Program Progress Performance Report for University Transportation Centers

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

OST-R Sponsor Award Number: DTRT13-G-UTC40 MOD02

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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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 serves 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, 2018 – September 30, 2018, 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, as well as a multi-institutional educational project, and a multi-institutional outreach project. 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. Both categories of research are geared towards the goal of advancing the region's transportation research.

In the last six months, PacTrans has been busy collecting the remaining outstanding draft technical reports for all projects that were funded under this grant. Once these reports are submitted they are circulated for peer review and the final report is then sent through our technical editor. Once finalized these reports are 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. The final reports for the first of the three years have all been through this process and the second and third year reports are currently in various stages of the process. We intend to have all three years' worth of reports finalized and published by the end of November.

One recent accolade of note is that during this reporting period, **the PacTrans multi-institutional outreach project that funded for all three research performance periods of this grant was recognized at the Oregon State University, Vice Provost Awards for Excellence Celebration**, an annual event that showcases 10 outreach and engagement projects that are particularly exceptional.

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 solicits 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 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 selects a handful of projects to receive sufficient funding to execute the proposed activity(s).

During this past reporting period, PacTrans selected fifteen projects that had been funded under this grant to receive additional funding for this purpose. We are currently in the process of receiving and reviewing the materials that were produced from these activities as well as the required write ups that accompany those materials. All of these materials will be published on our website and circulated to those partners to whom they may generate some interest in implementation.

During the reporting period, PacTrans PIs took many opportunities through conference, seminars, and workshops to showcase our accomplishments of the ongoing research projects.

One such example occurred in July of this year. **PacTrans Director, Yinhai Wang, co-chaired the ASCE International Conference on Transportation and Development (ICTD) in Pittsburgh July 15-18, 2018 as part of his role on the ASCE Transportation and Development Institute Board. In total, PacTrans sent twelve faculty and students to the conference to present our work.** Further, Dr. Wang initiated a UTC technology transfer workshop with Dr. Laurence Rilett, director of Region 7 UTC at the University of Nebraska-Lincoln, where several UTC representatives had the opportunity to present effective methods for impacts and implementations.

In August, PacTrans jointly sponsored a workshop with WSDOT on Commute Trip Reduction in the face of new mobility as a service provision. PacTrans Associate Directors, Jeff Ban and Anne Vernez Moudon, hosted the event with over 50 in attendance. Present were representatives from private industry such as new mobility service providers; public agencies such as transportation management agencies, cities, and public transit authorities; academic researchers, and nonprofits that help with CTR implementation.

Education

During this past six month performance period, PacTrans has been actively engaging students with a wide variety of activities and opportunities to further their education, experience, knowledge, and networks.

One such example occurred in May of this year. **PacTrans sponsored the third annual Transportation Engineering Education Workshop in Auburn, Alabama. The two-day workshop and conference invited transportation engineering faculty to share their best practices with one another, develop activities for their classes, and further build professional relationships.** Forty-five professors and a handful of PhD students were in attendance, as well as Prof. Kevin Chang, a PacTrans PI, from the University of Idaho as the guest speaker, and PacTrans Associate Director from OSU, David Hurwitz.

Another great example includes the student competition teams that PacTrans has been supporting over that last several years. The following us a summary of the accomplishments of several of these teams:

1. The PacTrans sponsored UW Hyperloop team recently placed 1st in the national and 4th worldwide in the Elon Musk Hyperloop Pod Competition.
2. The PacTrans sponsored OSU ITE student chapter received the student chapter of the year award.
3. The PacTrans sponsored UW Concrete Canoe team and the team placed seventh overall.

PacTrans consortium partners have also had significant success in recent years with summer research internship programs. Many of these internships are supported by PacTrans PIs and some have PacTrans financial support as well. A few examples include:

1. Oregon State University has a Summer Undergraduate Research Fellowship Program. In this program, each student is equipped with a $4,500 stipend, and a research project with a faculty mentor, and has 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 will present at a final symposium to highlight their work.
2. The UW just started an undergraduate summer research program and selected undergraduate students each receive $2000 to work with PacTrans PIs on a relevant research project.
3. University of Idaho had five summer research interns this year, several of them were working on PacTrans funded research projects.

