Center for Advanced Multimodal Mobility Solutions and Education

USDOT Tier 1 University Transportation Center
Semi-Annual Progress Report #12

Submitted to:	U.S. Department of Transportation Office of the Assistant Secretary for Research and Technology (OST-R)
Grant Number:	69A3551747133
Project Title:	Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE)
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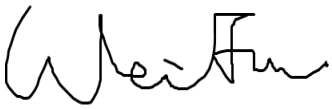
Submission Date:	April 10, 2023
DUNS:	06-630-0096
EIN:	56-0791228
Recipient Organization:	University of North Carolina at Charlotte
Project/Grant Period:	November 30, 2016 - September 30, 2023
Reporting Period Start Date:	October 01, 2022
Reporting Period End Date:	March 31, 2023
Report Term or Frequency:	Semi-annual
Signature of Submitting Official:	

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1. ACCOMPLISHMENTS

1.1. What are the major goals and objectives of the program?

The major goals and objectives of the program as outlined in the proposal include the following categories.

Research

CAMMSE will address the FAST Act research priority area of "Improving Mobility of People and Goods" by conducting multi-disciplinary, multi-modal research, education and workforce development, and technology transfer. CAMMSE is motivated by the recent advances in computing, smartphones and communication technologies, and ubiquitous data to create sustainable, efficient, and growth-enabling multimodal transportation systems. Cutting edge analytical methods and models will enhance the effectiveness, efficiency, and reliability of these systems accordingly. Recent technological advancements enable new perspectives and holistic approaches to address the well-known challenges in multimodal transportation systems planning, design, operations, and maintenance. In particular, the following research topic areas will be established to maximize synergy and adaptability across multiple modes and jurisdictions:

- Increase access to opportunities that promote equity in connecting regions and communities, including urban and rural communities;
- Generate innovations in multi-modal planning and modeling for high-growth regions;
- Develop data modeling and analytical tools to optimize passenger and freight movements;
- Innovations to improve multi-modal connections, system integration and security; and
- Smart Cities.

Leadership

The CAMMSE team is nationally and internationally recognized for its contributions to the field of transportation research, and for its deployment of successful solutions to critical, real-world transportation challenges. In addition, team members are committed advocates and longstanding leaders within the multimodal transportation community and the UTC system itself. Through this UTC grant, the Consortium plans to build on its demonstrated experience to mentor future leaders in the field of transportation. CAMMSE plans to nurture students through skill building and professional development activities that promote notable research scholarships and successful transportation careers.

Education and Workforce Development

With years of collective education, research, and UTC experience, CAMMSE will provide a transportation education program through its partner universities. The program will promote creative and multidisciplinary problem-solving and exposure to a myriad of educational and workforce development experiences. The program will serve to attract, educate, and train future and existing transportation professionals with the know-how to undertake and implement innovative projects being or to be conducted.

The workforce development program will leverage the existing training skills and delivery resources available within partner universities. On-line webinars will be designed and delivered using available technical resources, which could provide Continuing Education Credits (CEUs) to interested course participants. In addition, UTC funds will be used to support and host the monthly transportation seminar series, particularly while classes are in session. The target audience is current students and the local university community. UTC funds will also enhance our ability to host nationally and internationally

recognized speakers. The target audience is local and regional (onsite), and national when recording and posting talks online.

CAMMSE will support career-building activities that facilitate student transition from school to the workplace by offering enhanced student research opportunities, research seminars, guest speakers, professional conference travel and other professional networking opportunities. In addition, outreach programs at the pre-collegiate level (elementary to high school) will be designed to spark interest in transportation issues and to encourage youth to consider transportation academic programs and careers. The outreach initiatives will particularly focus on recruiting underrepresented minorities into transportation and other STEM fields.

Technology Transfer

The technology transfer program at CAMMSE is designed to support the USDOT in its objective of "expanding technology transfer to partners and stakeholders" by sharing research results quickly and to the widest possible audience. CAMMSE has demonstrated ability to disseminate research results, spur implementations, and conduct continuing education programs. The technology transfer program is a direct extension of the Center's research and education programs; in other words, these activities are designed to increase the scope and effectiveness of research accomplishments and education initiatives. General objectives within the technology transfer area in CAMMSE will be to:

- Increase the national visibility of CAMMSE research and education activities.
- Increase the availability and speed at which CAMMSE research results are disseminated.
- Provide technical assistance based on CAMMSE research and development.

Collaboration

CAMMSE has an extensive history of forming collaborative relationships at a variety of technical, fiscal and administrative levels. Across all its activities, from conducting pooled fund studies to hosting tech transfer events, CAMMSE will seek to work with collaborators from all sectors.

Diversity

In order for the transportation workforce to reflect the diversity of the national workforce pool, CAMMSE will continue to pursue the development of innovative programs to encourage new entrants, particularly those from groups currently underrepresented in the field. CAMMSE will actively participate in a number of committed activities through which the CAMMSE will increase interest in STEM disciplines and raise awareness of transportation-related careers amongst underrepresented groups.

1.2. What was accomplished under these goals?

Research

CAMMSE was funded by USDOT in November 2016 under the FAST act. During this reporting period, CAMMSE research results have been published in multiple journals, including *Accident Analysis & Prevention, ASCE Journal of Transportation Engineering, Part A: System, Expert Systems with Applications*, *Federal Reserve Bank of St. Louis Review, Future Transportation, IET Intelligent Transport Systems, International Journal of Disaster Risk Reduction, International Journal of Engineering Education, International Journal of Transportation Science and Technology, Journal of Public Transportation, Journal of Transportation Research Part D, Journal of Transportation Safety & Security, Research in Transportation Economics, Sustainability, Transportation Planning and Technology,* and *Transportation Research Record.* CAMMSE research results were also presented at several conferences on different occasions, which include the 2023 North Carolina Department of Transportation Research & Innovation Summit, the 11th International Conference on Transportation and Traffic Engineering (ICTTE 2022), the 5th Annual CAMMSE Virtual Research Symposium, the 102nd Annual Meeting of the Transportation Research Board, ASCE International Conference on Transportation & Development, and 2023 TSU research week.

Leadership

Representing the CAMMSE, Center Director Dr. Wei Fan was listed among the Top 2% of Scientists in a Global List of "Logistics & Transportation" specialty in 2021 released by the prestigious Stanford University in October 2022. Dr. Wei Fan also served as an affiliate faculty in the School of Data Science, UNC Charlotte since August 15, 2020. During this reporting period, CAMMSE Center Director and Associate Directors have been actively serving on many editorial boards (e.g., Editor-in-Chief of *International Journal of Transportation Science and Technology, Journal of Infrastructure Preservation and Resilience*, Guest Editor of *Vehicles, Special Issues on Recent Developments in the Intelligent Transportation System (ITS)*, Handling Editor of *TRR Inaugural Editorial Board, Transportation Research Record*, Associate Editor of *ASCE Journal of Transportation Engineering, Part A: Systems*, *International Journal of Transportation Science and Technology, IEEE Transactions on Intelligent Transportation Systems, Current Trends in Civil & Structural Engineering;* Editorial Board of *Transportation Planning and Technology*, *Journal of World Review of Intermodal Transportation Research*, *International Journal of Transportation Science and Technology*, *Journal of Transportation Research Part D*, *Asian Transport Studies*) and many professional committees (e.g., General Secretary of Chinese Overseas Transportation Association (COTA), Co-Chair of World Transport Convention Connected Autonomous Vehicles Section, Advisory Board Member of ASCE National Artificial Intelligence (AI) Committee, Member of ASCE National Connected & Autonomous Vehicles Impacts Committee, ASCE National Public Transport Committee, ASCE National Rail Transportation Committee, NCDOT Fully Autonomous Vehicle (FAV) Research Working Group Committee, NCSITE Scholarship Committee, Director of Washington State Transportation Center (TRAC), TRB Standing Committees (A0020C, ACP60, AP075, AHB60, AT045, AW010, AW010 (2)(3), AW020, AT050), Secretary of TRB Standing Committees (A0020C, AP075), World Transport Convention Shared Logistics and Transportation Systems Committee, Member of Maritime Education, Training, and Outreach Subcommittee of the Lone Star Harbor Safety Committee (LSHSC), Head of Publicity for the UT-Austin Student Transportation Council)), as well as several proposal and paper review committees (e.g., External Evaluator for Faculty Member Promotion at University of Sharjah, External Evaluator for Faculty Member Promotion and Tenure at Shenzhen Technology University, NCHRP (17-108, 08-157, 17-102), and the TRB 102nd Annual Meeting).

