Semi Annual Progress Report for University Transportation Centers

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

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

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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: through our newly developed Workforce Development Institute, PacTrans has a broad and flexible platform from which to offer continuing education, short term training courses to working professionals, as well as K-12 STEM outreach activities.

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 April 1, 2022 – September 30, 2022, 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 has 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 began during the previous 6-month performance period.

During this reporting period, we finalized and submitted the last remaining outstanding year 3 (2019 – 2021) projects. Further, we continued the collection, peer reviewing, and finalization of draft technical reports from Year 4 (2020 – 2022) projects, and began these same procedures for early finishers of Year 5 (2021 – 2022) projects. Finally, we monitored the progress of Year 6 (2022 – 2023) projects via Research Project Progress Reports.

Technology Transfer

During this past reporting period PacTrans' Board of Directors, with the assistance of our Technology Transfer Advisory Board, made their selection of our fourth and final round of success story project funding. This funding is meant to encourage investigators with meaningful research results to generate outputs that are geared toward practitioners and implementation. This year PacTrans selected a total of six such projects for funding. Proposals were reviewed and ranked by both PacTrans Board of Directors as well as the Technology Transfer Advisory Board. These projects are well underway and should be completed and documented before the end of this grant.

In late April, PacTrans hosted a webinar featuring collaborative work done between the UW STAR Lab and Yakima Nation on a project titled "Comprehensive Roadway Safety Data Visualization and Evaluation Platform." In this webinar, Hollyanna Littlebull of Yakima Nation, and Wei Sun and Sam Ricord of the University of Washington, summarized the work that was funded jointly by the USDOT Safety Data Initiative and PacTrans. A major technology transfer component of this work was the actual platform which analyzes and visualizes new sources of safety data. The UW research team also hosted a training session with the professionals from Yakima Nation to teach them about leveraging the newly developed platform for more informed decision making.

AIWaysion, Inc., the first PacTrans spinoff company, received a USDOT Small Business Innovation Research (SBIR) award to use computer vision technologies to address the dilemma zone problems at signalized intersections. The City of Bellevue is a collaboration partner for this project. AIWaysion was

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also selected as one of the five startup companies to compete for the International Road Federation (IRF) Startup Label.

In June, PacTrans staff and researchers actively participated in four important conferences around the country:

1. ASCE's 2022 International Conference on Transportation and Development
   - PacTrans Director, Yinhai Wang, co-chaired the conference
   - PacTrans researchers made over 15 presentations via podium and poster presentation
   - PacTrans and the UW CEE were a sponsor of the conference with an info booth
   - PacTrans student researcher, Cole Kopca, won Outstanding Younger Member Award
   - PacTrans director, Yinhai Wang, shared PacTrans' experience at the CUTC Tech Transfer Workshop at this conference
   - PacTrans showcased research products as an exhibitor
2. The 2022 Council of University Transportation Center's Summer Meeting
   - PacTrans Director, Yinhai Wang, organized and moderated an education panel
   - PacTrans Assistant Director, Cole Kopca, presented UW STAR Lab work on COVID trends
3. The 2022 National Travel Monitoring Exposition and Conference
   - PacTrans co-organized this virtual conference with Idaho Transportation Department
   - PacTrans Associate Director, Ahmed Abdel Rahim, co-chaired the conference
   - PacTrans Director, Yinhai Wang, delivered the keynote address
   - In total, 19 PacTrans student researchers delivered lightning talks on UTC funded work
4. NSF Artificial Intelligence Workshop
   - PacTrans hosted this workshop on the UW campus
   - PacTrans Director, Yinhai Wang, co-chaired this workshop
   - Seven PacTrans researchers showcased their research products to the audience
   - Over 100 transportation agency, industry, and institutional leaders participated in this workshop and a summary paper on challenges and opportunities of using AI in solving urban transportation problems will be published on the ASCE Journal of Transportation Engineering Part A

PacTrans Director, Yinhai Wang, was the editor of a recently published book titled, "Disruptive Emerging Transportation Technologies." The book was prepared by the Technical Committee on CAV Impacts of the Transportation & Development Institute of ASCE. It provides a forward-looking overview of the relevant 4IR technologies and their potential impacts on the future disruptive emerging transportation. It is a valuable reference for relevant educators to re-imagine their roles, redesign their curricula, and adopt very different pedagogical strategies to address this inevitability, particularly when they are introducing emerging technologies into transportation planning and development, infrastructure design, and traffic management.