Workforce Development

PacTrans had a number activities geared at workforce development during this reporting period. Notably, an ongoing multi-institutional education project titled *Workforce Development Institute*, is an ongoing project to scope the current and future continuing education needs of agencies and private industry in the Pacific Northwest. In the first year of this project, PIs scanned the resources and programs that are currently available nationwide, surveyed transportation professionals across the region about current and future continuing education needs, and began developing a business plan for the institute.

PacTrans hosted a number of great seminars during this reporting period to offer students the opportunity to hear from researchers and working professionals:

1. In April, PacTrans hosted Professor Xueming Chen, Professor and Head of the Department of Urban Planning and Design at Xi'an Jiaotong-Liverpool University, Suzhou, China. His talk was titled, *Probing into China's and Europe's Air-High Speed Rail Integration: A Policy Analysis*.
2. In May, PacTrans hosted our Spring quarterly Regional Transportation Seminar featuring Professor Lily Elefteriadou, Director of the UF Transportation Institute (UFTI) and the Kisinger Campo Professor of Civil and Coastal Engineering at the University of Florida. Her talk was titled, *Traffic Signal Control with Connected and Autonomous Vehicles in the Traffic Stream*.
3. In September, PacTrans hosted Professor Carl Thodesen, Head of Department at the Department of Civil and Environmental Engineering at the Norwegian University of Science and Technology. His talk was titled, *Green thinking in Norwegian infrastructure projects: connecting political goals, research, real world implementation, and international cooperation*.

Outreach

One of PacTrans' main focuses with regard to outreach involved promotion of STEM education and Transportation Engineering to our youth and undergraduate students. During this reporting period, several of our consortium partners were actively engaged:

1. In April, the University of Washington hosts an event for elementary- and middle-school age students called Engineering Discovery Days. Here students visit campus and have an opportunity to see and participate in hands on demos for many of the labs that operate in the college of engineering. PacTrans hosts a booth showcasing transportation engineering principles through kids' games.
2. In May, Oregon State University hosts an undergraduate Engineering Expo where students are invited to come all of the possibilities in the world of engineering.
3. Each May, University of Alaska Fairbanks' College of Engineering and Mines hosts an Engineering

Week Open House where students are invited to come and tour the engineering facilities and see/participate in hands on demos from many of the labs that exist there.

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.

Along those lines, PacTrans recently elected to hire an undergraduate student communications intern. This allows us to be more active and effective on emerging media platforms like social media. It also give practical, real-world experience to a communications student at the University of Washington. Our current intern, Leona Vaughn, has already increased our social media presence by over 500% and allowed us to expand the quantity, quality, and depth of our online website posts.

Another avenue for dissemination that PacTrans leans on heavily is presentations at conferences, workshops, and symposia. Already mentioned in this report was the ASCE ICTD conference where PacTrans had twelve presenters on our work. Each year we send roughly one hundred PIs and students (about 50 students) to the TRB annual meeting where we participate in over 120 committee meetings, poster presentations, workshops, and lecterns. Our annual conference each October also provides an invaluable platform for our researchers to present work either through presentation or poster.

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. This year these funds have been used to host workshops/training, produce informational videos, build online tools and procedure manuals, etc.

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

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

This will be the final program progress performance report for this grant.

Products (reporting period: April 1, 2018 – September 30, 2018)

	Total	UW	WSU	UI	OSU	UAF
Publications: peer reviewed journal articles	**95**	24	14	12	45	0
Publications: Book chapters and other edited manuscripts	**6**	5	0	0	1	0
Conference papers	**102**	30	5	25	34	2
Conference presentations	**125**	47	7	24	43	2
Lectures/Seminars /Workshops/ Invited Talks	**75**	38	14	8	13	2
Technologies or Techniques	**22**	6	1	9	4	2
Inventions, patent applications, and/or licenses	**0**	0	0	0	0	0
Websites or Other Internet Sites	**19**	14	0	0	4	1
Other products: data or databases, physical collections, audio or video products, software or NetWare, models, educational aids or curricula, instruments, or equipment	**35**	11	0	2	20	2

Examples of peer reviewed journal articles

Anderson, J. C., Hernandez, Salvador, Jessup, Eric and North, S. "Perceived Safe and Adequate Parking: A Random Parameters Binary Logit Analysis of Truck Drivers Opinions in the Pacific Northwest." International Journal of Transportation Science and Technology. Vol. 7, Issue 1, Pages 89-102, March 2018, ISSN: 2046-0430.