Education and Workforce Development

CAMMSE has been working with the Institute of Transportation Engineers (ITE) Student Chapter at UNCC in supporting and hosting the bi-weekly transportation seminar series in which guest speakers are invited to UNCC to present their current project activities while classes are in session. The target audience is current students and the local university community. Dr. Fan's transportation research group has also been conducting graduate student seminars on a weekly basis during this reporting period.

CAMMSE Center Staff (Drs. Wei Fan, Martin Kane, and Kim Wilson) has been meeting on a regular basis. Topics discussed among these important regular meetings include, but are not limited to, the annual research symposium, annual transportation summer camp at UNCC, research, education, and outreach as well as technology transfer activities. From November 10 to 11, 2022, CAMMSE successfully held its fifth annual research symposium virtually. CAMMSE has provided a medium for sponsored students to develop important soft skills. All these events required that students interact with the local community and think of creative ways to portray complicated concepts in a simple and easy way to understand. CAMMSE has impacted both the local community and the sponsored students by encouraging creativity and enhancing connections.

At UNCC, CAMMSE Center Director Dr. Wei Fan taught the "Traffic Flow Theory" course in the Fall 2022 semester and "Traffic Control and Operation" course in the Spring 2023 semester to several graduate students who were in attendance. He also served as a Committee Member for three Ph.D. candidates. During this reporting period, a total of four students at UNCC have been involved in CAMMSE projects and all of them were directly supported by CAMMSE. During this reporting period, Hengcong Guo and Yang Zhao were awarded the prestigious Don Blackburn Memorial Scholarship and the Roy D. Williams Memorial Scholarship, respectively on November 17, 2022. Paul D. Cribbins Cup was also awarded to UNCC as the Outstanding ITE Student Chapter on November 17, 2022.

At TSU, four undergraduate-level and seven graduate-level transportation-related courses were taught by CAMMSE personnel (Drs. Yi Qi, Mehdi Azimi, and Ms. Ursurla Williams). During the reporting period, there were a total of four graduate students participated in research projects and supported by CAMMSE. Among all students, one was male students and three were female students.

At UT Austin, there were a total of five students involved in CAMMSE projects, including both female and male students. Faculty members at UT have integrated CAMMSE research into courses taught. Jennifer Hall has organized multiple guest lectures, social events, and alumni panels for undergraduate and graduate students. She also manages the biweekly newsletter as well as the Instagram account that keeps the UT-Austin transportation program informed of upcoming events.

Technology Transfer

At UNCC, CAMMSE faculty, staff, researchers, and students have been making presentations at different meetings including the North Carolina Department of Transportation Research & Innovation Summit from March 29-30, 2023, FHWA Visit at UNC Charlotte, Guest Lecture in CEGR 6090/CEGR 8090/INES 8202 Course on March 7, 2023, the 11th International Conference on Transportation and Traffic Engineering (ICTTE 2022) from December 27-29, 2022, Invited Guest Lecture at Missouri University of Science and Technology on December 8, 2022, NC Transportation Center of Excellence in Connected and Autonomous Vehicle Technology (NC-CAV) on November 18, 2022, and the 5th Annual CAMMSE Virtual Research Symposium from November 10-11, 2022.

At WSU, Dr Xianming Shi was invited by the TRB AMS20 Committee to present his research at the 2023 TRB Annual Meeting on January 9, 2023. A presentation was made by Dr. Yong Deng in 5th Annual CAMMSE Virtual Research Symposium on November 10, 2022.

TSU CAMMSE team shared the research findings with students, transportation professionals, and the public through published journal papers, oral presentations, or posters. During the reporting period, TSU published eight peer-reviewed journal papers. Dr. Qi, Dr. Mehdi Azimi, and their graduate research assistants presented their research at CAMMSE Symposium in November 2022. One CAMMSE-supported graduate research assistant gave an oral presentation, and another graduate research assistant did a poster on TSU research week in March 2023.

At UT Austin, there are a total of four active projects sponsoring four Ph.D. students, one undergraduate student, two principal investigators, and one researcher. One of the best technology transfer tools is the students that work on these CAMMSE research projects. These UT Austin students are key to the technology development as they will carry the knowledge and technology developed through CAMMSE projects to the Transportation Engineering industry. They will carry the new technology with them and use it in their new jobs, teaching peers how to use the technology, thereby implementing the technology. Most importantly, these new techniques will continue to grow and improve as they are used. The professors at UT Austin have also used their classes to teach the new techniques developed through the CAMMSE UTC, therefore planting the new technology in students that are not directly supported by the UTC. In addition, information developed through UT Austin's research is being shared with the City of Austin as the City functions as a partner in the research efforts. Dr. Claudel has integrated results from past CAMMSE research in the CE 391F (advanced traffic flow theory) class taught in Fall 2022. Jennifer Hall competed in CAMMSE's Annual Student Graduate Student Symposium presentation competition in November 2022.

Collaboration

CAMMSE created a diverse collaboration network with different state and local government agencies, and educational and professional organizations, as well as community practitioners. CAMMSE also worked to build collaborative relations with international transportation centers and universities.

During the reporting period, CAMMSE Center Director Dr. Wei Fan has been actively collaborating with several other universities across the country and abroad (e.g., Arizona State University, Carnegie Mellon University, University of Central Florida, University of Texas at Austin, Missouri University of Science and

Technology, NC A&T and NC State University) in conducting research, co-writing proposals and/or papers.

At TSU, Dr. Yi Qi and Dr. Mehdi Azimi partnered with several universities to develop new UTC proposals, such as the University of Michigan, New York University, The George Washington University, the University of Nevada at Las Vegas, the University of Memphis, Texas State University, Texas Transportation Institute, University of Nebraska-Lincoln. In addition, Dr. Yi Qi and her team were invited by the City of Houston to conduct an independent study to evaluate the operational performance of Transit signal priority (TSP) at the selected corridor in the City of Houston, especially the impacts on general road users besides transit buses.

UT Austin has partnered with the Women in Transportation Seminar Heart of Texas (WTS-HOT) Student Chapter and the Institute of Transportation Engineers (ITE)/ Intelligent Transportation Systems (ITS) Student Chapter.

Diversity

Several Ph.D. students from underrepresented groups have been hired to conduct CAMMSE's research during this reporting period. For example, at UNCC, four international graduate students (including Mr. Tianjia Yang, Mr. Chengying Hua, Ms. Yang Zhao, and Mr. Hengcong Guo, all of whom came from P.R.China) joined the INES Ph.D. program and they have been working as CAMMSE research assistants. Three master students, Mr. Kiavash Riahipour from Iran, Ms. Ruth Kandolo from Congo, and Mr. Jeremy Shue from the United States were advised by Dr. Wei Fan to conduct their M.S. research.

At WSU, one female engineering faculty member and two female PhD students in the Department of Civil & Environmental Engineering at WSU contributed to the CAMMSE site activities.

TSU is one of the nation's largest historically black universities, with most students being minority students. During the reporting period, TSU CAMMSE supported four graduate students with different backgrounds, all of them were African American students and three were female students.

At UT Austin, the CAMMSE funds have supported several undergraduate and graduate students from various countries. These funds have also supported both male and female students from different ethnic backgrounds. For example, UT Austin has a female Latina supported by CAMMSE.

1.3. What opportunities for training and professional development has the program provided?

At UNCC, the CAMMSE bi-weekly seminars are open to the general public, particularly to the local and state transportation agencies, as well as the industry practitioners. CAMMSE has also been holding the weekly graduate seminar series at UNCC.

At UConn, CAMMSE researchers have organized and participated in a transportation graduate student seminar each week of the past two semesters. In the reporting period, this translates to twelve seminars attending by approximately 250 students, faculty and visitors in total.

TSU host seminars and workshops to provide more learning opportunities to their students. During the reporting period, four seminars and one workshop were organized. In addition, CAMMSE TSU continues to provide research assistantships to both undergraduate and graduate students who are interested in developing their careers in the transportation area. Sponsored students participated in CAMMSE research projects and work closely with their faculty members to receive extensive hands-on trainings.