PacTrans PI and University of Washington Associate Professor of Computer Science and Engineering, Jon Froehlich, was recently interviewed by Here & Now Radio for his research on efforts to make sidewalks accessible. PacTrans has funded two of Professor Froehlich's research projects on this subject, including:

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Combining Crowdsourcing and Machine Learning to Collect Sidewalk Accessibility Data at Scale and Enabling a New Data Science for Urban Accessibility for All. Sidewalks significantly impact the mobility and quality of life of millions of Americans. In his research, Froehlich described new, scalable methods for collecting data on sidewalk accessibility using machine learning, crowdsourcing, and online map imagery as well as new interactive visualizations aimed at providing novel insights into urban accessibility.

PacTrans Associate Director and OSU Professor of Civil and Construction Engineering, David Hurwitz, spoke about increases in traffic crashes on a Minnesota Public Radio new segment.

Education

During this past six-month performance period, PacTrans activities revolving around students and education have been incredibly successful.

In our previous Semi Annual Progress Report, PacTrans reported that we had successfully launched a student organized Doctoral Webinar Series. During this reporting period, that effort hosted three more outstanding installments of this series. The organizing committee also built out a new website to host information on upcoming webinars as well as recordings of previous ones.

PacTrans consortium partner institution Institute of Transportation Engineers (ITE) Student Chapters also had an outstanding year. So, for example, the OSU ITE Student Chapter took first place at the Western Region Collegiate Traffic Bowl, received the Student Chapter Annual Meeting Award, Graduate Student, Eileen Chai received the 2022 Outstanding Graduate Student Award. The UW undergraduate student Peter Yu received the 2022 Student Paper Award and graduate student Ziyuan Pu received the 2022 Outstanding Technical Paper Award from the ITE Western District.

Several other student related highlights from this reporting period included:

- The University of Idaho Clean Snowmobile team place third at their national competition
- The University of Alaska Fairbank Steel Bridge team won second at the nationals
- UW undergraduate student researcher, Peter Yu received four accolades include: the ITE Western District Best Student Paper Award, the R.H. Thomson Memorial Scholarship, the Luther E. Gregory Scholarship, and the Hans M. & Billie A. Skov Scholarship in Civil Engineering.
- Two PacTrans Students, Shuyi Yin and Beatriz Muniz Silva, received ITE Washington Student Scholarships

PacTrans welcomed three new PacTrans Fellows at the beginning of this school year; two from the University of Washington and one from Oregon State University. At UW, these are high achieving master's students who receive tuition funding from PacTrans in partnership with our respective departments. While in school, these students must maintain a high-grade point average and will all participate in internships to better prepare then for careers after they graduate. At OSU, this is a student research position given to just one student each year.

Workforce Development

During this reporting period, the PacTrans Workforce Development Institute (WDI) facilitated two important K-12 STEM activities.

At the University of Washington, PacTrans worked with the UW Continuum College's Youth and Teen Program to develop and offer a two-week course to middle school students called, Introduction to Autonomous Cars. In this course, 25 students learned principles of automation using LEGO Education Spike kits. To better connect what they were learning through these hands-on activities, the course also featured a series of guest speakers and UW lab visits where professionals presented on a variety of transportation related topics and demonstrated the state-of-the-art transportation research products.

Oregon State University hosted their third annual National Summer Transportation Institute (NSTI). In all, twenty-one, high-school age students had the opportunity to spend a week on the OSU campus, learning about a variety of transportation related disciplines, free of charge.

