



Semi Annual Progress 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: 69A355174110

Project title: **Pacific Northwest Transportation Consortium (PacTrans): Providing Data-Driven Solutions for the Diverse Mobility Challenges of the Pacific Northwest**

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Submission Date: April 30, 2023

DUNS: 605799469 **EIN:** 91-6001537

Report #12, SAPR reporting for six months (October 1, 2022 – March 31, 2023)

Project/Grant Period: November 30, 2016 - March 15, 2024

Reporting Period End Date: March 31, 2023

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 research partners, as well as Boise State University (BSU) and Gonzaga University (GU) as education partners. PacTrans' theme centers on "Developing Data Driven Solutions for the Diverse Mobility Needs of People and Goods in 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 mobility. 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 seven 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 and education activities.

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 October 1, 2022 – March 31, 2023, 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 mobility research.

As mentioned in previous Semi-Annual Progress Reports, PacTrans shifted our last two research performance periods forward on the calendar in an attempt to maximize the amount of time researchers have to conduct their work while still ensuring that all projects will be completed on time and technical reports will be submitted to the necessary repositories before the grant ends. Thus, all projects that will have been funded during the course of this grant were initiated before the end of the most recent performance period. All projects have project profiles on our website, the ongoing projects have active profiles on the Research in Progress (RiP) database, and completed projects have all been submitted to TRiD, NTL, etc.

During this reporting period, we have continued the collection, peer reviewing, and finalization of draft technical reports from Year 4 (2020 – 2022) projects, and Year 5 (2021 – 2022) projects. At present roughly 75% of Year 4 projects and 30% of Year 5 projects have been finalized. Finally, Year 6 (2022 – 2023) projects are coming due at the end of April so we have begun to prepare for this process.

There are several projects that have been hindered by COVID-19 and related setbacks. We are currently in the process of preparing a no-cost extension request for this grant to allow these PIs to finish their work in a meaningful way.

Technology Transfer

During this past reporting period, PacTrans PIs and staff have finalized our four 2021 success story projects, and have been monitoring our five 2022 success story projects and six 2023 success story projects. These projects are extensions of research that merit additional funding for the creation of outputs specifically geared toward industry in an attempt to make implementation one step closer for meaningful research results.

PacTrans and its PIs engaged in a number of great conferences, workshops, and symposiums during this reporting period that offered a great platform for us to showcase our research to a broader audience.

In early October, PacTrans hosted our annual Region 10 Transportation Conference and continued its partnership with the Center for Safety Equity in Transportation (CSET) Tier 1 University Transportation Center (UTC). This year we also added a new contributing partner to the conference, the UW Mobility Innovation Center. This was the first year since 2019 that we were able to offer this conference in-person. It was held on Friday, October 14, 2022, on the University of Washington campus. The theme

was, *Driving Multimodal Mobility & Safety Innovations into the Future*. With over two hundred in attendance, it was a very successful conference that included a keynote presentation, a plenary session, and two sessions of three breakout technical panels. Panels were on topics such as: transformative solutions, workforce development, artificial intelligence, connected and automated vehicles, rural safety, and supply chain disruptions. PacTrans also presented five annual awards and hosted a poster session that showcased over twenty ongoing/recently completed PacTrans research projects.

Also in October, PacTrans Assistant Director, Cole Kopca, attended the Tribal Colleges & Universities (TCU) and University Transportation Centers (UTC) Summit in Albuquerque, New Mexico that was organized in conjunction with the First Americans Land-Grant Consortium (FALCON) conference. The summit was meant to continue dialogue on how UTCs can better partner with Tribal Colleges and Universities across the country.

In December, several PacTrans researchers took part in, and presented work at, the ITS Washington Annual Meeting in Tacoma, Washington. Then, postdoc, Wei Sun, presented on a STAR Lab developed technology and some research that it has contributed to. This technology, Mobile Unit for Sensing Traffic (MUST), has since been patented and spun off into a startup company called AIWaysion. Graduate Research Assistant, Sam Ricord, presented research on data equity bias in transportation data, and Cole Kopca presented on his experience offering our first K-12 STEM Outreach middle school course on Autonomous Vehicles.

Also in December, PacTrans was a co-organizer of a two-part workshop on The Frontiers of Artificial Intelligence-Empowered Methods and Solutions to Urban Transportation Challenges. This activity took place in Gainesville, Florida. Other organizers included: the National Science Foundation, the TRB AED50 Artificial Intelligence and Advanced Computing Applications Committee, the American Society of Civil Engineers (ASCE) AI Committee, ASCE Connected and Automated Vehicle Impact Committee, the Southeastern Transportation Research, Innovation, Development and Education Center (STRIDE). Several UW student researchers also participated in the event.