Slocum, R.K., Adams, R.K., Buker, K., Hurwitz, D.S., and Mason, H.B., Parrish, C.E., and Scott, M.H. "Response spectrum devices for active learning in earthquake engineering education." HardwareX, October 2018.

Mason, H.B., Hurwitz, D.S., Adams, R.K., Buker, K., Slocum, R.K., and Scott, M.H. "Increasing student understanding of response spectra: An argument for the inductive learning approach." Earthquake Spectra, 34(2):459–469, May 2018.

Ammous, M., Belakaria, S., Sorour S., and Abdel-Rahim, A. "Optimal Cloud-Based Routing with In-Route Charging of Mobility On-Demand Electric Vehicles," accepted for publication in IEEE Transactions on Intelligent Transportation Systems.

Abadi, M. G. & Hurwitz, D. (2018) "Promoting Bicyclist Perceived Level of Comfort in Dense Urban Environments: Influence of Ambient Traffic, Engineering Treatments and Bicyclist Characteristics," Sustainable Cities and Society, Volume 40, 101-109.

Zhou Z. and Qiao P. "Durability of ultra-high performance concrete in tension under cold weather conditions," Cement and Concrete Composites, 94 (2018): 94-106. http://dx.doi.org/10.1016/j.cemconcomp.2018.08.019

Wang, Yong, Peng, Shouguo, Assogba, Kevin, Liu, Yong, Wang, H., Xu, Maozeng and Wang, Yinhai. "Implementation of Cooperation for Recycling Vehicle Routing Optimization in Two-Echelon Reverse Logistics Networks." In Press. Sustainability. Apr. 2018.

Dongfang, Ma, Song, Xiang, Li, Wenjing, Wang, Yinhai and Zhang, Weibin. "Time-of-Day Breakpoints Optimization through Recursive Time Series Partitioning." In Press. IET Intelligent Transport Systems. April 2018.

Liang, Yunyi, Wu, Zhizhou, Li, Jinyang, Li, Fuliang, and Wang, Yinhai. "A Shockwave-based Queue Length Estimation Method for Pre-Signals for Bus Priority." Journal of Transportation Engineering, Part A: Systems. In Press. April 2018.

Hossein, Sallehi, Ghods, Pouria and Isgor, Burkan "Formation factor of fresh cementitious pastes," Cement and Concrete Composites, Volume 91, August 2018, Pages 174-188.

Example of book chapters and other edited manuscripts

Siddique, N., Ban, X., 2018. Spectral analysis method for vehicle trajectory data, Submitted to the 23rd International Symposium on Transportation and Traffic Theory (ISTTT), 2nd revision.

Wang, Yinhai and Zeng, Ziqiang. Data-Driven Transportation Science: Methodologies and Applications. In Press. Elsevier. April 2018.

Examples of conference papers and presentations

Ammous, Mustafa, Belakaria, Syrine, Sorour, Sameh and Abdel-Rahim, Ahmed. "Joint Delay and Cost Optimization for Electric On-Demand Vehicles with In-Route Charging." In 2018 IEEE International Conference on Communications (ICC), pp. 1-7. IEEE, 2018.

Abdel-Rahim, Ahmed, and Gonzalez, Angel. "Improving the Safety of Left-Turn Operations at Signalized Intersections for High-Risk Groups." In International Conference on Transportation and Development, p. 329. 2018

Machado, Giron, Goodchild, A., Ivanov, B. "Commercial Vehicle Occupancy Study: Four Key Findings" US-EC Urban Freight Twinning Initiative Workshop, Baltimore, MD (9/18)

Parrish, C., 2018. “UAS Basics for Transportation.” UAS in Transportation Expo, July 30-31, Corvallis, Oregon.

Simpson, C., Parrish, C., Gillins, D., and Gillins, M. 2018. Lessons Learned from OSU PacTrans and ODOT UAS Projects. UAS in Transportation Expo, July 30-31, Corvallis, Oregon.

