by the City of Bellevue, on a project with Microsoft regarding near miss identification software that will revolutionize our ability to collect incident data. This press conference was highlighted on five local news stations and picked up by over twenty media outlets nationally.

Also in June, PacTrans Associate Director, Jeff Ban, attended the 2017 IEEE Intelligent Vehicle Symposium to present work he did with a student researcher. That paper received 2nd place in the Best Paper competition.

In June, PacTrans hosted a delegation led by Director Xiaochun Zhang, and included five other senior managers of the Shenzhen Urban Transport Planning Center. They were here performing a six day technology scan of the United States, very similar to the one that the Federal Highway Administration (FHWA), American Association of State Highway and Transportation Officials, and National Cooperative Highway Research Program sponsored in Europe in 2006. **During their visit PacTrans hosted a Technology Transfer Workshop** and invited representatives from public agencies, private industry, and academic researchers to present their most innovative solutions. Groups represented included: IDAX, Inc., UW CoMotion, Verizon, City of Bellevue, University of Washington, iSoftStone, NewSky Security, and Microsoft. Presenters had ten minutes to showcase their technologies, and then the audience had five minutes for questions. We heard a lot about big data and big data analytics, intelligent transportation systems, adaptive signal control, emerging detection methods and technologies, artificial intelligence, cyber security, and many others.

During the annual Institute of Transportation Engineering (ITE) conference in July, PacTrans hosted a Technology Transfer Showcase. PacTrans student researcher Ruimin Ke presented PacTrans research that related to the transit bus collision avoidance technology that we have reported on in the past. The title of his presentation was specifically, *Testing Transit Bus Automated Collision Avoidance Warning Systems in Revenue Operations — Active Safety Collision Warning Pilot in Washington State*. Mr. Ke also presented this work at the IEEE Conference on Computer Vision and Pattern Recognition (CVPR) Traffic Surveillance and Challenge Workshop that same month.

In August, PacTrans Director Yin Hai Wang gave a TEDx talk at Harbin University on intelligent transportation, big data, and what's to come with regard to the emergence of connected and autonomous vehicles.

Education

During this past six month performance period, PacTrans had several great educational accomplishments by PacTrans PIs. PacTrans Associate Director David Hurwitz and PacTrans PI Kevin Chang were both elected to the American Society of Engineering Education (ASEE) leadership team as vice-chair and secretary, respectively. Dr. Chang also won the University of Idaho Outstanding Young Faculty Award, and Dr. Hurwitz was awarded the 2017 Margaret and Thomas Meehan Honors College Eminent Mentor distinction.

Several student teams that are supported by PacTrans performed with excellence, including the UW concrete canoe team which qualified for nationals and the OSU ITE traffic bowl team which placed 2nd at the Western Districts.

UW student researcher Elyse O’Callaghan Lewis was awarded a National Science Foundation Graduate Research Fellowship. The GRFP is highly competitive, with a success rate of approximately 14%. Perhaps more remarkably, in 2016 only ten GRFP fellowships were awarded to civil engineering students nationwide.

In June the UW hosted a group of 45 students from the Colorado Educational Talent Search Program. Talent Search is primarily geared toward students who: come from a family in which neither parent has completed a four-year college degree, come from a family whose income is limited, are a student who is a US citizen or permanent resident of the US, and are a student who has demonstrated a need for program services in order to pursue the dream of a college education.

For several years now, OSU has offered a Summer Undergraduate Research Fellowship Program where students are equipped with a \$4,500 stipend, and research projects with a faculty mentors, and have the opportunity to participate in field trips for site-specific field work, weekly seminars from noted speakers, and informal lunch meetings to discuss graduate school. At the culmination of the program the students present their work at a final symposium. This year PacTrans sponsored two of those Fellowships and a handful of the mentors are PacTrans PIs.

One way PacTrans supports students is through our PacTrans Fellowship program. This year, **OSU’s first PacTrans fellow, Amy Wyman, who did her research in Dr. Hurwitz’s lab, was awarded the 2017 CE Outstanding Student Award.** Also during this reporting period, the UW offered a total of six PacTrans Fellowships to prospective graduate students and five accepted to begin their advanced degrees in the Fall.