The MUST technology has been deployed at the intersection of Highway 97 and Larue Road in Yakama Nation, a federated Tribe in Washington State. Seven people were killed at this intersection over the past twenty years, making it the deadliest in Yakama Nation. Several news agencies reported this story. AIWaysion hosted an exhibit at the 2023 TRB Annual Meeting to showcase this PacTrans research product and the MUST sensor attracted lots of interests.

In March, PacTrans Director, Yinhai Wang, and Assistant Director, Cole Kopca, participated in Carnegie Mellon and Mobility 21's 2023 National Mobility Summit of UTCs in Washington, D.C. Mr. Kopca presented a poster showcasing several highlight research, technology transfer, and education projects that we have funded during this grant.

PacTrans' recent spinoff company, AIWaysion, was a recent recipient of the 2022 U.S. Department of Transportation Small Business Innovation Research (SBIR) Award. The project, titled, Edge Server-Based AI Application for Dilemma Zone and Traffic Conflict, falls under the SBIR topic of, "AI Video Analysis of Dilemma Zone and Other Conflicts at Signal Controlled Intersections (22-FH2)."

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.

During this reporting period PacTrans hosted two installments of our quarterly doctoral webinar series. Presenters included Mingming Cai (UW), and Fiete Krutian (UW).

This past January, PacTrans supported over thirty-five students from consortium universities to participate in the 102th Transportation Research Board (TRB) Annual Meeting. In concert with the TRB Annual Meeting, PacTrans has the opportunity to present two annual outstanding student-of-the-year awards: The Region 10 Michael Kyte Student of the Year award and the USDOT UTC Outstanding Student of the Year Award. This year's Michael Kyte Outstanding Student of the Year award went to UW PhD student, Frank (Hao) Yang, and the PacTrans USDOT UTC Outstanding Student of the Year award went to OSU PhD student Lena Breuer. Several other accolades from this conference included:

- Meixin Zhu's dissertation entitled "Behavior Modeling and Motion Planning for Autonomous Driving Using Artificial Intelligence" received the Best Dissertation Award from the TRB AI and Advanced Computing Applications Committee (AED50);
- Chenxi Liu and his co-authors' paper (TRBAM-23-05178: Cooperative and Comprehensive Multi-task Surveillance Sensing and Interaction System Empowered by Edge Artificial Intelligence) won the 2023 Best Paper Award from TRB's AED30 Information Systems and Technology Committee.
- Both OSU and UW had finalist team for the 2023 TRB Traffic Control Device Student Challenge (TCDSC) where each finalist presented their proposal in a session.

PacTrans also hosted our annual Region 10 Student Conference. This event was also co-organized by CSET. This event was hosted on the UW campus the day after our annual conference and featured activities that included three speaker presentations, a career development panel, and the annual student poster competition.

Several other student related highlights from this reporting period included:

- UW's Peter Yu was featured in ASCE's annual New Faces in Civil Engineering installment
- OSU's Amy Wyman and Bryan Staes received a Dwight David Eisenhower Transportation Fellowship Program fellowship
- UAF's Steel Bridge team took second place at the national competition
- The OSU ITE Student Chapter won the Western District Traffic Bowl and are headed to nationals
- The UW Concrete Canoe team won their regional competition and are headed to nationals
- The UI Clean Snowmobile team won second at their national competition
- A student team from OSU traveled to Kyoto, Japan to compete in the NHTSA ESV Competition, they took second
- The WSU Construction Management team won both a regional and a national level competition
- The WSU CyberCougs was a local cybersecurity competition

- Two OSU students, Kezia Suwandhaputra (a PacTrans Fellow) and Syed Baqir Hussain, were named 2023 Lifesavers Traffic Safety Scholars.
- PacTrans Director, Yin Hai Wang, received two accolades from ASCE: the Francis C. Turner Award, and he was also made a distinguished member of the society
- UI's Kevin Chang received the 2022-2023 University of Idaho's Excellence in Teaching Award

Workforce Development

PacTrans had a number of activities geared at workforce development during this reporting period.

The PacTrans WDI is currently working with UW Teen and Youth Program to reoffer a course titled Introduction to Autonomous Cars that will be offered to sixth through eighth graders. This course was offered last summer with great success. This summer the course is being offered in two different sessions due to high demand.

The PacTrans WDI is also partnering with WSDOT and WSU to offer a new residential summer camp focused on Transportation. This summer camp will be a six day overnight camp aimed at attracting high school students to study and/or work in transportation. It will have two host locations, one on the UW campus and the other on the WSU campus. It is scheduled in late summer this year.

Furthermore, the WSDOT will collaborate with the PacTrans WDI for some more courses. To ensure we have the right person to handle new course developments, PacTrans will hire a professional as the director of the PacTrans WDI. The process is currently ongoing.