Further, the PacTrans WDI continued its dialog with transportation agencies and the local industry to prioritize the training courses in the coming fiscal year. WSDOT has signed a new contract with PacTrans for developing three new courses to directly address their critical needs. WSDOT has also allocated funds for a summer transportation camp program with PacTrans to bring high school students to both the UW and WSU campuses to learn transportation in the summer of 2023.

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 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. Three quick examples include: (1) UW is currently working with UW Summer Youth program to develop two transportation theme courses for middle- and high-school aged students, (2) PacTrans worked with ASCE to sponsor over 10 low-income Native American students from the Ocosta School District to participate in ASCE ICTD 2022 to present their research results with PacTrans PIs Jeff Ban and Dan Abramson; and (3) 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 twelve separate announcements for internship opportunities. Further, we regularly work with our external partners to develop internship programs or 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 leverages partnerships in a variety of ways that support training and professional development. For example, beyond collaborating on research, we regularly work with industry partners to provide opportunities for students to learn more about what they do. During this reporting period, PacTrans worked with Kittelson and Associates to promote a series of webinars that explores careers in transportation, internship opportunities, and expose students to real world projects.

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

PacTrans utilizes a full suite of avenues for effectively promoting our research and technology transfer efforts to local and state transportation agencies and private partners in the region. Research outcomes are posted on the PacTrans website, distributed through our *monthly newsletter* and *annual reports*, and promoted through social media such as *Facebook*, *LinkedIn*, *Twitter* 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. During this reporting period, for example, PacTrans was heavily involved in the 2022 International Conference on Transportation and Development, the 2022 CUTC Summer Meeting, and the 2022 National Travel Monitoring Exposition and Conference.

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, PacTrans recently began leveraging our own webinar series to highlight many of our PacTrans funded projects. As reported above, during this reporting period, PacTrans hosted one such webinar that featured one of our research projects. These webinars are recorded and published on our PacTrans youTube channel for future viewing.

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Pacific Northwest Transportation Consortium (PacTrans) – UTC for Federal Region 10
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Finally, per our obligation as a UTC, research results are posted on our website and are disseminated to all of the required repositories that include, TRID, USDOT, Transportation Library, Volpe National Transportation Systems Center, Federal Highway Administration Research Library and the US Department of Commerce National Technical Information Service.

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

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

Research

During this next reporting period PacTrans will continue processing and disseminating all remaining year 4 (2020 – 2022) projects. We will also continue to monitor all Year 5 (2021 – 2022) and Year 6 (2022 – 2023) projects.

Technology Transfer

During this next reporting period PacTrans will work to wrap up many of our remaining success story projects from the third and fourth years of funding. Innovations with potential of wide-range applications will be considered for patent applications. One such example is the UW STAR Lab's new technology that uses camera for visibility detection.

Also, during this next reporting period, PacTrans has several great opportunities for technology transfer. Two such examples are the PacTrans Region 10 Transportation Conference and the TRB Annual Meeting.

The PacTrans Region 10 Transportation Conference: this year it will be held in-person for the first time in three year, on the University of Washington campus. This event attracts hundreds transportation professionals from public agencies, private industry, and academia each year. During the event, several researchers will have the opportunity to present their work during moderated technical sessions and others will present at the poster session.

The Transportation Research Board (TRB) Annual Meeting: this has always been one of the most influential opportunities for our researchers to disseminate their work. Each year we send roughly one hundred PIs and students to the TRB annual meeting where we participate in over 120 committee meetings, poster presentations, workshops, and lecterns.

Education

During this next reporting period PacTrans will be very busy with education endeavors. Each consortium partner receives some money each year for education and outreach activities. Those funds are at the discretion of the Associate Director (PI of the subaward) from each of the partner institutions. Those funds tend to be used to support activities such as the following:

1. We support professional organization student chapters, such as the Institute of Transportation Engineers, and student competition teams, such 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 Regional Transportation Conference and the TRB Annual Meeting to present their work.