PacTrans hosted a number of great seminars during this reporting period to offer students the opportunity to hear from academic researchers, public agencies, and professionals from the private sector. In April, UW hosted Konstantinos Triantis, the John Lawrence Professor of Industrial Engineering and Operations Research in the Grado Department of Industrial and Systems Engineering (ISE) at Virginia Tech’s Northern Virginia Center. In May, OSU hosted C. Michael Walton, the chair of the UT Austin Civil Engineering department. In May, UW hosted a Leadership in Transportation Seminar where recent ASCE Transportation & Development (T&DI) president, Lenor Bromberg, presented. In September, UI hosted

its annual Michael Kyte Distinguished Lecture which featured City of Portland Signals & Street Lighting Division Manager Peter Koonce.

Workforce Development

PacTrans had a number activities geared at workforce development during this reporting period. Notably, the continuing education and workforce development program which was elaborated on in the previous reporting periods report, has officially been selected as PacTrans' new multi-institutional education project. This is a two year project that will wrap up in August of 2019.

PacTrans hosted a number of great seminars during this reporting period to offer students the opportunity to hear from academic researchers, public agencies, and professionals from the private sector:

1. In April, UW hosted Konstantinos Triantis, the John Lawrence Professor of Industrial Engineering and Operations Research in the Grado Department of Industrial and Systems Engineering (ISE) at Virginia Tech's Northern Virginia Center. The objective of this presentation was to highlight research themes and opportunities when considering the efficiency measurement paradigm as a way to pro-actively inform our thinking on the design and operation of engineered systems.
2. In May, OSU hosted C. Michael Walton, the chair of the UT Austin Civil Engineering department. The presentation concentrated on the issues of transport policy and the emerging models for delivering programs and services such as outsourcing/concessions, privatization, state owned enterprises, and financing of transport systems.
3. In May, UW hosted a Leadership in Transportation Seminar where recent ASCE Transportation & Development (T&DI) president, Lenor Bromberg, presented. Ms. Bromberg spoke about her professional development and career choices and implications of those choices.
4. In September, UI hosted its annual Michael Kyte Distinguished Lecture which featured City of Portland Signals & Street Lighting Division Manager Peter Koonce. His talk was titled, *Designing Cities in the 21st Century: Aligning what we know with what we need.*

Outreach & Collaborations

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. In July, PacTrans Director Yin Hai Wang met with freight semi-truck manufacturer PACCAR to discuss future potential collaborations in partnership.
2. In September, PacTrans Director Yin Hai Wang met with BlackBerry's Director, Security R&D. During this meeting, several opportunities for partnership were discussed including: internship opportunities for students, a new cyber security seminar, and research collaborations.

PacTrans also hosted a booth at this year's annual UW Engineering Discovery Days. This event brings thousands of middle- and high-school aged students to campus to tour facilities and interact in a hands-on environment with labs and current students. This is all done in an effort to promote STEM education

and specifically engineering paths. PacTrans, with our new theme on mobility, elected to offer students the opportunity to play a round of the kids game *Rush Hour*® where they could explore their problem solving abilities by applying them to themes surrounding mobility and congestion. While students are very unlikely to remember the name/existence of PacTrans beyond the five minutes they spent with us, we cannot begin to quantify how formative experiences like that may be for students when they begin making education/career choices in the future.

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.

As has been mentioned above PacTrans also encourages new, innovative dissemination materials through the identification of success stories, where PacTrans offers limited additional funds to projects that have results with potentially strong impacts. These funds can then be used to explore new and innovative opportunities to get knowledge, methods, and products gained, into the hands of practitioners.

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

PacTrans will be publishing technical reports from year 3 (2015-2016) and year 4 (2016) funding-cycle projects. These will then be promptly disseminated to the proper repositories. Year 5 (2016-2017) funding-cycle project draft reports will be due at the end of November and will be put through a peer review process.

Technology Transfer

The first and second round of research funding projects (also referred to as Year 3 and Year 4 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 be hosting our annual Regional Transportation Conference, which is expected to have attendance in the mid-200s. Each PacTrans funded research project requires that the PI not only be present at the event, but also presents their findings at the poster session during the conference. This year, the conference planning committee has also elected to highlight exception research outcomes as one of the breakout sessions.

Lastly, PacTrans will continue to support student travel to the 2018 TRB annual meeting in Washington D.C. in December. We expect to send of fifty student researchers and to have well over one hundred papers accepted at this year's conference.