At UT Austin, CAMMSE students presented papers at the TRB Annual Meeting. Attending this conference provides students the opportunity to network with practitioners, alumni, and academic professionals. Conferences are incubators for both personal relationships and research ideas/findings, providing rich professional development experience for students. CAMMSE research has been accepted

for podium presentation at the ASCE Annual Meeting in Austin, TX for this upcoming June and for international presentation in Canada at the ASCE Annual Meeting in May. Drs. Machemehl and Claudel presented research topics and findings from the CAMMSE program to their graduate and undergraduate classes. Dr. Machemehl teaches an undergraduate senior elective class with approximately 60 students each spring semester and he discusses all the CAMMSE research efforts during his lectures. Most of these students (about 85 percent) graduate in May 2023, and will become new engineers who bring with them results of the CAMMSE research projects. Dr. Mohamed (which received CAMMSE support) interned at Meta (former Facebook) and joined Meta after graduating, where he continues working on prediction of users/pedestrian actions.

1.4. How have the results been disseminated?

News items and information about CAMMSE have been regularly posted on the website at https://cammse.uncc.edu/news.

In particular, as mentioned before, UNCC has published many journal papers and made many presentations both nationally and internationally. The research of WSU has been disseminated through the presentations mentioned earlier. At TSU, CAMMSE research results were published in eight peer-reviewed journals. The research results were also disseminated through an invited presentation their faculty member gave, as well as the presentations and posters our students did. UT Austin has presented the results through published papers, technical reports, and technical presentations. Research results are disseminated through the classroom teaching of the principal investigators and their colleagues. Additionally, various papers were presented at the Transportation Research Board's Annual Meeting in Washington, D.C. Papers have been published by the TRR and JTRF journals.

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

The following tasks are planned in order to accomplish the goals and objectives of CAMMSE.

(1) All final project reports to be completed for year 6 (2021-2023) will be provided to the Transportation Research Board (Transport Research International Documentation database), the National Transportation Library, the U.S. DOT's Research Hub, the Transportation Library, the Volpe National Transportation Systems Center, FHWA's Research Library, and the U.S. Department of Commerce as required by OST-R. Present papers based on CAMMSE's research on different occasions including the TRB 103rd Annual Meeting from January 7-11, 2024.
(2) WSU researchers will continue their activities in journal article submission/revision and presentations when suitable while making progress on addressing other CAMMSE objectives.
(3) UConn will collect data for Project 2022 09, complete analysis for Project 2022 08, continue seminar activities during academic year, submit papers based on CAMMSE research to annual TRB call for papers, and participate in local, regional and national conferences to disseminate results.
(4) TSU will finish current active projects. The research findings will be summarized and submitted to peer-reviewed journals for publication. In addition, they will continue to provide research assistantships to students to encourage them to pursue careers in the transportation area. Finally, continue hosting transportation-related seminars or workshops for both CAMMSE-supported students and all other students majoring in transportation or interested in pursuing their careers in Transportation areas.
(5) UT Austin CAMMSE participants will travel to Moncton, B.C. in Canada for the CSCE Annual Meeting. Also, UT Austin CAMMSE participants will present and publish papers at the ASCE Annual Meeting in Austin, TX in June. At these meetings, CAMMSE researchers will present CAMMSE-work and discuss findings/insights with colleagues from all over the world. UT Austin will also continue submitting any finalized research product to journal publications whenever possible.

2. PARTICIPANTS AND COLLABORATING ORGANIZATIONS

2.1. Who has worked on the program?

The members of CAMMSE UTC include the University of North Carolina at Charlotte (UNCC); the University of Texas at Austin (UT Austin); the University of Connecticut (UConn); Washington State University – Pullman (WSU); and Texas Southern University (TSU). Table 1 lists the leadership team members who have worked on the program during this reporting period.

Table 1. CAMMSE Staff Working on the Program

Name	Wei Fan	Randy Machemehl	Nicholas Lownes	Xianming Shi	Yi Qi
Program/Project Role	Center Director	Associate Director at UT Austin	Associate Director at UConn	Associate Director at WSU	Associate Director at TSU
Contribution to Program/Project	Oversees overall operations of the program. Responsible for coordinating with stakeholders and developing and implementing the CAMMSE strategic plan	Serves as liaison between CAMMSE and UT Austin	Serves as liaison between CAMMSE and UConn	Serves as liaison between CAMMSE and WSU	Serves as liaison between CAMMSE and TSU
Funding Support	UNCC	UT Austin	UConn	WSU	TSU
Collaborated with Individual(s) in Foreign Country(ies)	Yes	No	Yes	Yes	Yes
Country(ies) of Foreign Collaborator(s)	P.R.China	No	Australia	P.R.China	P.R.China
Traveled to Foreign Country(ies)	N/A	N/A	N/A	N/A	N/A
If traveled to foreign country(ies), duration of stay	N/A	N/A	N/A	N/A	N/A

2.2. What organizations have been involved as partners?

Table 2. A List of Organizations Creating Partnerships with CAMMSE

Organization Name	Type / Location	Partners Contribution to Project				
		Financial Support	In-kind Support	Facilities	Collaborative Research	Personal Exchanges
Arizona State University	University /AZ				X	
Capital Metro – Austin Public Transit	Government /TX		X	X		

Carnegie Mellon University	University /PA				X	
Centralina Council of Governments	MPO /NC		X			
City of Austin	Government /TX				X	
City of Charlotte	Government /NC		X			
City of Houston	Government /TX				X	
Connecticut Department of Transportation	Government /CT				X	
George Washington University	University /DC				X	
Houston Bike Share	Non-profit /TX				X	
Houston BCycle	Non-profit/ TX				X	
Houston-Galveston Area Council	Non-profit /TX				X	
International Association of Maritime and Port Executives	Non-profit /Intl.				X	
Metropolitan Transit Authority of Harris County (METRO)	Government /TX				X	
Missouri University of Science and Technology	University /MO				X	
New York University	University /NYC				X	
North Carolina A&T University	University /NC				X	
North Carolina Department of Transportation	Government /NC		X			
North Carolina State University	University /NC				X	
North Carolina Turnpike Authority Automated Vehicle Proving Ground	Government /NC				X	
Texas A&M Transportation Institute	University /TX				X	
Texas Department of Transportation	Government /TX		X	X		
Texas Southern University	University /TX	X	X	X		
Texas State University	University /TX				X	
University of Houston	University /TX				X	
University of Central Florida	University /FL				X	
University of Connecticut	University /CT	X	X	X		
University of Memphis	University /TN				X	
University of Michigan	University /MI				X	

University of Nebraska-Lincoln	University /NE				X	
University of Nevada at Las Vegas	University /NV				X	
University of North Carolina at Charlotte	University /NC	X	X	X		
University of Texas at Austin	University /TX	X	X	X		
UT's Center for Transportation Research (UT Austin)	University /TX		X	X		
Washington Department of Transportation	Government /WA				X	
Washington State University	University /WA	X	X	X		
West Virginia University	University /WV				X	

Our CAMMSE UTC has successfully established an external advisory board which contains members from universities and government agencies. The detailed information about all five advisory board members is provided below:

- Dr. Michael Accorsi, Professor and Senior Associate Dean, School of Engineering, University of Connecticut.
  Email: michael.accorsi@uconn.edu
- Dr. Amit Bhasin, Director, Center for Transportation Research, Associate Professor, Transportation Engineering, The University of Texas at Austin.
  Email: a-bhasin@mail.utexas.edu
- Elizabeth Robbins, Planning Policy & Partnerships Manager, Multimodal Planning Division, Washington State Department of Transportation.
  Email: robbins@wsdot.wa.gov
- Neil Mastin, Research and Development Manager, North Carolina Department of Transportation.
  Email: jmastin@ncdot.gov
- Wade Odell, Research Engineer, Texas Department of Transportation.
  Email: Wade.Odell@txdot

2.3. Have other collaborators or contacts been involved?

Dr. Wei Fan, CAMMSE Director, has been collaborating and conducting research with faculty and researchers from UNCC, North Carolina A&T University and North Carolina State University (on projects sponsored by NCDOT). Dr. Wei Fan also collaborated with faculty and researchers from Arizona State University, Carnegie Mellon University, University of Central Florida, University of Texas at Austin, and Missouri University of Science and Technology, etc. A collaborative relationship has been successfully developed between these universities.

At WSU, Dr. Xianming Shi has met with the Director of WSU Vancouver School of Engineering and Computer Science to discuss possible collaboration in mobility solutions.

TSU CAMMSE faculty members teamed up with professors from different universities to develop new UTC proposals. Collaborators were from the University of Michigan, New York University, George Washington University, the University of Nevada at Las Vegas, the University of Memphis, Texas State University, Texas Transportation Institute, the University of Nebraska-Lincoln, etc.