Finally, during this reporting period, PacTrans offered five wonderful webinars/seminars to our students and our broader community:

1. In October we hosted Elise Miller-Hooks (George Mason University) for a talk titled, Optimization and Machine Learning in Urban Transportation Under a Sharing Economy
2. In December we hosted Dusty Rasmussen (Seattle Department of Transportation) for a talk titled, Traffic Operations Division 101: Seattle Department of Transportation
3. In December we also hosted Junfeng Jiao (University of Texas at Austin) for a talk titled, What do we know about E-Scooter Travels? A Story in Austin TX
4. In December we partnered with our new Tribal Technical Assistance Center to host Margo Hill (Eastern Washington University) for a talk titled, Tribal Sovereignty and Tribal Engagement: How to do Business with Tribes
5. In February we hosted Matt Neely (Park City Utah) for a talk titled, Opportunities in Transportation Engineering

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 selects research projects that offer 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. PacTrans also supports a wide variety of student activities geared toward enhancing their educations. Several examples include: supporting ITE student chapter activities, travel support for students to present accepted work at conferences, sponsorship of student competition teams, and so much more.

Outreach: PacTrans offers training and educational opportunities to K-12 students through its outreach activities. Two quick examples include: (1) UW is currently working with UW Teen and Youth Program to develop a course titled *Introduction to Autonomous Cars* that will be offered to sixth through eighth graders, and (2) this past summer with PacTrans support, OSU hosted 17 students for their annual National Summer Transportation Institute.

Funding assistance: PacTrans financially supports students through their participation in research activities, as well as fellowships. During this past reporting period, PacTrans welcomed four new graduate fellows (three from UW and one from OSU), and funded two undergraduate research fellows. The Undergraduate Research Fellowship offers undergraduate students the opportunity to participate in research while receiving a stipend for things like conference travel, or research supplies.

Seminars, workshops, and conferences: As outlined above, PacTrans offers many opportunities for training and professional development through its webinar series and various workshops, such as the seven webinars we hosted during this reporting period. PacTrans also emphasizes our Region 10 Transportation Conference and Region 10 Student Conference as important opportunities for training and professional development.

Internships: PacTrans regularly posts internship opportunities on our website as a student resource. During this reporting period for example, PacTrans circulated thirteen separate announcements for internship opportunities. Further, we regularly work with our external partners to develop internship programs for our students. With the WSDOT for example, we have set up internship opportunities both with their traffic management center and their tolling operations group.

Partnerships: PacTrans has developed strong partnerships with many agencies, companies, and non-profit organizations. For example, 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. PacTrans is also in a strong partnership with American Society of Civil Engineers in organizing the upcoming International Conference on Transportation and Development.

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 monthly newsletter and annual reports,

and promoted through social media such as LinkedIn and Facebook and the University of Washington press media. We also disseminate news, events and results via our website at www.pactrans.org.

Another avenue for dissemination that PacTrans leans on heavily is presentations at conferences, workshops, and symposia. Each year we send roughly one hundred PIs and students (about 70 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?

PacTrans is working hard to wrap up this iteration of our Center. As already mentioned, we intend to request a no-cost extension for this grant. That extension request is currently be formulated. In the meantime. Below are the center's identified plans and strategies for accomplishing its goals and objectives over the next reporting period.

Research

During this next reporting period PacTrans will wrap up any outstanding year 4 (2020 – 2022), year 5 (2021 – 2022), and year 6 (2022 – 2023) funded projects. As project technical reports are submitted, we will send them out for peer review, and then to a technical editor before considering them complete. We will then post the reports on our website and send them to TRID and Research Hub.

Technology Transfer

PacTrans will work with currently funded success story project PIs to get all projects completed and deliverables submitted and posted to our website. These small projects do not require technical reports but instead they require whatever the medium was that was developed through the project (website, webtool, video, recorded training, digital materials, etc.)

Also, during this next reporting period, PacTrans has several great opportunities for technology transfer, including: the 2023 ASCE International Conference on Transportation and Development, the National Travel Monitoring Exposition and Conference (PacTrans is a co-host of this conference), and the Women in Transportation Conference.

Education

To the extent that funds and time remain for this grant, PacTrans consortium partners will continue to support our students in the ways we have been over the past six years. Generally, those include:

1. We support professional organization student chapters, such as the Institute of Transportation Engineers, and student competition teams, such as UI's clean snowmobile team, and UW's Hyperloop team. Most of these teams have regional and national competitions during the spring.
2. Some of these funds are historically used to support the travel of students to conferences such as the ASCE International Conference on Transportation and Development to present their work.

Finally, PacTrans will continue to operation of our quarterly Doctoral Webinar Series with a Spring installment of the series.