Education

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

1. **PacTrans will host the 2017 Region X Student Conference in Seattle, Washington on October 7, 2017.**
2. University of Washington PacTrans student researchers will visit the Washington State Traffic Management Control Center on December 5, 2017.
3. PacTrans will provide financial support to qualifying graduate students to attend the annual TRB meeting in Washington DC in January.
4. PacTrans will begin advertising for and looking out for great candidates for PacTrans fellowships for next year.
5. PacTrans sponsored UW Hyperloop team will be competing in the next international student competition in California in January.

Workforce Development

PacTrans has a few important focuses for workforce development over this next reporting period:

1. The center will continue working with agency and academic partners to develop the PacTrans Workforce Development Institute. Part of this will include broader discussion of workforce development with the state DOTs and other agencies and industry professionals that comprise our external advisory board. This will occur at our annual EAB meeting scheduled for Thursday, October 5, 2017.
2. Professor Yueyue Fan from UC Davis has been invited to give a UW seminar on November 29th, 2017.
3. Professor Sherif Oshak, from University of Alabama in Huntsville, has been invited to give a seminar later this year.
- 4.

Outreach & Collaboration

As this center, which PacTrans refers to as "Center 2," (the MAP-21 center) begins to wind down, PacTrans has begun shifting focus from safety to mobility, which we see as a broader subject that includes safety. Therefore, outreach specifically geared toward this center will begin to taper while our steadfast commitment to promoting PacTrans as a premier regional university transportation center will

sustain. There are several items already in the works for this upcoming reporting period. For example: PacTrans director, Yin Hai Wang, will be giving a keynote talk at the Smart Transportation Workshop at the 2017 Future Forum in Beijing on October 28, 2017

With regard to collaboration. PacTrans' center 2 is still very actively looking to engage with collaborators, especially as we progress into our last round of technology transfer success stories. One such idea comes from the UW transportation faculty who recently had an annual retreat where they discussed implementing a transportation research open house day to showcase ongoing and completed research to regional agency and industry partners.

Products (reporting period: April 1, 2017 – September 30, 2017)

	Total	UW	WSU	UI	OSU	UAF
Publications: peer reviewed journal articles	162	68	7	25	62	0
Publications: Book chapters and other edited manuscripts	7	3	0	2	2	0
Conference papers	79	23	0	18	38	0
Conference presentations	102	30	3	18	48	3
Lectures/Seminars /Workshops/ Invited Talks	80	42	0	5	31	2
Technologies or Techniques	18	3	1	11	1	2
Inventions, patent applications, and/or licenses	0	0	0	0	0	0
Websites or Other Internet Sites	18	10	0	3	5	0
Other products: data or databases, physical collections, audio or video products, software or NetWare, models, educational aids or curricula, instruments, or equipment	5	0	0	1	3	1

Examples of peer reviewed journal articles

- Wygonik and Goodchild. (2017). "Evaluating the Impacts of Density on Urban Goods Movement Externalities." *Urbanism* 10(4) 487-499.
- Hussein, Krings, and Azadmanesh. (2017). "VANET Clock Synchronization for Resilient DSRC Safety Applications." *Proc. 7th Resilience Week Symposia, Wilmington, DE, (7 pages), September 18-22, 2017.*
- Mohamed, Dandekhya, and Krings. (2017). "Beyond Passive Detection of Sybil Attacks in VANET." *Proc. 6th IEEE International Conference on Reliability, Infocom Technologies and Optimization (ICRITO'2017), Amity University Uttar Pradesh, Indian, September 20-22, 2017.*
- M. Mohamed, S. Hussein, and A. Krings. (2017). "An Enhanced Voting Algorithm for Hybrid Jamming Attacks in VANET." *Proc. IEEE 7th Annual Computing and Communication Workshop and Conference (CCWC), Las Vegas, January 9-11, 7 pages, 2017.*