UT Austin collaborated with City of Austin Transportation Department and the Austin District of TxDOT.

3. OUTPUTS

3.1. Journal publications, conference papers, and presentations

Journal publications

[1] Song, L. and Fan, W., Performance of State-Shared Multi-Agent Deep Reinforcement Learning Controlled Signal Corridor with Platooning-Based CAVs, Accepted for Publication, *ASCE Journal of Transportation Engineering, Part A: System*, March 2023.

[2] Zhao, X.M., Gao, Y., Jin, S.J., Xu, Z., Liu, Z., Fan, W. and Liu, P, Development of a Cyber-Physical-System Perspective based Simulation Platform for Optimizing Connected Automated Vehicles Dedicated Lanes, *Expert Systems with Applications*, Volume 213, Part B, 118972, March 2023.

[3] Hua, C., Fan, W., Song, L. and Liu, S., Analyzing the Injury Severity in Overturn Crashes Involving Sport Utility Vehicles: A Latent Class Clustering and Random Parameter Logit Model, *ASCE Journal of Transportation Engineering, Part A: Systems*, Volume 149, Issue 3, March 2023.

[4] Song, L. and Fan, W., Intersection Capacity Adjustments Considering Different Market Penetration Rates of Connected and Automated Vehicles, *Transportation Planning and Technology*, February 2023.

[5] Yang, T. and Fan, W. Evaluation of Transit Signal Priority at Signalized Intersections under Connected Vehicle Environment, *Transportation Planning and Technology*, 46(2), 145-159, February 2023.

[6] Li, Y., Fan, W., Song, L. and Liu, S., Combining Emerging Hotspots Analysis with XGBoost for Modeling Pedestrian Injuries in Pedestrian-Vehicle Crashes: A Case Study of North Carolina, *Journal of Transportation Safety & Security*, January 2023.

[7] Yang, T., Fan, W. and Song, L., Modelling Pedestrian Injury Severity in Pedestrian-Vehicle Crashes Considering Different Land Use Patterns: Mixed Logit Approach, *Traffic Injury Prevention*, 24(2), 114-120, January 2023.

[8] Liu, S. and Fan, W., A Simulation Study on The Traffic Delay and Fuel Consumption of Connected and Autonomous Vehicles in Superstreet with Platooning, Signal Optimization, and Trajectory Planning, *Transportation Planning and Technology*, 46(1), 119-144, December 2022.

[9] Hua, C. and Fan, W., Freeway Traffic Speed Prediction under the Intelligent Driving Environment: A Deep Learning Approach, *Journal of Advanced Transportation*, November 2022.

[10] Liu, J., Qi, Y., Tao, J., and Tao, T., Analysis of the Performance of Machine Learning Models in Predicting the Severity Level of Large-Truck Crashes. *Future Transportation*, 2(4), 939-955. November 2022

[11] Fan, A, Chen, X., Yu, L. and Li., M., Investigating Heterogeneity in Travel Behavior Change When Implementing Soft Transport Interventions: A Latent Class Choice Model. *IET Intelligent Transport Systems*, March 2023.

[12] Zang, J., Jiao, P., Liu, S., Zhang, X., Song, G., and Yu, L., Identifying Traffic Congestion Patterns of Urban Road Network Based on Traffic Performance Index. *Sustainability*, 15(2): 948, January 2023, 15, 948.

[13] Peng, Y., Song, G., Guo, M., Wu, L. and Yu, L., Investigating the Impact of Environmental and Temporal Features on Mobile Phone Distracted Driving Behavior Using Phone Use Data. *Accident Analysis & Prevention*, Volume 180, 106925, February 2023.

[14] Zhang, L., Zhu, Z., Zhang, Z., Song, G., Zhai, Z. and Yu, L., An Improved Method for Evaluating Eco-Driving Behavior Based-On Speed-Specific Vehicle-Specific Power Distributions. *Journal of Transportation Research Part D*, Volume 113, 103476, December 2022.

[15] Jiang, Y., Song, G., Wu, Y., Zhai, Z., Zhang, Z. and Yu, L., The Impact of Cold-Start Emissions on Air Pollution Exposure During Active Travel. *Journal of Transportation Research Part D*, Volume 112, 103469, November 2022.

[16] Baumanis, C., Hall, J., and Machemehl, R., A machine learning approach to predicting bicycle demand during the COVID-19 pandemic. *Research in Transportation Economics*, 101276, March 2023.
[17] Baumanis, C., Hall, J., and Machemehl, R., Perceptions of Bicycle Signals Faces and Associated Compliance Results of an Online Survey. *Transportation Research Record*, In Press. March 2023.
[18] Willis, O., Zhang, Y., Reed, C., and Shi, X., Outreach Program for Middle and High School Students to Promote Transportation Engineering. *International Journal of Engineering Education*, 2023, accepted for publication.
[19] Ashraf, Md. T., Dey, K., Carrola, A., and Shi, X., Impacts of Real-time Transit Information on Transit Accessibility - A Case Study. *Journal of Public Transportation*, 25, March 2023.
[20] Ma, F., Lee, J. Y., Camenzind, D., and Wolcott, M., Probabilistic Wildfire risk assessment methodology and evaluation of a supply chain network. *International Journal of Disaster Risk Reduction*, 82, 103340, November 2022.

Conference papers

[1] Rezwana, S. and N. Lownes, Understanding the Changes in Public Perception towards Autonomous Vehicles Over Time. ASCE International Conference on Transportation & Development (Accepted ICTD 2023).
[2] Liu, H., Vishnoi, S., Claudel, C., A Two-Stage Stochastic Model Considering Randomness of Demand in Variable Speed Limit and Boundary Flow Control. Presented at the 102nd Transportation Research Board Annual Meeting, Washington, D.C. January 2023.

Presentations

[1] Hua, C. and Fan, W., Injury Severity Analysis in Overturn Crashes Involving Sport Utility Vehicles, Poster Presentation, 2023 NCDOT Research & Innovation Summit, North Carolina State University, Raleigh, NC, March 29-30, 2023.
[2] Yang, T. and Fan, W., Evaluation of Transit Signal Priority at Signalized Intersections under Connected Vehicle Environment, Poster Presentation, 2023 NCDOT Research & Innovation Summit, North Carolina State University, Raleigh, NC, March 29-30, 2023.
[3] Fan, W. and Li, Y., Analyzing Pedestrian Injuries in Pedestrian-Vehicle Crashes using Emerging Hotspots Analysis and XGBoost: A Case Study of North Carolina, Podium Presentation, 2023 NCDOT Research & Innovation Summit, North Carolina State University, Raleigh, NC, March 29-30, 2023.
[4] Fan, W., Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE): A Tier I University Transportation Center, FHWA Visit at UNC Charlotte, Charlotte, NC, March 29, 2023.
[5] Fan, W., Impact of CAVs on the Transportation System, Energy Consumption and the Environment, Guest Lecture, CEGR 6090/CEGR 8090/INES 8202 Course, UNC Charlotte, Thursday, March 7, 2023.
[6] Fan, W., Recurrent Traffic Bottlenecks: Systematic Identification and Mitigation Solutions, Keynote Presentation, The 11th International Conference on Transportation and Traffic Engineering (ICTTE 2022), Wuhan University of Technology, Wuhan, China, December 27-29, 2022.
[7] Fan, W., A New Era in Transportation: Challenges and Opportunities, Invited Guest Lecture, Missouri University of Science and Technology, Virtual Webinar, December 8, 2022.
[8] Song, L. and Fan, W., Intersection Capacity Adjustments Considering Different Market Penetration Rates of Connected and Autonomous Vehicles, NC Transportation Center of Excellence in Connected and Autonomous Vehicle Technology (NC-CAV), November 18, 2022.
[9] Hua, C. and Fan, W., Freeway Traffic Speed Prediction under the Intelligent Driving Environment: A Deep Learning Approach, Fifth Annual CAMMSE Virtual Research Symposium, UNC Charlotte, Charlotte, NC, November 11, 2022.
[10] Yang, T. and Fan, W., Evaluation of Transit Signal Priority at Signalized Intersections under Connected Vehicle Environment, Fifth Annual CAMMSE Virtual Research Symposium, UNC Charlotte, Charlotte, NC, November 11, 2022.
[11] Liu, S. and Fan, W., A Simulation Study on the Traffic Delay and Fuel Consumption of Connected and Autonomous Vehicles in Superstreet with Platooning, Signal Optimization, and Trajectory