We will also host the 2022 Region 10 Student Conference in October where students will have the opportunity to learn from practitioners, ask questions of a recent graduate panel, compete in a poster competition, and network with their student colleagues.

PacTrans will also continue to host our Doctoral Webinar Series. This series provides on opportunity once per month for a graduate student to present their research to an audience of their peers.

Workforce Development

PacTrans will host a workforce development workshop in Gainesville in collaboration with the University of Florida as the Phase II of the AI in Transportation Workshop funded by NSF. This workshop invites leaders from transportation agencies, industry, and research institutions to talk about state-of-the practice of AI applications in transportation, envision future workforce needs, recognize training gaps, and identify workforce development priorities.

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

- Developing new partnerships with transportation agencies and companies
- Developing the outlines and teaching plans of three new courses for WSDOT
- Plan for the 2023 summer transportation camps with funding provided by WSDOT
- Plan for two new K-12 courses in partnership with the UW Summer Youth Program
- Make existing courses accessible to working professionals who want to study the subjects

PacTrans will continue our quarterly Regional Transportation Seminar where we invite top experts from agencies, industry, and academia to come to campus and present in-person to students, faculty, and local industry professions about their research. These seminars are also livestreamed via YouTube. This Fall PacTrans will host Elyse Miller-Hooks, Professor and Chair in Infrastructure Engineering at George Mason University, to present at one such 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 10 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 10 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 10 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 10 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 10 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 10 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.

- **Wei Sun**, Ph.D., Research Associate in the PacTrans STAR Lab at the University of Washington, devotes 30 percent of his time in providing research, outreach, and workforce development support and oversight.

- 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
Oregon Department of Transportation	Government
Puget Sound Regional Council	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
ITS Washington	Professional Association
HDR Engineering	Private Industry
Port of Portland	Government
AIWaysion	Private Industry
Leidos	Private Industry
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
Innova EV	Private Industry
Inrix Inc.	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	**45**	19	4	8	13	1	0	0
Publications: Book chapters and other edited manuscripts	**2**	2	0	0	0	0	0	0
Conference papers	**68**	23	9	6	20	7	0	3
Conference presentations	**92**	38	12	10	21	5	3	3
Lectures/Seminars /Workshops/ Invited Talks	**71**	24	13	5	21	7	1	0
Policy Papers	**4**	0	1	1	1	1	0	0
Websites or Other Internet Sites	**9**	2	4	0	1	2	0	0
New Methodologies, Technologies or Techniques	**22**	8	3	5	3	3	0	0
Inventions, patent applications, and/or licenses	**1**	1	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	**16**	5	6	1	4	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	276
Number of software tools and technologies made available to practitioners	10	11

Examples of peer reviewed journal articles

Yang, H., Ling, Y., Kopca, C., Ricord, S. and Y. Wang "Cooperative Traffic Signal Assistance System for Non-motorized Users and Disabilities Empowered by Computer Vision and Edge Artificial Intelligence." Awaiting publication by Transportation Research Part C: Emerging Technologies, Sep. 2022.

Zhu, M., Yang, H.F., Liu, C., Pu, Z. and Y. Wang, "Real-time crash identification using connected electric vehicle operation data." Accident Analysis & Prevention, 173(2022), p.106708.

Geyin, M., Maurer, B. W., & Christofferson, K. (2022). An AI driven, mechanistically grounded geospatial liquefaction model for rapid response and scenario planning. Soil Dynamics and Earthquake Engineering, 159, 107348.

Baqer, M., Lowry, M., and Krings, A. (2022). "Reliability of Vehicle-to-Micromobility Safety Communication." Journal of Transportation Engineering, Part A: Systems, Vol 148, Issue 11.

Almalki, Sultan Ahmed, Ahmed Abdel-Rahim, and Frederick T. Sheldon. "Adaptive IDS for Cooperative Intelligent Transportation Systems Using Deep Belief Networks." Algorithms 15, no. 7 (2022): 251.