Workforce Development

PacTrans will offer two sessions of our Introduction to Autonomous Vehicles course to middle school students in July. We will also facilitate the inaugural offering of a new Residential Summer Transportation Camp in partnership with WSDOT and WSU. PacTrans will hire a professional to serve as director of the PacTrans WDI. This person will work with WSDOT and other partners to develop new courses. Our goal is to make the PacTrans WDI self-sustained in several years.

In addition, we will also continue hosting webinars the provide insights as to the current state of the industry and emerging researching needs and cutting-edge technologies and techniques. For example, Prof. Zong Tian of the University of Nevada Reno will join us for a Research-to-Technology-Transfer seminar.

Participant and Collaborating Organizations: Who has been involved?

What individuals have worked on the program?

- PacTrans Director, **Yinhai Wang**, Ph.D., Professor of Civil and Environmental Engineering at the UW, devotes 50 percent of his time directing PacTrans. Dr. Wang has overall responsibility for program management, oversight of PacTrans operations, including the Research Committee, the Education and Workforce Development Committee, and the Outreach and Technology Transfer Committee, and Student Leadership Council. He is the regional and national leadership for PacTrans, and the contact person for management relationships with USDOT Research and Innovative Administration (RITA) and other USDOT organizations.
- PacTrans Associate Director in Research, **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 Professor and Transportation Economist in the School of Economic Sciences at Washington State University (WSU), 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 75 percent of his time to the day-to-day operations in support of the PacTrans mission. His responsibilities include project management, grant management, events coordination and outreach, and managing the PacTrans operations team.
- PacTrans full-time Finance, Grants, and Research Manager, **Christina Yarbrough**, devoted 100 percent of her time to the Center’s budget, expenditure, and research management.
- PacTrans part-time Program Coordinator, **Melanie Paredes**, devoted 40 percent of her time to the Center’s fiscal matters, support with events coordination and outreach and day to day administration.
- PacTrans has 28 fulltime faculty at the UW engaged in transportation research. Our consortium partners (OSU, UI, WSU, UAF, GU, BSU) have 41 fulltime faculty directly involved in PacTrans research.

What other organizations have been involved as partners?

The following table highlights the institutions, organizations, agencies, and industry partners who have partnered with current PacTrans funded research projects to provide match, either cash or in-kind.

Partner	Type
Washington State Department of Transportation	Government
Alaska Department of Transportation and Public Facilities	Government
Oregon Department of Transportation	Government
City of Moscow	Government

Further, PacTrans has continuing relationships with many partners that have been cultivated over the

years. The table below highlights the many partnerships that PacTrans has built over the duration of the center:

Partner	Type
Alaska Department of Transportation and Public Facilities	Government
Idaho Transportation Department	Government
Oregon State Department of Transportation	Government
Washington State Department of Transportation	Government
City of Bellingham	Government
City of Seattle	Government
City of Lynnwood	Government
City of Bellevue	Government
City of Everett	Government
King County	Government
Snohomish County	Government
Pierce County	Government
Sound Transit	Government Agency
Washington Traffic Safety Commission	Government Agency
Washington State Transportation Insurance Pool	Government Agency
University of Alaska, Anchorage	Educational Institution
University of Washington Transportation Services	Educational Institution
Washington State Department of Ecology	Government
Puget Sound Regional Council	Government
Washington State Transportation Investment Board	Government Agency
American Society of Civil Engineers	Professional Association
Institute of Electrical and Electronics Engineers	Professional Association
Institute of Transportation Engineers	Professional Association
Yakama Nation	Federated Tribe
Northwestern Tribal Technical Assistance Program (NW TTAP) Center	University Center
ITS Washington	Professional Association
HDR Engineering	Private Industry
Port of Portland	Government
BMW Group	Private Industry
Western Trailers	Private Industry
Coral Sales Co.	Private Industry
National Institute for Transportation and Communities	University Transportation Center
Transportation for Livability by Integrating Vehicles and the Environment	University Transportation Center
Center for Environmentally Sustainable Transportation in Cold Climates	University Transportation Center
Aichele and Associates	Private Industry
Alstom Grid Inc.	Private Industry
Alta Planning and Design	Private Industry

Battelle	Private Industry
Cascade Bicycle Club	Non-profit/ Foundation
Feet First	Non-profit/ Foundation
DENSO	Private Industry
T Mobile	Private Industry
DKS Associates	Private Industry
Fehr and Peers	Private Industry
FLIR	Private Industry
Inrix Inc.	Private Industry
Wejo	Private Industry
AIWayision	Private Industry
Tom Tom	Private Industry
Amazon	Private Industry
Nokia	Private Industry
Transpo Group	Private Industry
Intelligent Transportation Systems of Washington	Professional Association
Luum	Private Industry
Kittelson and Associates	Private Industry
Microsoft	Private Industry
BlackBerry	Private Industry
Verizon	Private Industry
Q-Free	Private Industry
PACCAR, Inc.	Private Industry
West Salem High School	Educational Institution
The Bush School	Educational Institution