Planning, Fifth Annual CAMMSE Virtual Research Symposium, UNC Charlotte, Charlotte, NC, November 10, 2022.
[12] Song, L. and Fan, W., Performance of State-Shared Multi-Agent Deep Reinforcement Learning Controlled Signal Corridor with Platooning-Based CAVs, Fifth Annual CAMMSE Virtual Research Symposium, UNC Charlotte, Charlotte, NC, November 10, 2022.
[13] Li, Y. and Fan, W., Combining Emerging Hotspots Analysis with XGBoost for Modeling Pedestrian Injuries in Pedestrian-Vehicle Crashes: A Case Study of North Carolina, Fifth Annual CAMMSE Virtual Research Symposium, UNC Charlotte, Charlotte, NC, November 10, 2022.
[14] Qi, Y., Impacts of COVID-19 on Public Transit Ridership, 2022 CAMMSE Virtual Research Symposium, UNC Charlotte, November 10, 2022.
[15] Azimi, M., COVID-19 Effects on Bike Share Usage and Ridership in Houston, 2022 CAMMSE Virtual Research Symposium, UNC Charlotte, November 10, 2022
[16] Omosebi, O., Investigating the Impact of Airport Surface Technology (ASDE-X, RWSL and ASSC) in Mitigating Runway Incursion, 2022 CAMMSE Virtual Research Symposium, UNC Charlotte, November 11, 2022
[17] Acharya, S., Exploring Traffic Big Data for Real-Time Traffic Congestion Analysis, 2022 CAMMSE Virtual Research Symposium, UNC Charlotte, November 11, 2022
[18] Percy, Z., Investigate Age impacts on Controlled Flight into Terrain Aircraft Crashes in General Aviation, 2022 CAMMSE Virtual Research Symposium, UNC Charlotte, November 11, 2022
[19] Omosebi, O., Investigating Runway Incursions in the United States Airport. 2023 TSU Research Week, March 28, 2023
[20] Haley, S., Challenges and Issues of Nonemergency Medical Transportation Services in the United States of America, 2023 TSU Research Week, March 28, 2023
[21] Ivan, J., Estimation of Pedestrian Compliance at Signalized Intersections Considering Demographic and Geographic Factors, Fifth Annual CAMMSE Research Symposium, UNC Charlotte, Charlotte, NC, November 10, 2022.
[22] Lownes, N., A research perspective of integrating equity into public transportation planning, Fifth Annual CAMMSE Research Symposium, UNC Charlotte, Charlotte, NC, November 10, 2022.
[23] Zhu, J., An Enhanced Understanding of Resilience Assessment Using Points-of-interest (POI) Visit Dataset under Disaster, Fifth Annual CAMMSE Research Symposium, UNC Charlotte, Charlotte, NC, November 10, 2022.
[24] Atkinson-Palombo, C., Characteristics of Pooled Trips Offered by Ride-sourcing Services in Chicago, Fifth Annual CAMMSE Research Symposium, UNC Charlotte, Charlotte, NC, November 10, 2022.
[25] Rezwana, S., A Modified Social Force Model (SFM) for Pedestrian Behavior in the Presence of Autonomous Vehicles (AVs), Fifth Annual CAMMSE Research Symposium, UNC Charlotte, Charlotte, NC, November 11, 2022.
[26] Packer, Q., Pedestrian Signal Compliance Under Concurrent and Exclusive Phasing at Traffic Signals Considering Geo-Spatial Factors, Fifth Annual CAMMSE Research Symposium, UNC Charlotte, Charlotte, NC, November 11, 2022.
[27] Mantri, S., An Analysis of the Impacts of Autonomous Vehicles on Private Household Vehicle Ownership in The State of Connecticut, Fifth Annual CAMMSE Research Symposium, UNC Charlotte, Charlotte, NC, November 11, 2022.
[28] Zheng, R., An Enhanced Understanding of Disaster Resilience Assessment Using Points-of-interest (POI) Visit Dataset Under a Natural Disaster, Fifth Annual CAMMSE Research Symposium, UNC Charlotte, Charlotte, NC, November 11, 2022.
[29] Baumanis, C., Visualizing Perceptions, AED80 Visualization Lightning Talks at the 102nd Annual Meeting of the Transportation Research Board, Washington, D.C., January 8-12, 2023.
[30] Baumanis, C., Enhancing Active Transportation Safety, Doctoral Student Research in Transportation Safety: Special Hybrid Session at the 102nd Annual Meeting of the Transportation Research Board, Washington, D.C., January 8-12, 2023.
[31] Baumanis, C., J. Hall, and R. Machemehl., Perceptions of Bicycle Signal Faces and Associated Compliance Results of an Online Survey, 102nd Annual Meeting of the Transportation Research Board, Washington, D.C., January 8-12, 2023.
[32] Hall, J., Equity as a Criterion for Transit Service Reduction During the COVID-19 Pandemic, Fifth Annual CAMMSE Research Symposium, UNC Charlotte, Charlotte, NC, November 11, 2022.

[33] Vishnoi, S., Traffic State Estimation for Connected Vehicles using the Second-Order Aw-Rascle-Zhang Traffic Model, Fifth Annual CAMMSE Research Symposium, UNC Charlotte, Charlotte, NC, November 11, 2022.
[34] Claudel, C., Transforming Transportation with Machine Learning, Fifth Annual CAMMSE Research Symposium, UNC Charlotte, Charlotte, NC, November 10, 2022.
[35] Machemehl, R., Travel Preference Survey and Mode Choice Model, Fifth Annual CAMMSE Research Symposium, UNC Charlotte, Charlotte, NC, November 10, 2022.
[36] Shi, X., Beneficial Use of Fruit Wastes for Greener Anti-icing Practices on Roadways, 102nd Annual Meeting of the Transportation Research Board, Washington, D.C., January 9, 2023.
[37] Deng, Y., and Shi, X., Prediction of Traffic Mobility Based on Historical Data and Machine Learning Approaches, Fifth Annual CAMMSE Research Symposium, UNC Charlotte, Charlotte, NC, November 10, 2022.

3.2. Website(s) or other internet site(s)

The CAMMSE website is located at http://cammse.uncc.edu/. This website has been used to disseminate any information related to the program. Other internet sites include: http://sboyles.github.io/, https://sites.utexas.edu/machemehl/ and http://www.mass-lab-ut.com/.

3.3. Technologies or techniques

Nothing to report.

3.4. Inventions, patent applications, and/or licenses

Shi, X. Biologically-derived deicer. Non-Provisional patent approved on Sept. 29, 2022. US Patent 11535780. (Note that this is the outcome of a previous Tier 1 UTC CESTiCC).

3.5. Other outputs

CAMMSE Graduate Seminar Series @ UNCC, Sponsored by CAMMSE

[1] “Rule-based Methods on Freeway Operation: A Holistic Evaluation", Presented by Mr. Chengying Hua (CAMMSE INES Ph.D. research assistant), October 5, 2022, EPIC CEE Conference Room 3344.
[2] “Introduction to Artificial Intelligent: Optimization", Presented by Mr. Tianjia Yang (CAMMSE INES Ph.D. research assistant), October 12, 2022, EPIC CEE Conference Room 3344.
[3] “Complex-Condition-Controlled Urban Traffic Estimation through Generative Adversarial Networks", Presented by Ms. Yang Zhao (CAMMSE INES Ph.D. research assistant), October 19, 2022, EPIC CEE Conference Room 3344.
[4] “Introduction to Actor-Critic Algorithm", Presented by Mr. Hengcong Guo (CAMMSE INES Ph.D. research assistant), October 26, 2022, EPIC CEE Conference Room 3344.
[5] “DRL-Based VSL Control in CV Environments", Presented by Mr. Chengying Hua (CAMMSE INES Ph.D. research assistant), November 2, 2022, EPIC CEE Conference Room 3344.
[6] “Introduction to Deep Q-Network", Presented by Mr. Tianjia Yang (CAMMSE INES Ph.D. research assistant), November 9, 2022, EPIC CEE Conference Room 3344.
[7] “Training Skills for Machine/Deep Learning", Presented by Ms. Yang Zhao (CAMMSE INES Ph.D. research assistant), November 16, 2022, EPIC CEE Conference Room 3344.
[8] “Policy Gradient Theorem", Presented by Mr. Hengcong Guo (CAMMSE INES Ph.D. research assistant), November 30, 2022, EPIC CEE Conference Room 3344.
[9] “2023 TRB Experience and Summary: Research Progress and Trends", Presented by Mr. Chengying Hua (CAMMSE INES Ph.D. research assistant), January 18, 2023, EPIC CEE Conference Room 3344.
[10] “TSP Using DQN: Results Presentation", Presented by Mr. Tianjia Yang (CAMMSE INES Ph.D. research assistant), January 25, 2023, EPIC CEE Conference Room 3344.