Challa, H. and Frenzel, J., "Pedestrian Tracking using Ultra Wideband Radio", PacTrans Conference, University of Washington, Oct. 2016.

Mason, H.B., Scott, M.H., Hurwitz, D.S., Buker, K., and Adams, R.K. “An inductive learning approach to teaching earthquake response spectra.” 11th National Conference on Earthquake Engineering, Los Angeles, CA, June 2018.

Akin, M (2018) "Connected Vehicles for Winter Maintenance" presented at 2018 Pacific Northwest Snow Fighters Conference, Spokane, WA, June 5-6, 2018

Lowry, M. and Nordback, K. (2018). “The AADB Website: Providing communities spatial mapping of bicycle count data” Presented at the Walk Bike Conference, New Orleans, Louisiana.

Nordback, K. and Lowry, M. (2018). “Optimizing Washington State’s Bicycle and Pedestrian Count Program” Presented at the Walk Bike Places Conference, New Orleans, Louisiana.

Belz, N.P., Chang, K. Hansen, R. (2019). “Using Field and Simulation Data to Assess Passing Zone Behavior on Rural Two-Lane Highways”, 2019 TRB Conference, Washington D.C. (accepted for presentation)

Robins, G., Hernandez, S., (2018) “An Optimal Route Risk model for improved Safety and Operational Efficiency: A New Zealand Case Study.” IRF Conference Nov. 2018 (Accepted)

Example of lectures/seminars/workshops/invited talks

Moudon, Anne “Washington State School Walkability Index” presentation by Graduate Student Yefu Chen at the PacTrans Board meeting, May 1, 2018

Moudon, Anne Yunnan University of Finance and Economics. Invited lecture “Built environment, transportation, and health" May 22, 2018

Wang, Yinhai FHWA State Transportation Innovation Councils. “Smart Traffic Sensing and Big Data Analytics.” Olympia, WA. May 15, 2018.

Wang, Yinhai Keynote at Jiangsu ITS Conference. “Artificial Intelligence Methods for Complicated Transportation Problems.” Nanjing, China. May 6, 2018.

Wang, Yinhai Washington Traffic Safety Conference. “Regional Map Based Analytical Platform for Safety Data Collection and Analysis.” Kennewick, WA. April 25, 2018.

Technologies or Techniques

Convolutional Vehicle Detection from Airborne LiDAR Scans of Traffic Corridors

Optimal Vehicle Dimensioning for Multi-Class Autonomous Electric Mobility On-Demand Systems

Optimal Local and In-Route Charging Management of Electric Mobility-On-Demand Systems

Manawadu, Y. Zhou, Z., and Qiao, P. (2018). Effectiveness of Surface-bonded PZT Patch System in the Determination of Wave Modulus of Elasticity (WMoE) of Concrete

Self-Adaptive Sampling (SAS) method of mobile sensing data

Jadon, A., Williams, Z., Kafka, C., Rotta, H., Roy, S. and Lum, C. "Characterization of Wireless Communication Links for Unmanned Aerial Systems," AIAA SciTech Conference, Kissimmee, FL, Jan. 2018 and associated database http://uavchannel.ee.washington.edu:8080/index/

Louis, J. (2018) "Location and View-Frustum Tracking System of Workers for Safety Applications on Construction Work-zones" Technical Report.

GIS-Based Traffic Data Collection Tool: https://uidaho.maps.arcgis.com/apps/CrowdsourceReporter/index.html?appid=a0d9806557c8458691cf0185ba71e018

Field collection and automated counting of OHVs using video data, Belz N.P. and Sayre, T. (2018)

Spectral Library of Road Salt and related chemicals, Belz, N.P. and Fulton, G. (2018)

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

2018 datasets were obtained for several sites at Glitter Gulch and Long Lake, Alaska. They have not formally been published.

http://uavchannel.ee.washington.edu:8080/index/

Training videos, Training calculators &Training presentations

Jung, J., Olsen, M.J., Hurwitz, D., Parrish, C. Sight Object Distance Analysis Tool, learnmobilelidar.com.