Outputs

	Total	UW	WSU	UI	OSU	UAF	GU	BSU
Publications: peer reviewed journal articles	38	13	2	6	2	1	1	1
Publications: Book chapters and other edited manuscripts	11	10	0	0	1	0	0	0
Conference papers	59	23	3	13	15	2	1	2
Conference presentations	93	56	9	11	11	3	1	2
Lectures/Seminars /Workshops/ Invited Talks	51	35	0	4	19	2	0	0
Policy Papers	0	0	0	0	0	0	0	0
Websites or Other Internet Sites	3	2	0	0	1	0	0	0

New Methodologies, Technologies or Techniques	12	4	0	4	1	3	0	0
Inventions, patent applications, and/or licenses	0	0	0	0	0	0	0	0
Other products: data or databases, physical collections, audio or video products, software or NetWare, models, educational aids or curricula, instruments, or equipment	10	7	0	1	2	0	0	0

OUTPUTS: Technology Transfer Plan Output Metrics	Annual Targets	Numbers for Reporting Period
Number of publications, presentations, and posters made at conferences or workshops explaining or promoting the research outputs	200	241
Number of software tools and technologies made available to practitioners	10	12

Examples of peer reviewed journal articles

Khanal, M. and Edelman, N. "Application of Connected Vehicle Data to Assess Safety on Roadways" Eng 4, no. 1: 259-275. 2023. <https://doi.org/10.3390/eng4010015>

Madkour, F.E., Lowry, M., Abdel-Rahim, A., Hammad, A., Vibhav, D., and Yu, P. "Analysis of Wind Force on Cyclists from Passing Vehicles." Transportation Research Record (2023): 03611981231159126.

Elshazli, M.T., Ibrahim, A., and Abdel-Rahim, A. "Truck platooning impact on existing Bridges' load ratings." In Structures, vol. 51, pp. 1706-1721. Elsevier, 2023. <https://doi.org/10.1016/j.istruc.2023.03.131>.

Wang, Y., & Shen, Q. A latent class analysis to understand riders' adoption of on-demand mobility services as a complement to transit. Transportation, 1-19. (2022).

Madkour, F., Lowry, M., Abdel-Rahim, A., Hammad, A., Vibhav, D. and Paulo, Y. (In press -2023). "Analysis of Wind Force on Cyclists from Passing Vehicles." Transportation Research Record: Journal of the Transportation Research Board.

Yang, H., Cai, J., Liu, C., Ke, R., and Wang, Y. "Cooperative Multi-camera Vehicle Tracking and Traffic Surveillance with Edge Artificial Intelligence and Representative Learning." Transportation Research Part C: Emerging Technologies. Vol. 148, March 2023, 103982, 2023. <https://doi.org/10.1016/j.trc.2022.103982>.

Ke, R., Cui, Z., Chen, Y., Zhu, M., Yang, H., Zhuang, Y., and Wang, Y. "Lightweight Edge Intelligence Empowered Near-crash Detection Toward Real-time Vehicle Event Logging." IEEE Transactions on Intelligent Transportation Systems. In Press. 2023. <https://doi.org/10.1109/TIV.2023.3241934>.

Liu, C., Yang, H., Ke, R., and Wang, Y. "Toward a Dynamic Reversible Lane Management Strategy by Empowering Learning-Based Predictive Assignment Scheme." IEEE Transactions on Intelligent Transportation Systems. Vol. 23(12), 23311-23323, 2022. <https://doi.org/10.1109/TITS.2022.3202487>.

Examples of Book Chapters and Manuscripts

- Shen, Q., & Wang, Y. (2022). Supplementing Fixed-Route Transit with Dynamic Shared Mobility Services: A Marginal Cost Comparison Approach. PacTrans Project Report.
<https://digital.lib.washington.edu/researchworks/handle/1773/49486>
- Shen, Q., Ban, X., Lowry, M., Moudon, A., Cai, M., Ashour, L., Wang, Y., & Brown, M. (2023). Shared Mobility Options for the Commute Trip: Opportunities for Employers and Employees. PacTrans Project Report. Accepted for publication.
- Shen, Q., & Ashour, L. (2023). Understanding the Impact of TNC Pricing Strategies on the Prospect of Transit Agency-TNC Partnerships. PacTrans Project Report. Under review.