[11] "Dynamic Speed Harmonization of CAVs at Nonrecurrent Freeway Bottlenecks", Presented by Mr. Chengying Hua (CAMMSE INES Ph.D. research assistant), February 1, 2023, EPIC CEE Conference Room 3344.
[12] "Microscopic Model-Based RL Approaches for Traffic Signal Control Generalize Better than Model-Free RL Approaches", Presented by Mr. Tianjia Yang (CAMMSE INES Ph.D. research assistant), February 8, 2023, EPIC CEE Conference Room 3344.
[13] "Integrated CACC and VSL Controls for Reducing Rear-End Collision Risks Near Freeway Bottlenecks", Presented by Mr. Chengying Hua (CAMMSE INES Ph.D. research assistant), February 15, 2023, EPIC CEE Conference Room 3344.
[14] "Traffic Signal Optimization under Connected-Vehicle Environment: An Overview", Presented by Mr. Tianjia Yang (CAMMSE INES Ph.D. research assistant), February 22, 2023, EPIC CEE Conference Room 3344.
[15] "Reinforcement Learning Based Variable Speed Limit Control for Mixed Traffic Flows", Presented by Mr. Chengying Hua (CAMMSE INES Ph.D. research assistant), March 8, 2023, remotely via Zoom.
[16] "Using Reinforcement Learning with Partial Vehicle Detection for Intelligent Traffic Signal Control", Presented by Mr. Tianjia Yang (CAMMSE INES Ph.D. research assistant), March 15, 2023, remotely via Zoom.
[17] "RL-based VSL to Reduce Crash Risks on Freeways", Presented by Mr. Chengying Hua (CAMMSE INES Ph.D. research assistant), March 22, 2023, EPIC CEE Conference Room 3344.

ITE Seminar Series @ UNCC, Co-organized and sponsored by UNCC ITE Student Chapter and CAMMSE

[1] "Career Development as an Engineer & What Jobs Entail", lectured by Mr. Alexander Wiseman and Mr. Trent Moody, Transportation Engineers from STV Inc., EPIC 3226, November 2, 2022.
[2] "Career Development and Planning, and Job Search Preparation", lectured by Ms. Megan Corkery, Assistant Director and Career Coach from the University Career Center at UNC Charlotte, Epic 3222, February 8, 2023.
[3] "Modelling Projects in VISSIM and TransModeler", lectured by Ms. Kellie Reep, Transportation Engineer from Stantec, Epic 1249, March 7, 2023.

ITE Seminar Series @ TSU, Co-organized and sponsored by TSU ITE Student Chapter and CAMMSE

[1] "Houston District Transportation Systems Management & Operations (TSMO)", lectured by Ugonna U. Ughanze, Director of Transportation Operations, Houston District, Texas Department of Transportation (TxDOT), October 13, 2022
[2] "Disruptive Transportation Trends", lectured by Josh Peterman, Principal and Dallas Office Leader, Fehr & Peers, November 3, 2022.
[3] "Transportation Infrastructure Investment in the Houston Region", lectured by Steven Granson, Associate Vice President, HNTB, March 1, 2023
[4] "Aviation Engineering in Texas", lectured by Devon Tiner, Houston Area Leader, RS&H, March 23, 2023.

L.E.A.D – Leadership, Excellence, Achievement and Development Workshop @ TSU, Co-organized and sponsored by TSU Department of Transportation Studies, March 2, 2023.

INTERVIEWS & MEDIA EVENTS/MENTIONS

[1] Dr. Wei Fan was interviewed by a "Smart Cities Dive" Freelance Writer Ms. Kalena Thomhave on Micromobility, January 17, 2023. https://www.smartcitiesdive.com/news/micromobility-growth-2023-industry-experts-scooters-e-bikes/640757/

Technical Reports

[1] NC Transportation Center of Excellence on Connected and Autonomous Vehicle Technology (NC-CAV); Karimoddini, A., Fan, W., Samandar, S., Homaifar, A., Rouphail, N., Cunningham, C., Hajbabaie, A., Lin, S.C., Findley, D., Kelly, J., Hashemi, L., Jiang, S., Eroglu, A., Khan, M., Report Number: NCDOT TCE2020-03, NCDOT, Raleigh, NC, March 2023.

4. OUTCOMES

4.1. Increased understanding and awareness of transportation issues

Controlled Flight into Terrain (CFIT) crash is one of three high-risk accident occurrence categories identified by the International Civil Aviation Organization (ICAO). TSU CAMMSE's research "Investigate Pilot-related Factors on Controlled Flight into Terrain (CFIT) in General Aviation" utilized the General Aviation CFIT crash data collected from the National Transportation Safety Board (NTSB) and pilots' information from the Federal Aviation Administration (FAA) to perform statistical analysis to reveal the impacts of pilot's age and other pilot-related contributing factors on the occurrence of CFIT crashes in General Aviation. The research findings help policymakers to better understand the underlying reasons for General Aviation CFIT crashes.

Research done under Dr. Randy Machemehl (UT Austin) characterizing public transportation during the pandemic in Austin, TX gleaned insights into how public transportation might have failed to supply essential travel to minority groups. The scooter project thus far has highlighted how geofences alone do not significantly affect scooter crash rates, but how parking restrictions have in the context of the University of Texas campus.

4.2. Passage of new policies, regulation, rulemaking, or legislation

Nothing to report.

4.3. Increases in the body of knowledge

In the research project "Countermeasures for Maintaining Safe and Effective Public Transit Service in Post-COVID-19 Era", TSU CAMMSE team developed a model to quantitively evaluate the infection risk of riding public transit. By utilizing the developed model, the effectiveness of different countermeasures could be evaluated and compared. The model results showed that face masking, social distancing, and vaccination can all reduce the infection risk for passengers, and also approved that the COVID-19 infection risk is highly related to the exposure time and the risk can be controlled by reducing the exposure time.

The bicycle signals research done by UT Austin increased understanding of people's perceptions of bicycle signal faces in terms of comfort and safety, which has been identified as a knowledge gap. This survey pinpoints the characteristics that are associated with a negative or positive view of the signals. The survey also improved our understanding of perceptions of interactions between modes (cyclist-pedestrian & cyclist-vehicle) at intersections with signals. The results from this study have In Press for publication under TRR.

4.4. Improvement of existing techniques, practices, technologies

TSU's research project "Investigate Pilot-related Factors on Controlled Flight into Terrain (CFIT) in General Aviation" revealed the impacts of the pilot's age and other pilot-related contributing factors on the occurrence of CFIT crashes in General Aviation. Based on the analysis, technology-based and policy-level new countermeasures were proposed to reduce CFIT crashes in General Aviation. The research findings will help policymakers to update their current practices and regulations.

Research under Dr. Randy Machemehl (UT Austin) highlights how predictive methods have been conflated with explanatory methods in transportation count-based demand modeling. The issue that the *A machine learning approach to predicting bicycle demand during the COVID-19 pandemic* paper aims to highlight is how the terms predictive and explanation have been used interchangeably in our field like in many other fields, and that many times when we're trying to make predictive models we're really using explanatory approaches (even though we still call it a predictive model). The reality is that these are not the same, and often are opposing forces. This paper also serves as a plea to the transportation demand community to not

focus on explanation of behavior as the best predictive method and to really focus on prediction in the fundamental/statistical sense.

4.5. Enlargement of the pool of trained transportation professionals

Nothing to report.

4.6. Incorporation of new techniques, practices, technologies

Nothing to report.

5. IMPACTS

The CAMMSE is currently conducting a variety of research, education and outreach, technology transfer, and diversity activities and as such, the impact of this program cannot be comprehensively measured during this reporting period.

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

Increasing bicycle travel can reduce congestion, fuel consumption and emissions plus it improves the physical condition of the rider. The only negative aspect of bicycle usage is rider safety. The bicycle signal research is a step toward making bicycle travel safer and more desirable, thereby increasing bicycle travel.

5.2. What is the impact of technology transfer on industry and government entities, on the adoption of new practices, or on research outcomes which have led to initiating a start-up company?