- Zeng, Ziqiang, Wenbo Zhu, Ruimin Ke, John Ash, Yin Hai Wang*, Jiuping Xu, Xinxin Xu. "A Generalized Nonlinear Model-based Mixed Multinomial Logit Approach for Crash Data Analysis." *Accident Analysis & Prevention*. Vol. 99: 51-65. 2017, published.
- Zou, Yajie, Jinjun Tang, Lingtao Wu, Kristian Henrikson, and Yin Hai Wang*. "Quantile Analysis of Factors Influencing the Time Taken to Clear Road Traffic Incidents." *Proceedings of the Institution of Civil Engineers – Transport*, Vol 170 (5), 296-304, 2017, published.
- Zhu, Wenbo, Zhibin Li, John Ash, Yin Hai Wang*, and Xuedong Hua. "Capacity Modeling and Control Optimization for Two-lane Highway Lane Closure Work Zones." *Journal of Transportation Engineering, Part A*, Vol. 143(12), 2017, published.
- O'Banion, M., Olsen, M., Rault, C., Wartman, J., and Cunningham, K. (2017) Suitability of Structure from Motion for Rock-slope Assessment, *Journal of Photogrammetry and Remote Sensing*, Accepted
- S. Belakaria, M. Ammous, S. Sorour, and A. Abdel-Rahim. "Fog-Based Multi-Class Dispatching and Charging for Autonomous Electric Mobility On-Demand." submitted to *IEEE Transactions on Intelligent Transportation Systems*.
- M. Ammous, S. Belakaria, S. Sorour, and A. Abdel-Rahim. "Optimal Cloud-Based Routing with In-Route Charging of Mobility On-Demand Electric Vehicles." submitted to *IEEE Transactions on Intelligent Transportation Systems*.
- Li., Q. and Stuedlein, A.W. "Simulation of Torsionally-loaded Deep Foundations Considering State-Dependent Load Transfer." *J. Geotech. Geoenviron. Engng.*, under review
- Hosseini Sallehi, Pouria Ghods, and O. Burkan Isgor. "Formation factor of fresh cementitious pastes." *Cement and Concrete Composites*, 2017, under review.
- Chen Chen, Jason Anderson, Haizhong Wang, Yin Hai Wang, Rachel Vogt, and Sal Hernandez. "How bicycle level of traffic stress correlate with reported cyclist accidents injury severities: A geospatial and mixed logit analysis", *Accident Analysis and Prevention*, Volume 108, November 2017, Pages 234-244. <http://www.sciencedirect.com/science/article/pii/S0001457517303160>
- Alireza Mostafizi, Shangjia Dong, and Haizhong Wang. "Percolation Phenomenon in Connected Vehicle Network through a Multi-agent Approach: Mobility Benefits and Market Penetration." *Transportation Research Part C: Emerging Technologies*, Volume 85, Pages 312-333, December 2017. <http://www.sciencedirect.com/science/article/pii/S0968090X1730253X>.
- Alireza Mostafizi, Haizhong Wang, Dan Cox, Lori Cramer, and Shangjia Dong. "Agent-Based Tsunami Evacuation Modeling of Unplanned Network Disruptions for Evidence-driven Resource Allocation and Retrofitting Strategies." *Natural Hazards*, September 2017, Volume 88, Issue 3, pp 1347-1372. <https://link.springer.com/article/10.1007/s11069-017-2927-y>.
- O'Banion, M.S.*, Olsen, M.J., Rault, C., Wartman, J., and Cunningham, K. (Accepted with Revisions). "Suitability of Structure from Motion for Rock Slope Assessment," submitted to the *Photogrammetric Record*.
- Jung, J. Olsen, M.J., Hurwitz, D.S., Kashani, A.G., and Buker, K. (Accepted with Revisions). 3D Virtual Intersection Sight Distance Analysis Using Lidar Data, *Transportation Research Part C*.
- Dunham, L., Wartman, J., Olsen, M.J., O'Banion, M.S*, & Cunningham, K. (2017). "Rockfall Activity Index (RAI): A Lidar-derived, morphology-based hazard assessment system," *Engineering Geology*, 221, 184-192. <https://doi.org/10.1016/j.enggeo.2017.03.009>

Example of book chapters and other edited manuscripts

Yin Hai Wang, Ziqiang Zeng. *Data-driven Transportation Science: Methodologies and Applications*. Elsevier, 2017, book, other.