Examples of conference papers and presentations

- PacTrans Region 10 Transportation Conference, virtual (2021). "Data-Driven Assessment of Post-Earthquake Bridge Functionality and Regional Mobility." (oral presentation, virtual poster session).
- PacTrans Region 10 Transportation Conference, Seattle, USA (2022). "Data-Driven Assessment of Post-Earthquake Bridge Functionality and Regional Mobility." (poster presentation).
- Geyin, M., and Maurer, B.W. (2022). "An AI-Driven, Mechanistically Grounded Framework for Geospatial Modelling of Soil Liquefaction." *Geocongress 2022: Geophysical and Earthquake Engineering and Soil Dynamics* (A Lemnitzer and A.W. Stuedlein, eds.), Geotechnical Special Publication 334: 455-494. American Society of Civil Engineers.
- Edelmann N. and Khanal M. "Using Harsh Braking Data for Connected Vehicles as a Surrogate Safety Measure", Paper Number: TRBAM-23-01347, 102nd Annual Meeting of the Transportation Research Board, January 8-12, 2023, Washington, DC.
- Edelmann N. and Khanal M. "Review of Surrogate Safety Measures for Roadway Safety Analysis", Proceedings of the 8th IAJC International Conference, 14 October 2022, Orlando, FL.
- Mohamed E., Ibrahim, A. and Abdel-Rahim, A., "Truck Platooning Impact on Existing Bridges Load Ratings", Transportation Research Board 102nd Annual Meeting, January 08-12, 2023, Washington D.C.
- Madkour, F., Lowry, M., Abdel-Rahim, A., Hammad, A., Vibhav, D. and Paulo, Y. "Analysis of Wind Force on Cyclists from Passing Vehicles, Transportation Research Board 102nd Annual Meeting, January 08-12, 2023, Washington D.C.
- Almalki, S. A., Abdel-Rahim, A., and Sheldon, F. "Disrupting the Cooperative Nature of Intelligent Transportation Systems." In 2022 IEEE World AI IoT Congress (AllIoT), pp. 131-137. IEEE, 2022.
- UAVs for monitoring slope response, ASCE Geoinstitute annual conference, Los Angeles, March 2023.
- Liao, H.. Accessibility to emergency or community food services and public transit in Seattle, WA. Annual Meeting of American Association of Geographers (AAG). March 23-27. Denver, CO. 2023
- Martha Lum, Presented at the WSU Showcase Event for Undergraduate Research, March 27, 2023. Impacts of Covid On Washington Agricultural Market Exports
- Sen, F., Che, E., Simpson, C., Assessing the Accuracy and Feasibility of Utilizing UAS-based Point Cloud in Pavement Smoothness/Roughness Measurement. 2022 Region 10 Transportation Conference. (10/14/2022)
- Velasquez, B., Hernandez, S., Anderson, J.C., Hernandez, S.V., (2023). Covid-19 and The Impacts on Trucking Operations and Hours-of-Service for Truck Drivers. 102nd Transportation Research Board, Washington D.C., USA.
- Ji, D., Turkan, Y., Calvi, P. (2022). "Toward Automation in Crack Detection and Measurements: Benchmarking of CNN-based Algorithms", Proceedings of the International Symposium on Automation and Robotics in Construction, 2022, 2022-July, pp. 136–143
- Shen, Q. and Y. Wang. 2023. An Economic Analysis of Incorporating New Shared Mobility into Public Transportation Provision. Presentation given at the 102nd Annual Meeting of Transportation Research Board, Washington DC, January 10.

- Ashour, L. and Q. Shen. 2023. Understanding the Impact of TNC Pricing Strategies on the Prospect of Transit Agency-TNC Partnerships. Poster presentation given at the 102nd Annual Meeting of Transportation Research Board, Washington DC, January 9.
- Cai, M., Q. Shen, and Others. 2023. Examining Commute Mode Choice of Essential Workers before and during the Covid-19 Pandemic Using Travel Survey Data. Poster presentation given at the 102nd Annual Meeting of Transportation Research Board, Washington DC, January 10.
- Xu, Ang and Yan, Chiwei, A Locational Demand Model for Free-floating Micro-mobility Systems, PacTrans Region 10 Transportation Conference, 2022. Xu, Ang and Yan, Chiwei, A Locational Demand Model for Free-floating Micro-mobility Systems, INFORMS TSL Conference, 2023.
- Madkour, F., Lowry, M., Abdel-Rahim, A., *Hammad, A., Vibhav, D. and *Paulo, Y. (2023). "Analysis of Wind Force on Cyclists from Passing Vehicles." Annual Meeting of the Transportation Research Board.
- Peterson, B., and Hess, H., "Comparison Between Finite Element Analysis and Winding Function Theory of a Field Regulated Reluctance Machine," IEEE Industrial Electronics Society Global On Line Conference (ONCON) 2022, December 2022, Mumbai, India.
- Garcia, S., Peterson, B., Hess, H., and Berven, Christine, "Flywheel Energy Storage System," 49th Power Sources Conference, Fort Washington, MD, June 30, 2023.
- Tsai, Meng-Ju, Zhiyong Cui, Chenxi Liu, Hao Yang, and Yinhai Wang. "An Incremental Learning-based Framework for Non-stationary Traffic Representations Clustering and Forecasting." IEEE International Intelligent Transportation Systems Conference. Oct. 2022, Macau, China.
- Yin, Shuyi, Zhiyong Cui, and Yinhai Wang. "Reinforcement Learning for Curbside Space Management with Infrastructure Autonomy and Mixed Vehicle Connectivity." IEEE International Intelligent Transportation Systems Conference. Oct. 2022, Macau, China.