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), **Eric Jessup**, Ph.D., Associate Research Professor 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.
- PacTrans full-time 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.
- **Leona Vaughn**, undergraduate student in the College of Communications at the University of Washington was recently hire to do communications work for PacTrans. She's spends 20 percent of her time on website upkeep and social media networking and posting.
- 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	
Blackberry	Private Industry				X	X
PACCAR, Inc.	Private Industry				X	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

This being PacTrans' final Program Progress Performance Report, this section will be utilized to highlight many of the great technology transfer success stories that have been referenced in previous reports and above in this report.

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

Each and every project highlighted in this impact section has had considerable impact in our principal discipline of transportation. Here we choose two to highlight as the rest will be highlighted in later subsections:

- Many PacTrans PIs have utilized the emerging technology of unmanned aircraft systems as part of the methodology, primarily for data collection, in their PacTrans funded research projects. Oregon State University Associate Professor, Chris Parrish, is one such PI. He utilized PacTrans success story funds to host a UAS in Transportation Expo, where forty people representing private industry, public agencies, and research institutions, gathered for two days to discuss the state of UASs. At the culmination of the event, Dr. Parrish held a discussion with attendees to identify three key items: lessons learned, unsolved challenges in UAS for transportation, and potential solutions. This event offered public agencies a unique opportunity to share valuable information, processes, and procedures with one another, and offered researchers a plethora of new ideas for research areas as UAS moves forward in areas of, traffic operations, geotechnical surveying, bridge inspection, and others.
- In 2016, 7.2 million crashes occurred in the United States. Of these, 161,000 crashes involved cyclists/pedestrians, and 90% of those crashes involved serious injuries. Over the course of this grant, the UW STAR Lab has been developing a smart road sticker to address transportation safety concerns such as these. This sticker detects Bluetooth signals and comes equipped with a long range communicate module. When these sensors are placed in succession on the roadway, trajectories of vehicles, cyclists, and pedestrians can all be calculated and warning messages can be sent to each system user of the presence of danger. Since its creation, many partners have employed the STAR Lab to leverage this technology for other purposes as well. Tongji University deployed over one hundred of these devices to identify student movements around campus. Norwegian Public Roads will soon be deploying these sensors to monitor road condition on their critical highway that connects their fisheries to Helsinki. They will soon be deployed on the Burke Gilman Trail just outside of Seattle to monitor bicycle and pedestrian traffic. Sound Transit has begun utilizing this smart road sticker to monitor parking at one of its largest park and ride facilities, and UW transportation services will soon be doing the same.

What is the impact on other disciplines?

Much of the work done at PacTrans transcends far beyond the bounds of the classical transportation field. Several good examples from this grant include:

- As the Internet of Things (IoT) has become more prevalent, Oregon State University Assistant Professor, Joseph Louis, has become very interested in leveraging the technology to revolutionize the construction industry. More specifically, he have applied the internet of things (IoT) paradigm of connected sensors to improve worker safety in work zones by delivering timely warnings of visibility and proximity related hazards. Dr. Louis is currently utilizing PacTrans Success Story funds to upgrade the hardware from a UAB tracking technology that requires anchors in the field, to a commercially available “smart helmet.” These helmets come equipped with an extensible API that also allows researchers to utilize data collected for other tasks geared toward making construction zones safer and more efficient. Dr. Louis’s work is well positioned to modernize the work zone of tomorrow.
- Urban freight delivery has emerge as a significant presence on today’s transportation system. The Supply Chain Transportation Logistics Center and Urban Freight Lab at the University of Washington

have been working with industry to better understand its opportunities and challenges. Work funded by PacTrans enabled Dr. Goodchild and her lab to develop a toolkit and protocol for inventorying all truck relevant features in an urban area. This then allowed them to conduct a common carrier delivery locker pilot in the City of Seattle to identify time and cost savings for delivering to centrally located lockers instead of each office in a high rise. PacTrans success story funds were then utilized to expand the Urban Goods Delivery System Tool Kit to include more features, GIS mapping, and generalization so that the toolkit can now be more readily used by other urban areas across the country. As e-commerce continues to grow, this work will become more necessary as we battle urban congestion.

What is the impact on transportation workforce development?