Examples of conference papers and presentations

- Ganji, A., Li, Q., Arduino, P., and Stuedlein, A.W. (2017). "Performance Assessment of Laterally-Loaded Normal and High Strength Steel-reinforced Drilled Shafts using 1-D and 3-D Numerical Methods." Paper no. 4921, 16th World Conf. on Earthquake Engineering 16WCEE, Santiago, Chile, 9 - 13 January 2017, 12 pp.
- Ke, Ruimin, Zewen Pan, Ziyuan Pu, and Yin Hai Wang*. "Roadway Surveillance Video Camera Calibration Using Standard Shipping Container." 2017 IEEE International Smart Cities Conference. Sept. 15-17, 2017. Wuxi, China.
- Cui, Zhiyong, Ruimin Ke, and Yin Hai Wang*. "Deep Stacked Bidirectional and Unidirectional LSTM Recurrent Neural Network for Network-wide Traffic Speed Prediction." UrbCom'17, Aug. 14, 2017, Halifax, Nova Scotia, Canada.
- Ke, Ruimin, Jerome Lutin, Jerry Spears, and Yin Hai Wang*. "A Cost-effective Framework for Automated Vehicle-pedestrian Near-miss Detection through Onboard Monocular Vision." 2017 IEEE Conference on Computer Vision and Pattern Recognition Workshops. Honolulu, Hawaii, July 21, 2017.
- Connor, B. (2017). ITS Alaska - Development of a Low Cost RWIS Alaska Environmental Conference: Development of Dust Management for Alaska Rural Communities.
- Parrish, C. (2017). Unmanned Aerial Systems. GIS in Action, 17-18 April, Portland, Oregon.
- Gillins, D.T., C. Simpson, and C. Parrish, 2017. (2017). Emerging Technology: Unmanned Aircraft Systems (UAS) for Bridge Inspection, 2017 Bridge & Tunnel Inspectors Conference, 4-6 April, Vancouver, Washington.
- Chan, K. and Louis, J. (2017). "Leveraging Telematics and Real-time Sensor Data to Increase Safety of Equipment- Intensive Construction Operations." Proceedings of CSCE Construction Research Congress 2017, Vancouver BC.
- Hernandez, S. (2017). Contributed Talk, Pacific Northwest Transportation Consortium (PacTrans) Region 10 Conference, "Safe and Adequate Truck Parking in the Pacific Northwest: Analysis of a Truck Driver Survey." October 2017.
- Hernandez, S. (2017). Contributed Talk, 58th Annual Forum of the Transportation Research Forum, at the University of Illinois at Chicago, "Uncovering Confounding Factors of Large Trucks Crashes and Safety Critical Events: An Exploratory Analysis of a Northwest Truck Driver Survey." April 2017.
- Hernandez, S. (2017). Contributed Talk, 96th Transportation Research Board, Washington D.C., USA "Heavy Vehicle Crash Rate Analysis: A Comparison of Heterogeneity Methods Using Idaho Crash Data." January 2017.
- Cunningham, K. (2017). "Analytical Tools for Resilience of Lifeline Highway Bridges to Tsunami Events." PacTrans Regional Conference, Seattle, WA, October 2017.
- Ha, O. and Brown, S. (2017). "Spatial Reasoning Difference between Civil and Mechanical Engineering Students in Learning Mechanics of Materials Course: A Case of Cross-sectional Inference." 124th ASEE Annual Conference & Exposition, Columbus, Ohio. 2017.
- Ironsides, A., N. Pitterson, S. Brown, K. Fisher, S. Gestson, D. Simmons, and O. Adesope. (2017). "Incorporating Faculty Sense Making in the Implementation and Modification of an Instrument to Measure Social and Cognitive Engagement." 124th ASEE Annual Conference & Exposition, Columbus, Ohio. 2017.
- Brown, S. and Barner, S. (2017). "Examining engineering concepts in practice: Is conceptual understanding relevant to practice?" 124th ASEE Annual Conference & Exposition, Columbus, Ohio. 2017.

- Islam S.M.A.* and A. Hajbabaie. (2017). "A Two-Stage Model for Predicting Crash Frequency by Severity Type." The 51st Annual Pacific Northwest Regional Economics Conference, Bend, OR, 2017 (Podium).
- Chang, K. (2017). "Safety Data Management and Analysis: Addressing Our Continuing Education Needs; ITE Western District Meeting; San Diego, CA.
- Garcia, A., Lowry, M., Camacho-Torregrosa, F., and Lopez, G. (2017). "Estimating cyclist volumes on two-lane rural roads using Strava data" Presented at the Road Safety and Simulation International Conference, The Hague, Netherlands.