Example of lectures/seminars/workshops/invited talks

- Ahmed Abdel-Rahim, "Artificial Intelligence-Empowered Urban Transportation solutions– Are civil engineering graduates Ready for the Next Generation Transportation system?", NSF's Frontiers of Artificial Intelligence-Empowered Methods and Solutions to Urban Transportation Challenges - Phase II: Best Practice, Education, and Workforce Development - December 15, 2022, Gainesville, Florida – Invited Speaker.
- Wartman, J. Remote sensing for rockfall assessment, GNS Science research seminar, February 2023.
- T. H. Wu honor lecture, Ohio State University, January 2023
- Haifeng (Felix) Liao. 2023. Smart Growth and Sustainable Cities. Guest Lecture. Environmental Sciences Program Seminar Series. The University of Idaho. November 16, 2022.
- Shen, Q. and Y. Wang. 2023. An Economic Analysis of Incorporating New Shared Mobility into Public Transportation Provision. PhD Research Seminar of the Interdisciplinary PhD Program in Urban Design and Planning, January 17.
- Xu, Ang and Yan, Chiwei, A Locational Demand Model for Free-floating Micro-mobility Systems, PacTrans Region 10 Transportation Conference, 2022.
- Wang, Y. George Mason University Seminar. "Forecasting Traffic Like Weather: An Advanced Deep Neural Network Approach." March 22, 2023.

Examples of Website(s) or other Internet site(s)

https://github.com/angxu1/bike_sharing

Examples of New Methodologies, Technologies or Techniques

- Shen, Q., Ashour, L. Exploration of new time-series modeling of TNC price changes using big data published by Chicago.
- https://github.com/angxu1/bike_sharing contains the source code of the estimation algorithms for inferring bike-sharing demand based on vehicle data only. It is scalable for the data in the city of Seattle.
- Hess, H. Feedback control to stabilize two axes of a six-axis shaftless reluctance motor.

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

Geyin, M. and Maurer, B.W. (2021). "RapidLiq: Software for Near-Real-Time Prediction of Soil Liquefaction." DesignSafe-Cl. <https://doi.org/10.17603/ds2-4bka-y039>. (Software)

Visualization interface to determine the locations and sizing of layover charging infrastructure for battery electric buses.

Impact of Bicycle Rolling Stop Laws on Safety-Relevant Behaviors in the Pacific Northwest [supporting dataset].

Two datasets produced for the completed PacTrans project "Shared Mobility Options for the Commute Trip: Opportunities for Employers and Employees

https://github.com/angxu1/bike_sharing contains all synthetic data and Seattle bike-sharing data in July 2018 used for the study. It can be used for reproduction and benchmarking purposes.

The "Avalanche Monitoring System in Mountainous Area based on IoT Sensor Network" project produced a prototype sensor that is currently being evaluated by WSDOT and Norwegian Public Roads Administration

Outcomes

OUTCOMES: Technology Transfer Plan Outcomes Metrics	Annual Targets	Numbers for Reporting Period
Number of early adopters of our research outputs	10	7
Changes made to the transportation system, or its regulatory, legislative, practice manuals, design standards, or policy frameworks	2	2

In a 2020 PacTrans funded research project titled, *Economic and Health Metrics of Active School Travel: A Practical Tool for Transportation Planners and Educators*, a UW team of researchers set out to develop a tool called the Children Walking To Health Tool (CW2H) for use by Departments of Transportation to measure the health and monetary benefits of Active School Travel. This tool builds on previous research results from the research team that developed a Washington School Walk Score, which estimates the school-level rates of Active School Travel for more than 1,300 K-8 schools in Washington State. Outputs from this tool will be estimates of the corresponding health and economic outcomes of the School Walk Score inputs. Used interactively, CW2H serves to test different scenarios and examine the impact of changes in the School Walk Score. This is currently being used by the Washington State Department of Transportation.