Mohamed, M., Belz, N.P., (August 2022, in review). Safety Impacts of Road Weather Information System Implementation in Alaska, Transportation Research Record, Journal of the Transportation Research Board, of the National Academies, Washington, D.C.

Massey, C. I., Olsen, M. J., Wartman, J., Senogles, A., Lukovic, B., Leshchinsky, B. A., et al. (2022). Rockfall activity rates before, during and after the 2010/2011 Canterbury earthquake sequence. Journal of Geophysical Research: Earth Surface, 127, e2021JF006400. https://doi.org/10.1029/2021JF006400

Ashour, L.A. and Shen, Q., 2022. Incorporating ride-sourcing services into paratransit for people with disabilities: Opportunities and barriers. Transport Policy, 126, pp.355-363.

Examples of conference papers and presentations

C. Liu, H. Yang, R. Ke and Y. Wang*. "Traffic Sign Detection and Recognition for Autonomous Driving in Virtual Simulation Environment." Podium Presentation of AI & Big Data Track, AI in Transportation I, Proceedings of 2022 ASCE International Conference on Transportation and Development (ICTD), May 2022. Seattle, USA.

H. Yang, C. Liu, R. Ke, M. Zhu and Y. Wang*. "Real-time Iot System for Traffic Sensing by Edge Computing and Multi-camera Vehicle Re-identification (ICTD32-RISTS)", Podium Presentation of AI & Big Data Track, Sensing and Data Analytics, Proceedings of 2022 ASCE International Conference on Transportation and Development (ICTD), May 2022. Seattle, USA.

M. Zhu, Z. Cui, H. Yang, S. Yin, and Y. Wang*. "Transfollower: Long Sequence Car-Following Trajectory Prediction through Transformer." Podium Presentation of AI & Big Data Track, AI in Transportation I, Proceedings of 2022 ASCE International Conference on Transportation and Development (ICTD), May 2022. Seattle, USA.

Young, Rhonda. "Bicycle Rolling Stop". Presented at the 2022 Western District Annual Meeting of the Institute of Transportation Engineers, June, 2022 in Palm Springs, CA.

Herrman, D., Darrow, M., Olsen, M., Wartman, J., Leshchinsky, B. (2022). "Analysis of the long-term effects of construction on rockfall along the Parks Highway, Alaska." AEG 65th Annual Meeting, 14-16 September 2022, poster.

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.

Nazari S.E. and Khanal M. "Development of a Turning Movement Estimator Using CV Data", Paper Number: TRBAM-23-01941, 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.

Forecasting post-earthquake rockfall activity, 5th Joint International Symposium on Deformation Monitoring, Valencia Spain, (June 2022).

Olsen, M.J., Massey, C., Holtan, K. Wartman, J., Leshchinsky, B., Darrow, M., and Senogles, A. (2022) Application of the rockfall activity rate system, RoARS, Extended Abstract in Proceedings of the International Society for Rock Mechanics and Rock Engineering, Eurock 2022, Helskinki, Finland.

D. Ji, Y. Turkan, P. Calvi, Toward Automation in Crack Detection and Measurements: Benchmarking of CNN-Based Algorithms, Proceedings of the International Symposium on Automation and Robotics in Construction, Bogota, Colombia, July 12-15, 2022. https://doi.org/10.22260/ISARC2022/0021

Olsen, M. J., Massey, C., Holtan, K., Wartman, J., Leshchinsky, B., Darrow, M., Senogles, A. (2022). "Application of the rockfall activity rate system (RoARs)." EUROCK 2022 Helsinki, 12-15 September 2022.

Geyin, M., & Maurer, B. W. An AI-Driven, Mechanistically Grounded Framework for Geospatial Modelling of Soil Liquefaction. In Geo-Congress 2022 (pp. 455-464).

Almalki, Sultan Ahmed, Ahmed Abdel–Rahim, and Frederick T. Sheldon. "Disrupting the Cooperative Nature of Intelligent Transportation Systems." In 2022 IEEE World AI IoT Congress (AIIoT), pp. 131-137. IEEE, 2022.