Example of lectures/seminars/workshops/invited talks

- Moudon, A.V. (June 2017). "Urban infrastructure design for healthy travel modes." Presented at ILUTM3 3rd INTERNATIONAL WORKSHOP ON LAND USE TRANSPORT MODELING Urbanization process, dynamics and mega-cities. Tongji University, Shanghai.
- Moudon, A.V. (September 2017). "Built Environment and Health in the Age of Big Data." Presented at The European Colloquium on Theoretical and Quantitative Geography. York, UK.
- Goodchild, A. (April, 2017). Northwestern University Transportation Seminar. "Delivering Sustainability: Transporting Goods in Urban Spaces." Evanston, IL.
- Goodchild, A. (April, 2017). Washington Society of Professional Engineers. "Delivering Sustainability: Transporting Goods in Urban Spaces." Seattle, WA.
- Stuedlein, A. (April 2017). "Recent Developments in the Axial, Lateral, and Torsional Response of Drilled Shaft Foundations." Annual Kansas City Geotechnical Conference 2017, Overland Park, KS.
- Stuedlein, A. (May 2017). "Developments in the Axial, Lateral, and Torsional Response of Drilled Shaft Foundations." University of South Florida, Tampa, FL.
- Connor, B. (2017). "Low Cost RWIS which should become commercially available in fourth quarter of 2017 Development of the Dust Fall Column test method to test the effectiveness of dust palliatives."
- Simpson, C., R. Slocum, and C. Parrish, (2017). "Laser geolocation software and procedures for Velodyne Puck lidar and OxTS xNAV 200 installed on DJI S1000 unmanned aircraft system."
- Hernandez, S. (February 2017). Contributed Talk, ATSSA's 47th Annual Convention & Traffic Expo. "Automated/Autonomous Vehicles: Human Factors Issues and Challenges." Phoenix, AZ.
- Barnes, D.L., B.G. Connor, P. Rettinger. (2017). Dust Management. A workshop presented at the National Tribal Transportation Conference, Tucson, AZ.
- Wartman, J. (May 2017). "Lifeline Interdependencies: Landslides and Liquefaction Impacts on Lifeline Systems." Earthquake Engineering Research Institute, Portland, OR.
- Wartman, J. (June 2017). "Co-seismic Landslide Modeling," University of Oregon/USGS landslide workshop, Eugene, OR.

Examples of Websites

- <http://web.engr.oregonstate.edu/~simpsoch/surveyfield.html>
- <http://www2.cs.uidaho.edu/~krings/publications.html>
- <http://uidaho.maps.arcgis.com/apps/webappviewer/index.html?id=88af7e023fd24d31965c4d0b62fdad9>

Examples of Data/Database/Video/Software/Educational Aids/Curricula/Equipment

- Video showing the test method for using the Dust Column developed by UAF.
- Safety Data Management and Analysis: Practitioner Tools

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 25 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. This number is down from previous reports because Dr. Wang has begun shifting his attention to the new center, Center 3.
- PacTrans Associate Director in Research, **Jeff Ban**, Ph.D., Associate Professor of Transportation Engineering in 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 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 50 percent of his time to the day-to-day operations in support

of the PacTrans mission. His responsibilities include outreach and marketing, communications, and oversight of the PacTrans operations team including: events coordination and research management number has reduced because Mr. Kopca has begun focusing half of his attention on PacTrans' new center.

- PacTrans full-time Program Coordinator, **Melanie Paredes**, devoted 50 percent of her time to the Center's fiscal matters, support with events coordination and outreach and day to day administration. This number has reduced because Ms. Paredes has begun focusing half of her attention on PacTrans' new center.
- During this reporting period PacTrans has hired a new grants, finance, and research manager. Christina Yarbrough, devotes 50 percent of her time to matters for grant management, financial and budgeting processes, and research management. She spend the rest of her time on PacTrans' new center.
- **Kristian Henrickson**, doctoral candidate and research assistant in the PacTrans STAR Lab at the University of Washington, devotes 25 percent of his time in providing research support and oversight.
- PacTrans has also hired a new graduate student intern, **Chris Gottsacker**, who is also a research assistant in the PacTrans STAR Lab at the University of Washington. Mr. Gottsacker commits 5 percent of his time miscellaneous tasks such as updating contact lists and keeping minutes during partnership meetings.
- 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?

Much of the time, when researchers think about the transportation system, they focus on the personal vehicle. Recently, there has been an upward trend in alternative modes of transportation use. Walking, cycling, and use of public transit have become much more prominent in our urban centers. During this reporting period, PacTrans has finalized a number of research reports that specifically investigate bicycle safety.