TSU CAMMSE team works closely with industry and government agencies by collaborating on research projects. For example, Dr. Yi Qi and her team were invited by the City of Houston to conduct independent research to evaluate the operational performance of Transit signal priority (TSP) at the selected corridor. This research results will be transferred to the City of Houston seamlessly.

TSU CAMMSE team also hosts seminars and workshops open to all transportation professionals, which could also help the technology transfer.

The research at UT Austin is performed by students and faculty supervisors who work closely with industry and government entities. As with the traffic volume estimation project, the working relationship with industry and government enables immediate technology transfer, plus the students who develop the new technology carry that knowledge with them into their eventual transportation sector employment.

5.3. What is the impact on the body of scientific knowledge?

The research findings from conducting CAMMSE projects increased the body of scientific knowledge. One of the best technology transfer tools is the students that work on these CAMMSE research projects. These UT Austin students are key to the technology development as they will carry the knowledge and technology developed through CAMMSE projects to the Transportation Engineering industry. They will carry the new technology with them and use it in their new jobs, teach peers how to use the technology, thereby implementing the technology. Most importantly, these new techniques will continue to grow and improve as they are used.

5.4. What is the impact on transportation workforce development?

TSU CAMMSE sponsored seminars or workshops which provide great opportunities for students to communicate and network with experts from both industry and academia. What they learned will help them build their future careers. In addition, TSU CAMMSE offers research assistantships to both graduate students and undergraduate students. By participating in CAMMSE research projects and being mentored by CAMMSE faculty members, students learned first-hand technologies and methods on how to analyze transportation-related problems. What they learned here will help them in their future work.

The professors at UT Austin have also used their classes to teach the new techniques developed through the CAMMSE UTC, therefore planting the new technology in students that are not directly supported by the UTC. In addition, information developed through UT Austin's research is being shared with the Dallas District of TxDOT as a partner in the research efforts.

6. CHANGES AND PROBLEMS

6.1. Changes in approach and reasons for change

Nothing to report.

6.2. Actual or anticipated problems or delays and actions or plans to resolve them

At UConn, significant progress was made on 2022 Project 09. During the pandemic experimental data were not obtained due to health and safety concerns. Additionally, IRB imposed stricter health and safety protocols on human subject data collection. In the reporting period October 1, 2022 – March 31, 2023 investigators developed an IRB protocol and safety plan that is in the final stages of approval. Further, equipment and software necessary for the physiological data collection has been updated and installed in the virtual reality (VR) lab at the Connecticut Transportation Institute in preparation for data collection. participants will be recruited shortly and the empirical data will be collected in the next reporting period.

6.3. Changes that have a significant impact on expenditures

The COVID pandemic has brought many challenges to all CAMMSE partner institutions. As we are getting back to normal, all CAMMSE partner institutions are actively taking on the challenges and continue working hard to resolve all relevant issues.

6.4. Significant change in use or care of animals, human subjects, and/or biohazards

Nothing to report.

6.5. Changes of primary performance site location from that originally proposed

At CAMMSE, most of our researchers and student workers were working at home due to COVID 19.

6.6. Additional information regarding products and impacts

Nothing to report.

7. SPECIAL REPORTING REQUIREMENTS

(1) External Advisory Board: Available on the program website: https://cammse.uncc.edu/directory/external-advisory-board

(2) Financial and Annual Recipient Share Reports: The SF 425 requirements will be met by separate reports.

APPENDIX

CAMMSE @ UNC Charlotte Funded Projects, 2016-2018 (Year 1), All Completed

University	Principle Investigator	Category	Title of the Funded Project
University of North Carolina at Charlotte	Wei Fan	Advanced Research	Estimation of Origin-Destination Matrix and Identification of User Activities Using Public Transit Smart Card Data
	Wei Fan	Applied Research	Improving the Movements of People and Freight: A Case Study of the Piedmont Atlantic Megaregion
University of Texas at Austin	Randy Machemehl	Applied Research	Forecasting Ridership for Commuter Rail in Austin
	Randy Machemehl	Advanced Research	Corridor Level Adaptive Signal Control
University of Connecticut	Nicholas Lownes	Basic Research	Stochastic Multimodal Network Modeling
	Nicholas Lownes	Basic Research	Robust Routing, Assignment, and Simulation of Transit Systems
Washington State University	Xianming Shi	Applied Research	The Use of Connected Vehicle Technology to Facilitate Multimodal Winter Travel
	Jia Yan	Applied Research	The Effect of Competition of Transport Modes on Mobility
Texas Southern University	Mehdi Azimi Yi Qi	Applied Research	Use of Vessel Automatic Information System Data to Improve Multi-modal Transportation in and around the Ports
	Yi Qi	Applied Research	Use of Innovative Intersection Designs for Improving Mobility and Reducing Roadway Traffic Congestion

CAMMSE @ UNC Charlotte Funded Projects, 2017-2019 (Year 2), All Completed

University	Principle Investigator(s)	Category	Title of the Funded Project
University of North Carolina at Charlotte	Wei Fan	Advanced Research	Use of Multisensor Data in Modeling Freeway Travel Time Reliability
	Wei Fan Martin Kane	Applied Research	Using General Transit Feed Specification (GTFS) Data as a Basis for Evaluating and Improving Public Transit Equity
	Wei Fan Yu Wang	Applied Research	Evaluating the Potential Use of Crowdsourced Bicycle Data in North Carolina
	Wei Fan	Advanced Research	Impact of Connected and Automated Vehicles (CAVs) on Freeway Capacity
	Wei Fan	Advanced Research	Optimal Variable Speed Limit Control for the Mixed Traffic Flows in a Connected and Autonomous Vehicle Environment
University of Texas at Austin	Randy Machemehl	Applied Research	Characterization of Bicycle Rider Behavior among Various Street Environments
	Randy Machemehl	Applied Research	Evolution of Advanced Transit Signal Priority with Gap-Based Signal Recovery Strategy
	Stephen Boyles	Applied Research	Assessment of Parcel Delivery Systems Using Unmanned Aerial Vehicles
	Christian Claudel	Advanced Research	Deep-learning Based Trajectory Forecast for Safety of Intersections with Multimodal Traffic
University of Connecticut	Nicholas Lownes Charles Patton Kelly Bertolaccini	Applied Research	Investigating the Linkage between Transit Access to Services and Affordable Housing Availability
	Karthik Charan Konduri	Advanced Research	Development of Continuous Time, Temporally Constrained and Behaviorally Consistent Tour Pattern Generation System for Modeling the Impacts of Autonomous Vehicle Future
	Norman Garrick Carol Atkinson - Palombo	Applied Research	What Do We Want from Autonomous Vehicles (AVs)? Using Participatory Planning and Scenario Analysis of Alternative Futures to Identify Stakeholders' Desired Outcomes from the Strategic Deployment of Emerging Transportation Technology
Washington State University	Xianming Shi	Applied Research	Developing Friction Data to Support the Optimal Use of Pre-wet Deicing Salt for Enhanced Winter Mobility
	Xianming Shi	Applied Research	Modeling the Macroscopic Effects of Winter Maintenance Operations on Traffic Mobility on Washington Highways
Texas Southern University	Yi Qi Mehdi Azimi Qun Zhao	Applied Research	Determination of Freeway Acceleration Lane Length for Smooth ad Safe Truck Merging
	Yi Qi Mehdi Azimi Qun Zhao	Applied Research	Innovative Countermeasures for Reducing the Truck Waiting Time at Marine Terminals

	Mehdi Azimi Yi Qi Qun Zhao	Applied Research	Investigating the Impact of Different Attributes on Bicycling Mode Share as A Multimodal Connectivity Strategy in Large Cities: A Case Study in Houston