Ahmed Abdel-Rahim and FAtma Madkoor, "Monitoring Forces on Bicycles Traveling on Two‐Lane Highways" the 2022' National Travel Monitoring Exposition and Conference, NaTMEC 2022

Kiran Adhikari and Ahmed Abdel-Rahim, "Estimating Statewide AADT Using Network Centrality", the 2022' National Travel Monitoring Exposition and Conference, NaTMEC 2022

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Liao, Felix Haifeng. 2022. Urban resilience and inequality in the post-pandemic era. Presented at Annual Meeting of American Association of Geographers. New York City/Virtual

Kasi, Z., Simpson, B., Scott, M.H. (2022). "An application of Physics-Informed Deep Learning for Structural Dynamics" Vision for the Future: HPC and AI in Structural Engineering, Structures Congress, Atlanta, Georgia, April 20-23

Kasi, Z., Simpson, B., Scott, M.H. (2021). "Nonlinear Structural Analysis using Physics Informed Deep Learning" Recent Advanced in Hybrid Numerical and Experimental Simulation Conference (MMLDT-CSET 2021), San Diego, California, September 26-29.

Example of lectures/seminars/workshops/invited talks

Keynote Speech at the 2022 National Travel Monitoring Expo and Conference (NaTMEC). "Traffic Sensing and Edge Computing for Safer and Smarter Transportation Systems." Online Conference. June 13, 2022.

University of Michigan NGTS Distinguished Lecture Series. "Edge-AI-Empowered Technology for Comprehensive Traffic Sensing and Cost-Effective V2X Applications." Ann Arbor, MI. March 31, 2022.

An overview of RAPID facility-supported projects: Rock slope failures along Highways in Alaska. RAPID Facility training workshop, 30 participants, Seattle, July 2022.

D. Ji, Y. Turkan, P. Calvi, "AI-Enabled Drone Image Processing for Rapid Bridge Inspection and Management", 2022 ASCE Engineering Mechanics Institute (EMI), May 31-June 3, 2022, Baltimore, Maryland.

Lamis Ashour, Qing Shen, Don Okazaki, Jeremy Trenhaile, Matthew Weidner, 2021. Incorporating Ride-Sourcing Service into ADA Paratransit Opportunities & Challenges for Public Transit Agencies. PacTrans webinar.

Qing Shen, 2022. Supplementing Public Transit with On-demand Shared Mobility Services: An Economic Analysis. Presentation given online for School of Public Affairs, Zhejiang University.

Examples of New Methodologies, Technologies or Techniques

McCormack, E. As part of this research, DOT staff working with the researchers, tested Structure from Motion (SfM) software (photogrammetry) on unmanned aircraft above test sites in Alaska and Washington. The SfM data includes accurate information on snowpack depth and snowpack volume which help DOT avalanche experts assess risk and determine if mitigation was necessary. In addition, the digital images collected as part of the SfM provided additional useful information.

Heckendorn, R. Using machine learning approaches to learn traffic behavior to predict arrival times along street segments to create a fast-realistic traffic model for stochastic optimization.

Shen, Q. We developed an analytical framework for comparing the economic costs of micro transit service and those of extending/improving traditional fixed-route transit service, as options for first mile/last mile travel.

Yan, C. A locational demand model to estimate rider demand of free-floating micro-mobility services.

Hurwitz, D. Implementation of a novel method for networked multimodal driving & bicycling simulator studies.

Louis, J. We applied a fire simulation and GIS-based methodology to identify sections of roadway impacted by wildfires.

Examples of Websites

Quantifying the Impact of Rockfall on the Mobility of Critical Transportation Corridors [supporting datasets], https://rosap.ntl.bts.gov/view/dot/61769

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

Phillips, A. A database of WSDOT bridge parameters was extended by approximately 70-80 bridges as part of a PacTrans funded research project. The extension provided additional information about secondary routes west of the I-5 corridor and is being used by a joint UW-WSU team to analyze predicted bridge network response to a Cascadia Subduction Zone earthquake.

