



## Center for Advanced Multimodal Mobility Solutions and Education

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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.

## **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 *Applied Stochastic Models in Business and Industry*, *ASCE Journal of Transportation Engineering, Part A: System, Future Transportation*, *IET Intelligent Transport Systems*, *Philosophical Transactions of the Royal Society A*, *Promet - Traffic&Transportation*, *Sustainability*, and *Transportation Research Part D: Transport and Environment*. During this reporting period, CAMMSE research results were also presented at several conferences on different occasions, which include the 11<sup>th</sup> International Conference on Traffic and Logistic Engineering (ICTLE 2023), the 23<sup>rd</sup> COTA International Conference of Transportation Professionals (CICTP 2023), Chang’an University International Symposium, the International Conference on Transportation and Development (ICTD) 2023 at Austin, TX on June 14-17, the Proceedings of the 14<sup>th</sup> International Conference on Applications of Statistics and Probability in Civil Engineering at Dublin, Ireland on July 9-13, the International Conference on Software and Data Technologies (ICSOFT), the Biennial Conference on the Marine Transportation System Innovative Science and Technologies Toward Greater Sustainability, and PacTrans & WSDOT Summer High School Transportation Camp at Pullman, WA on July 29.

In addition, CAMMSE has completed 3 more research projects of year 6 (2021-2023) during this reporting period. Those final project reports have already been posted on the CAMMSE’s website and 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. These projects have resulted in valuable findings and advanced models, which will advance both the state of the art and the state of the practice in respective fields.

## Leadership

Center Director Dr. Wei Fan was selected as the Distinguished Scholar in the William States Lee College of Engineering (LCoEN) at UNC Charlotte in April 2023. He also served as an affiliate faculty in the School of Data Science, UNC Charlotte since August 15, 2022. 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*, Handling Editor of *TRR Inaugural Editorial Board*, *Transportation Research Record*, Associate Editor of *Accident Analysis and Prevention*, *ASCE Journal of Transportation Engineering, Part A: Systems*, *Current Trends in Civil & Structural Engineering*, *IEEE Transactions on Intelligent Transportation Systems*, *International Journal of Transportation Science and Technology*, *Transportation Planning and Technology*, *Journal of Nondestructive Evaluation*, *Journal of Transportation Safety and Security*; Editorial Board Member of *Asian Transport Studies*, *International Journal of Transportation Science and Technology*, *Journal of Transportation Research Part D*, *Journal of World Review of Intermodal Transportation Research*, *Transportation Planning and Technology*; 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, American Society of Civil Engineers (ASCE), NCDOT Fully Autonomous Vehicle (FAV) Research Working Group Committee, NCSITE Scholarship Committee, TRB Standing Committees (A0020C, ACP60, AP075, AHB60, AT045, AW010, AW010 (2)(3), AW020, AP025, ADB10, AMS20), World Transport Convention Shared Logistics and Transportation Systems Committee, the Organizing Committee Member for the 23<sup>rd</sup> COTA International Conference of Transportation Professionals, Director of Washington State Transportation Center (TRAC), WSU Site Director for the new Region 10 UTC: Pacific Northwest Transportation Consortium (PacTrans), WSU Site Director for the new Tier 1 UTC: Environmentally Responsible Transportation Center for Communities of Concern (ERTC3), the Lone Star Harbor Safety Committee (LSHSC), Associate Director for ASCE's Young Transportation Members at the ASCE International Conference on Transportation & Development, ASCE Public Transportation Committee, Connecticut Transportation Institute, as well as several proposal and paper review panels/committees (e.g., NCHRP (17-108, 08-157, 17-102)).

## 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 researchers have been meeting on a regular basis. 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 had 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 Control and Operation" course in the Spring 2023 semester and "Discrete Choice Modeling" course in the Fall 2023 semester to several graduate students who were in attendance. He also served as a Committee Member for four Ph.D. candidates. During this reporting period, a total of three students at UNCC have been involved in CAMMSE projects and all of them were directly supported by CAMMSE.

At WSU, Dr. Jie Zhao taught the following undergraduate level course related to transportation: CE 405/505 “Decision-making for sustainable and resilient civil infrastructure” and converted it into online course, there were around 35 students during Spring/Summer 2023 semesters.

At TSU, three undergraduate-level and fourteen graduate-level transportation-related courses were taught by CAMMSE personnel (Drs. Yi Qi, Mehdi Azimi, Fengxiang Qiao, and Ms. Ursula Williams). During the reporting period, five CAMMSE-supported graduate students successfully received their master’s degree in Transportation Planning and Management. Three of them passed their thesis defense based on the research work they have done for the CAMMSE projects. Among all five students, two was male students and three were female students.

At UT Austin, there was one female student involved in CAMMSE projects. Faculty members at UT have integrated CAMMSE research into courses taught.

### **Technology Transfer**

At UNCC, CAMMSE faculty, staff, researchers, and students have been publishing many journal papers and making presentations at different meetings including the 11<sup>th</sup> International Conference on Traffic and Logistic Engineering (ICTLE 2023) at Macau, China on August 25, the 23<sup>rd</sup> COTA International Conference of Transportation Professionals (CICTP 2023) at Beijing University of Technology in Beijing, China on July 16, Chang’an University International Symposium at Chang’an University in Xi’an, China on July 12, the International Conference on Transportation and Development (ICTD) 2023 in Austin, TX on June 16 2023.