Another excellent outcome example from our research portfolio comes from one of our multi-institutional research projects that was a collaboration between WSU and UW. The project titled, *Data-Driven Assessment of Post-Earthquake Bridge Functionality and Regional Mobility*, set out to (1) create a database of bridge performance metrics for 100,000 simulated cases of bridge and intensity measure; (2) improved bridge fragility relationships for PNW retrofitted and non-retrofitted bridges; (3) a model for predicting subsurface Vs-depth profiles in the PNW; (4) assessment of post-earthquake functionality of approximately 10,000 PNW bridges following an M9 CSZ earthquake; and (5) regional assessment of

network mobility, wherein the likelihood of post-event route serviceability is quantified probabilistically. This work is now being used to inform priority for seismic retrofit of bridges to promote post-earthquake mobility in Washington State.

Impact

IMPACTS: Technology Transfer Plan Impacts Metrics	Annual Targets	Numbers for Reporting Period
Number of research outputs that positively contribute to the reduced roadway vehicle to vehicle or vehicle to ped/bike crash rates	3	1
Number of research outputs that positively contribute to improving roadway travel reliability, efficiency, accessibility	7	4

What is the impact on the effectiveness of the transportation system?

In 2020, PacTrans funded a research project titled, *Evaluation of the Idaho (Bicycle) Stop Laws in the Pacific Northwest*. This was a multi-institutional effort between OSU, UI, and GU. This team’s objectives included: (1) to clarify the anticipated safety impact of the Stop as Yield (“Idaho Stop”) for all roadway users in Oregon (and its potential application in neighboring states such as Washington where such a law is being considered), and (2) to evaluate the historical impact this law has had in the state of Idaho since adoption in the early 1980s. Since completion of this work. The team has had representatives from six states who are currently considering enacting such a law reach out to hear more from the team about their finds and they have traveled to several states, including California to make presentations on their research to elected officials. The findings of this work are influencing state laws around the country to help increase bicycle safety on our roadways.

What is the impact on the adoption of new practices, or instances where research outcomes have led to the initiation of a start-up company?

In many previous Semi-Annual Progress Reports, we have chronicled the journey of the development of the Mobility Unit for Traffic Sensing technology, commonly referred to as the MUST sensor. Several years ago, the product was commercialized through CoMotion at University of Washington and a spinoff startup company called AIWaysion was created.

A recent partnership between the UW STAR Lab, PacTrans, and the UW Mobility Innovation Center has provided funding for this technology to be deployed in Yakima Nation. Over the last 10 years, the corridor of Highway 97 between Union Gap and Toppenish has seen 350 serious injury crashes and 22 fatal crashes. Seven people were killed in the past twenty years at the intersection of Highway 97 and Larue Road, making this intersection the deadliest in Yakama Nation, a federally recognized Native American Tribe in Washington State. The MUST technology is selected for safety improvement at this challenging location.

What is the impact on the body of scientific knowledge?

PacTrans extensive research portfolio contributes greatly to the scientific body of knowledge in the transportation field. For example, the STAR Lab at the University of Washington has been on the leading edge of Artificial Intelligence and Machine Learning applications in the transportation space. Several highlights include: (1) we co-organized a two-part AI in Transportation workshop with NSF, ASCE, and several other UTCs, (2) the STAR Lab director, Dr. Yin Hai Wang and two STAR Lab alumni, Dr. Zhiyong Cui and Dr. Ruimin Ke, are in the midst of publishing a new textbook in transportation engineering, Machine Learning for Transportation Research and Education, and (3) the STAR Lab director has been invited to give a presentation during the FHWA library seek on AI and Edge Computing for Safer and Smarter Highways.

What is the impact on transportation workforce development?

Recently our Workforce Development Institute has been pursuing several incredibly important and promising K-12 STEM Outreach efforts. The, which first was established last year, is a partnership with the UW Youth and Teen Program to offer a transportation related course to middle school kids about Autonomous Vehicles. The second is a new partnership with WSDOT and WSU where a week-long residential camp is being developed. Students will live on campus a hear from speakers, visit labs, and go on field trips to learn about many different aspects of the transportation industry. All of these experiences will culminate with a final project that students will present at the end of the week. Also the two intern programs with WSDOT, the Traffic System Management Center intern program and the Toll Office intern program keep producing the workforce needed by WSDOT when training the future transportation engineers.

Changes/Problems

None.

Special Reporting Requirements

Research Project Requirements

Per our research update above, PacTrans is working diligently to wrap up all remaining ongoing research projects. Records of these projects have all been uploaded to RiP and put on our website. Further, PacTrans has begun include the requirement for an ORCID number from each PI before their project funds are released.

Submission of Final Research Reports

As final versions of technical project reports are completed and checked for ADA compliance, they are then uploaded to our repository and linked on the research project profiles on the PacTrans website. Then they are submitted to TRID and Research HUB as well. PacTrans staff is currently finishing the publication of Year 4 and Year 5 technical reports and preparing to begin receiving draft technical reports for Year 6 funded projects.