Wagner, J. Shelter animal database, WSU parking database, Pullman transit database

Geyin, M., & Maurer, B. (2021). RapidLiq: Software for Near-Real-Time Prediction of Soil Liquefaction.

Wartman, J. https://rosap.ntl.bts.gov/view/dot/61769

Shrestha, K. Developed 30 second video as requested for PacTrans Annual Conference 2022.
Olsen, M. Terrestrial Laser Scan Survey of Alaska Rockslopes
Olsen, M. Terrestrial Laser Scan Survey of Oregon Rockslopes

Outcomes

OUTCOMES: Technology Transfer Plan Outcomes Metrics	Annual Targets	Numbers for Reporting Period
Number of early adopters of our research outputs	10	6
Changes made to the transportation system, or its regulatory, legislative, practice manuals, design standards, or policy frameworks	2	4

The following are several great examples of the outcomes seen due to PacTrans funded research:

Early in this grant, PacTrans funded a small project led by UW's Don MacKenzie titled, *How does Charging Network Design Affect Electric Vehicle Adoption?* Leveraging the promising research results of this work, Professor MacKenzie successfully applied for, and received, PacTrans supplemental Success Story Funding to develop an open source software application called ChargEval. ChargEval is a set of simulation tools for informing EV fast-charging station planning along Washington's highway network. These tools have since been used by WSDOT to help develop the plan for the EV mapping & forecasting tool and their development of a NEVI plan.

Recently, the multi-institutional research team that has been development a suite of new methods, technologies, and applications to better analyze critical rock slopes along transportation infrastructure, has updated their rock fall activity index (RAI), which was originally developed through a PacTrans funded project several years ago. During this reporting period, the RAI system has been adopted for a much larger national scale FHWA pooled fun research project on rockfall run out hazards. The adoption of this larger pooled fund project Will enhance safety along Highway corridors doors across all of the United States.

Several years ago, PacTrans funded a small project led by OSU's Michael Olsen titled, *Efficient Extraction and Classification of Complex Pavement Markings from Mobile Laser Data*. Leveraging the promising research results of this work, Professor Olsen successfully applied for, and received, PacTrans supplemental Success Story Funding to (1) optimize the algorithms, (2) package the algorithms into a tool with a graphical user interface, and (3) develop training materials for the package. This summer, they finalized a licensing agreement with OSU and have been further developing this software through their new spin off tech transfer company EzDataMD LLC. A lidar data service provider is currently evaluating our Road marking extraction and classification software for transportation asset management. The Transport Ministry of Quebec also reached out and demoed of the road marking software as they work on their transportation asset management program.

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	1

The first PacTrans spin-off company, AIWaysion, Inc., received a USDOT's Small Business Innovation Research Award to use the computer vision technologies developed by PacTrans to address the dilemma zone challenges. This technology is proven more effective than the classical methods that deploy a fixed detector in the dilemma zone.

PacTrans PI Yinhai Wang's truck parking research project was selected as one of the sixteen high value research projects by the American Association of State Highway and Transportation Officials (AASHTO). This technology is being tested in a larger scale with funding support from Federal Motor Carrier Safety Administration.

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

Researchers at the University of Washington's STAR Lab have partnered with the Washington State Department of Transportation and PacTrans to perform research associated with the Signal Phasing and Timing (SPaT) Challenge. The project is titled, *Enhancing Safety and Accessibility for Active Users at Signalized Intersections under the Signal Phasing and Timing (SPaT) Challenge*. In this work a Vision Enhanced Non-Motorized Users Services (VENUS) smart node was developed. With customized up-to-date computer vision algorithms and an artificial intelligence pipelines on the edge, the VENUS smart node collects necessary active-user information (including location, class, pose direction and mobility status), and generates directional crossing requests for every pedestrian and cyclist in real time. Further, the communication system makes the VENUS node a reliable information hub to share the SPaT messages and carry interactions to/from the signal controller, connected vehicles and user personal information devices (i.e., cell phones, wearable devices) through various protocols. This new technique will revolutionize the way that non-motorists, especially those with disabilities, move through historically dangerous intersections.