UW PacTrans PI Anne Goodchild recently completed a project titled *An Evaluation of Safety Impacts of Seattle’s Commercial Vehicle Load Zones*. This project explored how commercial vehicle parking in Seattle’s downtown area affects the safety of bicyclists. The research determined that from bicyclists’ perspectives, illegally parked trucks were a more serious problem than the locations of designated commercial vehicle load zones. The take-away was that implementation of value pricing to better manage parking availability, together with increased enforcement to prevent non-commercial vehicles from parking in CVLZs, could help provide more effective legal parking options for drivers, decreasing cyclists exposure to danger. Dr. Goodchild, along with OSU PacTrans PI, David Hurwitz, are currently finishing a supplementary report utilizing Dr. Hurwitz’s bicycle simulator to further explore interactions between commercial vehicles and bicycles in urban contexts.

A second project comes from OSU PacTrans PI Haizhong Wang titled *Bicycle Safety Analysis: Crowdsourcing Bicycle Travel Data to Estimate Risk Exposure and Create Safety Performance Functions*. Highway Safety Manual provides an evidence-based approach – safety performance function (SPFs) to evaluate the safety for common traffic, however, not for bicycle. Thus a data driven and evidence-based bicycle safety evaluation method were created. Based on the first bicycle SPFs created by Krista Nordback in 2013, Dr. Wang used STRAVA bicycle count data (a type of crowdsourcing bicycle travel data), other traffic count data and bicycle crash data to established Pacific Northwest SPFs in terms of bike count and crash frequency for road intersections. The SPFs demonstrated the relationship between crash frequency and traffic and bike volume. The intersections with higher traffic volume have higher bicycle crash frequency. In addition, this project improved the usability of a GIS tool that had been created during a previous PacTrans project to estimate bicycle exposure. State DOTs and other agencies

can use the SPFs to screen and identify the prior bicycle black spots in Pacific Northwest region in order to optimize safety investments.

Finally, UW PacTrans PI Anne Vernez Moudon completed a project titled *Safe Main Street Highways*. This project contributed to the Washington State Strategic Highway Safety Plan, whose goals are to achieve zero road fatality and serious injury by 2030 and to reduce the number of pedestrians and bicyclists involved in motor-vehicle collisions on state highways. The study focused on “main street highways” (MSHs), which are stretches of State Routes that also act as main streets for the local populations. The goal was to identify hotspots of pedestrian and bicyclist collisions, and (2) develop models for estimating socio-economic and environmental predictors of collision locations. Results showed that high risk pedestrian and bicyclist collision locations were significantly associated with collisions occurring (1) at street and road intersections (versus mid-blocks); (2) on wider roads; (3) on roads with bicycle lanes; (4) in low income and non-white neighborhoods.

What is the impact on other disciplines?

While transportation engineering is our natural focus due to the fact that our consortium PIs at four of the five universities are housed in the civil engineering departments, PacTrans has engaged many researchers and students from other disciplines. We have had a number of geotechnical engineers perform PacTrans funded research on critical slope analysis methodologies. We’ve had computer science engineers researching new communications technologies. We’ve funded research investigating gender differences with regard to safety in construction zones. We’ve funded research from structures engineers exploring bridge inspection and torsional aspects of traffic signal posts. We’ve have had several materials and concrete experts researching pavement markings, pervious surfaces, and concrete installation. We’ve funded urban planners who investigate the influence of built environment characteristics on transportation safety.

With regard to students, we also look beyond our transportation engineering silo to support students from other disciplines. During this grant PacTrans has supported numerous student teams including concrete canoe (materials), big beam (structures), steel bridge (structures), clean snowmobile (mechanical engineering), and Hyperloop (interdisciplinary: mostly mechanical engineers). PacTrans has also elected to sponsor the OSU hosted national steel bridge competition this upcoming year.

What is the impact on transportation workforce development?

In program progress performance reporting, PacTrans regularly references the PacTrans fellowship program. Each year PacTrans distributes funds to consortium universities for PacTrans funded research projects, for outreach, and for education purposes. The center does not dictate how each university spends its education money but allows each university to put those funds toward students in whatever manner they deem best.