CAMMSE @ UNC Charlotte Funded Projects, 2018-2020 (Year 3), All Completed

University	Principle Investigator(s)	Category	Title of the Funded Project
University of North Carolina at Charlotte	Wei Fan	Applied Research	Predicting Travel Time on Freeway Corridors: Machine Learning Approach
	Wei Fan Martin Kane	Applied Research	Optimizing Transit Equity and Accessibility by Integrating Relevant GTFS Data Performance Metrics
	Wei Fan Yu Wang	Applied Research	Analyzing Cycling Behavior during Different Time Periods Using Crowdsourced Bicycle Data
	Wei Fan	Applied Research	Trajectory Optimization of Connected and Autonomous Vehicles (CAVs) at Signalized Intersections
University of Texas at Austin	Randy Machemehl	Applied Research	Forecasting Bicycle Facility Demand to Estimate Societal Impacts
	Randy Machemehl	Applied Research	Corridor Level Adaptive Signal Control (Phase II)
	Stephen Boyles	Applied Research	Assessment of Parcel Delivery Systems Using Unmanned Aerial Vehicles (Phase II)
	Christian Claudel	Advanced Research	Deep-learning Based Trajectory Forecast for Safety of Intersections with Multimodal Traffic (Phase II)
University of Connecticut	Jeffrey Cohen Nicholas Lownes	Applied Research	Highways and Wealth Distribution: A Geospatial Analysis
	Karthik Konduri Nalini Ravishanker	Applied Research	Are Transportation Network Companies Synergistic with Other Shared Ride Mode Offerings? An Exploratory Analysis of Demand Data from NYC Utilizing High Resolution Spatiotemporal Models
	Norman Garrick Carol Atkinson - Palombo	Applied Research	Understanding the Surprising and Oversized Use of Ridesourcing Services in Poorer Neighborhoods in NYC
Washington State University	Michelle Akin Xianming Shi	Educational Research	Multimodal Transportation Engineering Curriculum for Middle and High School Students
	Xianming Shi	Applied Research	Effects of Incorporating Connected Vehicle Technologies into No-Notice Emergency Evacuation during Winter Weather
	Ali Hajbabaie	Applied Research	Dynamic Speed Harmonization in Connected Urban Street Networks: Improving Mobility
Texas Southern University	Yi Qi Mehdi Azimi Qun Zhao	Applied Research	Development of Guidelines for Implementation of Contraflow Left-Turn Lanes at Signalized Intersections
	Yi Qi Qun Zhao Mehdi Azimi	Applied Research	Signal Timing Strategy for Displaced Left Turn Intersections
	Mehdi Azimi Yi Qi	Applied Research	Impacts of Bicycling Corridor Improvements on Users' Behaviors in Large Cities

CAMMSE @ UNC Charlotte Funded Projects, 2019-2021 (Year 4), All Completed

University	Principle Investigator(s)	Category	Title of the Funded Project
University of North Carolina at Charlotte	Wei Fan	Applied Research	Travel Time Forecasting on a Freeway Corridor: a Dynamic Information Fusion Model Based on the Random Forests Approach
	Wei Fan Martin Kane	Applied Research	Optimization of Long-Term Highway Work Zone Scheduling
	Wei Fan	Applied Research	Impact of Connected and Autonomous Vehicles on Nontraditional Intersection Design: Superstreets
	Wei Fan	Applied Research	Machine Learning-based Trajectory Optimization of Connected and Autonomous Vehicles
University of Texas at Austin	Randy Machemehl	Applied Research	Quantification of Societal Bicycle Impacts (Phase III)
	Randy Machemehl	Applied Research	Corridor Level Adaptive Signal Control (Phase III)
	Stephen Boyles	Applied Research	Assessment of Parcel Delivery Systems Using Unmanned Aerial Vehicles (Phase III)
	Christian Claudel	Advanced Research	Deep-learning Based Trajectory Forecast for Safety of Intersections with Multimodal Traffic (Phase III)
University of Connecticut	Nicholas Lownes	Advanced Research	Prioritizing People - Mixed Equilibrium Assignment for AV Based on Occupancy
	Nicholas Lownes Timothy Becker	Advanced Research	Using Computational Biology to Mitigate Path Overlap in Transit Assignment
	Jin Zhu	Applied Research	Disaster Resilience through Diverse Evacuation and Emergency Transportation Systems
	John Ivan Amy Burnicki	Applied Research	Estimation of Pedestrian Volume Using Geospatial and Traffic Conflict Data
Washington State University	Xianming Shi	Applied Research	Multimodal Connected Vehicle Pilot for Winter Travel
Texas Southern University	Yi Qi Mehdi Azimi Qun Zhao	Applied Research	A New Method for Estimating Truck Queue Length at Marine Terminal Gates
	Mehdi Azimi Yi Qi	Applied Research	Analysis of Intermodal Vessel-to-Rail Connectivity
	Mehdi Azimi Yi Qi	Applied Research	Bicycle Network Connectivity and Accessibility: A Study on the Effects of Bike Infrastructures on Bicycle Sharing System Demand

CAMMSE @ UNC Charlotte Funded Projects, 2020-2022 (Year 5), All Completed

University	Principle Investigator(s)	Category	Title of the Funded Project
University of Texas at Austin	Randy Machemehl	Applied Research	Impacts of Speed on Dockless Electric Scooter Crashes
	Randy Machemehl	Applied Research	Optimizing Type and Location of Pedestrian Crossing Signs at Non-signalized Intersections
	Christian Claudel	Advanced Research	Predicting Paths of Controlled Pedestrians at Intersections Using Deep Learning Models
University of Connecticut	John Ivan Amy Burnicki	Applied Research	Estimation of Pedestrian Compliance at Signalized Intersections Considering Demographic and Geographic Factors
	Carol Atkinson Palombo Norman Garrick	Applied Research	An Evaluation of the Transportation Equity Impacts of Uber and Lyft Usage in Chicago
	Nicholas Lownes	Applied Research	Pedestrian Behavior and Interaction with Autonomous Vehicles
Washington State University	Ji Yun Lee	Advanced Research	Effect of Connected and Autonomous Vehicles on Supply Chain Performance
Texas Southern University	Mehdi Azimi Yi Qi	Applied Research	Studying the Impact of Pandemic Outbreaks on Maritime Transportation and Port Operation
	Yi Qi Mehdi Azimi Qun Zhao	Applied Research	Short Term Intersection Traffic Flow Forecasting
	Yi Qi Mehdi Azimi Qun Zhao	Applied Research	The Impacts of COVID-19 on Public Transit

CAMMSE @ UNC Charlotte Funded Projects, 2021-2023 (Year 6), Some Completed, Some Ongoing

University	Principle Investigator(s)	Category	Title of the Funded Project
University of North Carolina at Charlotte	Wei Fan	Applied Research	Evaluating and Comparing the Impact of Connected and Autonomous Vehicles on Conventional Intersections and Superstreets
	Wei Fan	Advanced Research	Real-time Traffic Flow Prediction based on Spatiotemporal Patterns in Connected and Autonomous Vehicles Environment
	Wei Fan	Advanced Research	Online Cooperative Lane-changing Model of Connected and Autonomous Vehicles
	Wei Fan	Applied Research	Impact of Connected and Autonomous Vehicles on Signalized Intersections with Transit Signal Priority
	Wei Fan	Advanced Research	Dynamic Coordinated Speed Control and Synergistic Performance Evaluation in Connected and Automated Vehicle Environment
	Wei Fan	Advanced Research	Transit Signal Priority Control with Connected Vehicle Technology: Deep Reinforcement Learning Approach
University of Texas at Austin	Randy Machemehl	Applied Research	Impacts of Speed on Dockless Electric Scooter Crashes (Phase II)
	Randy Machemehl	Applied Research	Optimizing Type and Location of Pedestrian Crossing Signs at Non-signalized Intersections (Phase II)
	Randy Machemehl	Applied Research	Developing Robust Smart Traffic Signal Control
University of Connecticut	Nicholas Lownes	Advanced Research	Prioritizing People - Mixed Equilibrium Assignment for AV Based on Occupancy (Phase II)
	Nicholas Lownes	Advanced Research	Pedestrian Behavior and Interaction with Autonomous Vehicles (Phase II)
	Jin Zhu	Applied Research	Disaster Resilience through Diverse Evacuation and Emergency Transportation Systems (Phase II)
	John Ivan Amy Burnicki	Applied Research	Estimation of Pedestrian Compliance at Signalized Intersections Considering Demographic and Geographic Factors (Phase II)
Washington State University	Xianming Shi	Applied Research	Prediction of Traffic Mobility Based on Historical Data and Machine Learning Approaches
Texas Southern University	Mehdi Azimi Yi Qi	Applied Research	Investigating the Impact of COVID-19 Pandemic Outbreak on Bike Share Usage and Ridership: A Case Study in Houston
	Yi Qi Mehdi Azimi Qun Zhao	Applied Research	Countermeasures for Maintaining Safe and Effective Public Transit Service in the Post-COVID-19 Era

	Yi Qi Qun Zhao Mehdi Azimi	Applied Research	Investigate Age Impacts on Controlled Flight into Terrain (CFIT) Crashes in General Aviation

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