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?

As exemplified in the outcomes section of this report, many of PacTrans transformative solutions begin as funded research, then progress to technology transfer funding, and ultimately lead to

implementation of new practices. The procedure that has been refined over the past decade has proven effective time and again.

Another great example of this comes from a UW PI named Brett Maurer. Several years ago PacTrans funded a small project titled, *Informing Predictions from Above with Data and Below: AI-Driven Seismic Ground-Failure Model for Rapid Response and Scenario Planning*. The promising research results of this work then led to a Success Story project that was funded last year. With this supplemental technology transfer funding, this project embedded the AI models that were developed during the research into a free, simple-to-use Windows software. The only input is a ground-motion raster, downloadable minutes after an earthquake or available for countless future scenarios. This gives the product near-real-time capabilities, such that ground failure may be predicted by anyone across PacTrans Region 10 (e.g., the State of Washington) minutes after an earthquake. The software is called software RapidLiq, and is now being used by researchers and practitioners to model the impacts of soil liquefaction for transportation infrastructure at regional scale in advance of scenario earthquake events.

What is the impact on the body of scientific knowledge?

PacTrans research regularly and substantially contributes to the scientific body of knowledge, a good example of this is a recently funded, and ongoing project out of the UI by Fredrick Sheldon titled, *IoT Platforms for Smart City Implementation in Rural and Urban Communities: A Comparative Review*. The primary impact was developed from gaining greater awareness of the issues facing rural/urban communities important to assuring safety, security and value within a Smart City mobility implementation context (performance, reliability and extensibility/scalability of IoT systems) thereby Informing research in AI for cybersecurity toward developing robust models for authentication, threat and anomaly detection.

What is the impact on transportation workforce development?

This summer, the PacTrans Workforce Development Institute worked with the UW Continuum College's Youth and Teen Program to develop and offer a two-week course to middle school students called, Introduction to Autonomous Cars. In this course, students learned principles of automation using LEGO Education Spike kits. To better connect what they were learning through these hands-on activities, the course also featured a series of guest speakers and UW lab visits where professionals presented on a variety of transportation related topics.

PacTrans Assistant Director, Cole Kopca, co-taught this course with a recent high school graduate, Erik Ma. Erik, until graduating, was part of the FTC 18225HD robotics team that has successfully won the state competition the past two years in a row. Erik was the primary developer of the hands-on exercises and robotics components while Cole coordinated the guest speakers/visits and handled the transportation components of the course.

Lego Education Spike Kits come with a "Hub" (basically a CPU and battery), four motors (two small and two medium), and four sensors (two color, one distance, and one pressure). They also come with all of the wheels, axels, and other components necessary to build a "vehicle." The software used to communicate with the hub is incredibly intuitive with drag-and-drop code, and the desktop program comes with a plethora of supplemental training exercises and how-to videos.

Students spent the first week going through exercise to learn about how to use all of the various components to make a vehicle perform tasks, and then spent the second week putting together final projects. Final projects required students to identify a real-world vehicle and identify three common tasks that vehicle needs to accomplish on a regular basis. While their vehicles did not need to visually resemble their identified vehicle type, they had to build a vehicle and program it to do all three of those tasks in an automated fashion. The final day of the course, friends and family were invited to watch the eight teams present their final projects.

Changes/Problems

NONE.

Special Reporting Requirements

Research Project Requirements

Per our research update above, PacTrans has already selected the final year of funded projects for this grant and those projects are still ongoing. PacTrans has maintained 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 have completed submission of our Year 1 and Year 2 final technical reports, almost all of year 3 final technical reports, and about one-third of Year 4 final technical reports.