At the University of Washington, PacTrans director Yin Hai Wang has used a significant portion of those funds, matched with department funds, to fund the PacTrans fellowship program. This program seeks to attract the most competitive graduate level prospective students to the University of Washington. The Fellowship pays for the students’ tuition and each student is highly encouraged engage in an internship

which is not only paid but also awards them six credits toward their degree. These students are also required to volunteer at a number of PacTrans events throughout the school year including the regional transportation conference and the Engineering Discovery Days. Thus far the fellowship program has supported sixteen graduate students at the University of Washington, most of whom, enter the transportation workforce here in the Pacific Northwest upon completion of their degree.

As mentioned previously in this report, recently Oregon State University has elected to implement the same model. They have partnered with their civil and construction engineering department to offer one PacTrans fellowship to the best and brightest candidate in the prospective student class. In its first year OSU's PacTrans Fellow Amy Wyman did her thesis research in the lab of PacTrans Associate Director David Hurwitz, and was awarded the Civil Engineering Student of the Year award at OSU.

This program has proven to be a very effective tool for promoting continuing education in transportation engineering and to better equip the workforce of tomorrow with the tool and knowledge they will need to help revolutionize the transportation system of the future.

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

During this grant, PacTrans has had two ongoing multi-institutional projects that engage at least one PI from each of the five consortium partner universities. In our previous PPPR (PPPR #5), we reported on the education project, which has been developing datasets, course modules, and tools for educational needs in transportation safety.

PacTrans' other project has been focused on outreach. This effort, led by PacTrans Associate Director from OSU, David Hurwitz, has been exploring innovative ways to better educate youth in our region about common dangers in transportation through coordinated outreach. One portion of this work included a college- and high-school age student competition involving lane departure crashes. Students were required to do some contextual investigation of lane departure crashes and then produce a series of media (a poster, a video, and a series of either tweets or Instagram posts) that helped educate their peers on these dangers.

Student researchers were sent out to schools around the region to give presentations on lane departure crashes and give an introduction to the contest. PacTrans set up a portal on our website and ran the competition for several months. Above and beyond the hundreds and thousands of students who attended the presentations, we received dozens of submissions from across the region. The submissions were outstanding, with great creativity and substance.

The team has now transitioned focus to elementary school aged students. They have tailored the presentation to the younger audience and have equipped teams with resources to be able to facilitate in-class projects that have similar deliverables to the competition just described.

What is the impact on technology transfer?

In this section of the previous PPPR (PPPR #5) PacTrans reported on a series of funded research projects involving the utilization of UAVs or drones by a team of researchers comprised of Joe Wartman (UW),

Michael Olsen (OSU), and Keith Cunningham (UAF). They have used LIDAR and newly developed algorithm index called the Rockfall Activity Index (RAI), seeking to identify critical slopes that dangerous to roadway infrastructure below in a safe, reliable, and time/cost effective way.

In the previous report, PacTrans asserted that the Oregon Department of Transportation had begun implementing this new process in their critical slopes analysis. Since then, Alaska Department of Transportation has similarly begun to utilize these new methods and have been actively done control work to eliminate the danger of uncontrolled slides.

Further, Dr. Wartman, due in large part to these projects, has opened his own National Science Foundation Center, the Post-Disaster Rapid Response Research Facility. They are exploring further utilization of the methods developed in the PacTrans funded work to allow us to better respond to natural disasters.

What is the impact on society beyond science and technology?

This center's focus has been on safety. It is true, PacTrans PIs use scientific theory and technology to perform research and to education the next generation of transportation professionals, but it is easy to overlook the real-world impact from which these activities result.

Over 80% of the projects PacTrans has funded during this grant have been applied (practical) projects as opposed to advanced (theoretical) projects. As discussed previously, PacTrans has funded a number of projects geared toward making alternative transportation options safer. When they are safer more people will use them, and the benefits to alternative transportation over the personal vehicles of society are endless. We've funded research on palliatives for better dust control in rural places where unpaved roads wreak havoc on peoples' daily lives. We've funded several projects surrounding critical events, natural disasters, and lifeline infrastructure in a region that has serious exposure to dangers of earthquakes, landslides, and tsunamis. We've funded several studies that explore different signal operations to make intersections safer for all users and more efficient. We've funded studies on advanced technological innovations such as adaptive street lighting and fast charging electric vehicle stations.

This 30,000 foot summary of much of the work PacTrans has engaged has obvious implications to peoples' everyday lives, to the way they from one place to another, and how they do so efficiently and safely.

Changes/Problems

NONE.

Special Reporting Requirements

NONE.