Many of the new techniques developed by PacTrans PIs during funded research, are quite advanced. With limited tax dollars, state and local agencies do not have the resources to properly explore, let alone train, their employees on such methods. Therefore, a number of PacTrans technology transfer efforts have been geared toward making these techniques more accessible, as well as training workshops and webinars on the use of them. Several such examples include:

- University of Idaho Assistant Professor, Kevin Chang, has spent a considerable amount of time during this grant using safety (crash) data. Dr. Chang original PacTrans funded research involved the development of a comprehensive understanding of needs and priorities regarding safety data management and analysis as well as the development of a set of core skills to that effect. He is now utilizing PacTrans Success Story funds to take the documentation that was developed as part of that original research and folding it into a new Institute of Transportation Engineers (ITE) Road Safety Professional (RSP) certification program. More specifically he has facilitated discussion with ITE on his research results, and modified their training modules accordingly.
- Safety Net is a part the of the Digital Roadway Interactive Visualization and Evaluation Network (DRIVE Net), a region-wide, web-based transportation decision support system that adopts digital roadway maps as the base, and provides data layers for integrating and analyzing a variety of data sources. This platform has been in development in the UW STAR Lab for a number of years. Safety Net is essentially phase two of this work where a serious of safety performance modules have been developed. Using PacTrans Success Story funds, Dr. Wang's team developed two videos highlighting these new functionalities and then they hosted a training workshop where three WSDOT employees were physically present and over thirty joined remotely. Many of the modules built into DRIVE Net are meant to produce metrics that WSDOT and other state agencies regularly report on but with significantly less resources than the processes require now.
- Oregon State University Professor, Michael Scott, bridge structures. PacTrans recently funded a project by Dr. Scott where he developed a simplified analytical models for estimating the horizontal force imparted on bridge superstructures due to hydrodynamic loading. He then utilized PacTrans Success Story funding to host a half-day workshop and to record a brief webinar (approximately 30 minutes) on the use of OpenSees (a popular software framework for finite element simulation of bridge response) for computing the horizontal load imparted on bridge structures by tsunami loads.

What is the impact on technology transfer?

The novel techniques and technologies that are developed by PacTrans researchers are only of value to society if they make it to the hands of those with the power to implement them. The purpose of all of the projects highlighted in this impacts section is to do just that. Here are several example of some of the more successful technology transfer efforts that have been done by our researchers over the course of this grant:

- University of Washington Professor, Joe Wartman, and his team from Oregon State University and the University of Alaska Fairbanks have done significant investigation of rock fall for PacTrans during this grant. In one of those projects, they developed a Rockfall Activity Index (RAI), a point cloud-derived, high-resolution, morphology-based method for assessing rockfall hazards. This index was implemented (as C++ code) the various components necessary to determine the RAI as a computationally efficient executable that requires one to edit parameters and settings in text files and to run the program within the command prompt. Over the past year, state DOTs in the Pacific Northwest and across the nation have expressed significant interest in adopting the RAI system in their respective regions. However, in its current form, the current software environment is burdensome and not appropriate for use by non-experts. Therefore Dr. Wartman's team leveraged PacTrans Success Story Funds to transition the previous prototype RAI processing software into a robust, user-friendly software application for use by DOTs and their consultants, thus promoting the use of the RAI system across the United States and beyond.
- Provision of adequate Sight Distance (SD) is a key component in the safe design, operation, and maintenance of highways. In a recent PacTrans project funded under this grant, Dr. Michael Olsen, Associate Professor at Oregon State University, and his research team developed a 3D virtual visibility sight distance analysis algorithm using lidar data. This method showed several benefits over conventional measurements: flexibility in evaluating various transportation modes, including multi-modal transportation; the algorithm-generated viewshed enables maintenance personnel and transportation engineers to easily identify intersection obstructions and helps informed decision making. To promote wider distribution and rapid dissemination of the program, Dr. Olsen and his team utilized PacTrans Success Story funds to cleanup, optimize, package, and disseminate the code into an easy to use program with a simple, yet powerful, graphical user interface (GUI) that can readily be used by a typical transportation engineer in their workflows. They developed data converters such that the program can use the standard ASPRS las format as well as ASCII text files as input for efficiency, and created with some basic training materials (e.g., sample dataset, program user manual, and videos of examples) to support it. To ensure the tool is quickly visible to a wide audience for adoption, the product create has now been distributed via the e-learning website.
- The University of Washington STAR Lab has developed a novel multisource traffic sensor which is called Mobile Unit for Sensing Traffic (MUST) version 2. The cost of MUST 2 is only about 20% of the cost of other similar products in the market. The main function of MUST 2 is catching the Media Access Control (MAC) address of the mobile devices in the surrounding area of the sensor. The MAC address of a mobile device can be used as a unique identifier of each traveler to record the traveler's spatial-temporal movement characteristics so that traffic parameters can be extracted including travel time, traffic speed, traffic volume and etc. Using PacTrans Success Story funds, Dr.

Wang and his team have developed a video to highlight the functionalities and many of the potential uses of this technology. Further, this sensor has already been deployed along SR-522 in Washington State.

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

In the course of research, many PacTrans outcomes have included the development of new techniques and procedures that become great resources for the university from which they are created, for other universities around the world, and to professionals in the industry. Several great examples that were generated as part of this grant include:

- Oregon State University Professor, David Hurwitz, has, in his lab, created a state of the art bicycle simulator. This simulator has been used on several PacTrans funded research projects investigating topics such as cyclist/freight vehicle interactions and intersection safety surrounding varying intersection configurations and traffic signal progressions. One original project led to a series of dynamic models and sensitivity analysis in the OSU Bicycling Simulator that allowed for the precise calibration of speed measurements with greater than 99% accuracy. Leveraging the methodology of the previous study, Dr. Hurwitz and his team used PacTrans Success Story funds to expand the calibration procedures to include latency, the time delay between an input stimulus and an observable system response. The latency calibration findings were then combined with the previously prepared speed calibration framework in a technical guide that will be shared with bicycle simulator labs around the world constituting the first documentation and dissemination of transferable calibration standards for bicycle simulation.
- The quality of concrete is the most important factor that determines the long-term performance of transportation infrastructure. Despite all efforts and streamlined procedures, many structures suffer from performance and long-term durability problems due to low-quality concrete. The formation factor of concrete is directly related to critical performance indicators of concrete and provides critical information about both durability and mechanical performance of structures during their service life. Several Oregon State University researchers are leading the efforts to establish formation factor of concrete as a rapid performance index. The OSU team is part of a pooled-fund study that involves several state DOTs and FHWA to establish standard protocols for the determination and specification of formation factor for durable concrete. Dr. Burkan Isgor, Professor at OSU, is leveraging PacTrans Success Story funding to take these newly developed techniques one step further. He has developed on online calculator to predict formation factor of concrete, developed an online training module for that calculator, and organized an educational webinar on the subject.

What is the impact on society beyond science and technology?

All research that PacTrans funds endeavors to extend beyond the world of science and technology. Namely, our ultimate goal under this grant was to move people more safely. This may have been done through the new sensing technologies or more precise methods for predicting rock fall events, but the

end user has always been our ultimate goal. Here are a few examples of PacTrans projects that transcend science and technology:

- Over the past several years, PacTrans Director and Professor at the University of Washington, Yinhai Wang, and his team have been working in partnership with Washington State Transit Insurance Pool on a TRB IDEA grant testing collision avoidance systems on transit buses. An offshoot project, funded by PacTrans during this grant, sought to use the video data collected from these detection systems to build a machine learning neural network to identify near miss events. Unlocking the potential of near miss events allow transportation professionals to be far more proactive in the realm of transportation safety. The algorithm developed during that project was run on a desktop computer. Dr. Wang's team used PacTrans Success Story funding to transfer that system to a real-time onboard near-miss detection system, taking real-time video inputs and generate warnings to drivers when any conflict is detected. This technology transfer required some modification of the algorithms since onboard computers are generally less powerful in terms of computational power. The funding was further used to make an educational video to introduce this new technology to the transportation community.
- Oregon State University Associate Professor, Haizhong Wang, has conducted two separate investigations on different aspects of bicycle safety under this grant. He then leveraged PacTrans Success Story funds to host several interactive workshops with local engineers and communities, educating them on the findings of these studies. He further went to two different conferences internationally to present this work on the world stage.

Changes/Problems

NONE.

Special Reporting Requirements

NONE.