At WSU, Dr. Xianming Shi attended the PacTrans & WSDOT Summer High School Transportation Camp at Pullman, WA on July 29, researchers made poster presentations at different meetings including the International Conference on Transportation and Development (ICTD) 2023 at Austin, TX on June 14-17.

TSU CAMMSE team shared the research findings with students, transportation professionals, and the public through published journal or conference papers, presentations, or student thesis works. During the reporting period, TSU published one peer-reviewed journal paper, one conference paper, one technical report and one presentation. In addition, three CAMMSE-sponsored students published their thesis works in the ProQuest.

At UT Austin, there were a total of two active projects sponsoring one PhD student, one principal investigators, and one researcher. One of the best technology transfer tools were the students that work on these CAMMSE research projects. These UT Austin students were 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. 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.

### **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., NC A&T University) in co-writing proposals and/or papers.

At TSU, Dr. Yi Qi and Dr. Mehdi Azimi partnered with several universities to develop new proposals, such as Virginia Polytechnic Institute and State University (Virginia Tech - VT), the University of Nevada Las Vegas (UNLV), the University of Texas Grand Rio Valley (UTGRV), Penn State Altoona, California State University Fresno (Fresno State), University of South Carolina, and Morgan State University. In addition, Dr. Yi Qi, Dr. Mehdi Azimi, and their teams also collaborated with the Argonne National Laboratory, City of Houston, Houston BCycle, Houston METRO, TxDOT, and Texas District of the Institute of Transportation Engineers (ITE) on various research projects.

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, three international graduate students (including Mr. Tianjia Yang, Mr. Chengying Hua, both of them came from P.R.China, and Mr. Mujeeb Abiola Abdulrazaq came from Nigeria) joined the INES Ph.D. program and they have been working as CAMMSE research assistants.

At WSU, two female engineering faculty members and one international Ph.D. student in the Department of Civil & Environmental Engineering contributed to the CAMMSE site activities.

TSU is one of the nation's largest historically black universities, with most students being minority students. TSU CAMMSE supported graduate students with different backgrounds, most of them were African-American students and half were female students.

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 hosts seminars and workshops to provide more learning opportunities to our students. During the reporting period, two seminars and one summer school were organized. In addition, CAMMSE TSU continues to provide research assistantships to students who are interested in developing their careers in the transportation area. During this period, four CAMMSE Sponsored students graduated from our program and successfully placed in transportation industries.

At UT Austin, the research resulted in two paper and poster presented at the ASCE International Conference on Transportation & Development. Attending this conference provides 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.



#### **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. TSU CAMMSE research results were published in one peer-reviewed journal, one conference paper, one technical report, and three student theses. The research results were also disseminated through an invited presentation our students and faculty members gave. 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, a paper was submitted to 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.
- (2) Present papers based on CAMMSE's research on different occasions including the North Carolina Section Institute of Transportation Engineers (NCSITE) Annual Meeting on November 9, 2023, and the TRB 103<sup>rd</sup> Annual Meeting from January 7-11, 2024.
- (3) WSU researchers will continue their activities in journal article submission/revision and presentations where suitable.
- (4) TSU CAMMSE team will finish current active projects. The research findings will be summarized in technical reports and will also be submitted to peer-reviewed journals for publication. In addition, TSU CAMMSE 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 Washington, D.C. for the TRB Annual Meeting. Also, UT Austin CAMMSE participants will submit papers to the CSCE Annual Conference in Canada. 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
<b>Program/Project Role</b>	Center Director	Associate Director at UT Austin	Associate Director at UConn	Associate Director at WSU	Associate Director at TSU
<b>Contribution to Program/Project</b>	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
<b>Funding Support</b>	UNCC	UT Austin	UConn	WSU	TSU
<b>Collaborated with Individual(s) in Foreign Country(ies)</b>	Yes	No	Yes	Yes	Yes
<b>Country(ies) of Foreign Collaborator(s)</b>	P.R.China	No	Australia	P.R.China	P.R.China
<b>Traveled to Foreign Country(ies)</b>	N/A	N/A	N/A	N/A	N/A
<b>If traveled to foreign country(ies), duration of stay</b>	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
Capital Metro – Austin Public Transit	Government /TX		X	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 Transportation Institute	University /CT				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	
North Carolina A&T University	University /NC				X	
North Carolina Department of Transportation	Government /NC		X		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 District of the Institute of Transportation Engineers (ITE)	Non-profit /TX				X	
Texas Southern University	University /TX	X	X	X		
UConn Human Rights Institute	University /CT				X	
University of Connecticut	University /CT	X	X	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		
US DOT National Center for Sustainable Transportation (NCST)	University /CA				X	
U.S. DOT Volpe Center	Government /MA				X	
UT's Center for Transportation Research (UT Austin)	University /TX		X	X		
Verisk Extreme Event Solutions	Company /NJ				X	
Washington Department of Transportation	Government /WA				X	
Washington State University	University /WA	X	X	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](mailto: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](mailto:a-bhasin@mail.utexas.edu)
- Elizabeth Robbins, Planning Policy & Partnerships Manager, Multimodal Planning Division, Washington State Department of Transportation.  
Email: [robbins@wsdot.wa.gov](mailto:robbins@wsdot.wa.gov)
- Neil Mastin, Research and Development Manager, North Carolina Department of Transportation.  
Email: [jmastin@ncdot.gov](mailto:jmastin@ncdot.gov)
- Wade Odell, Research Engineer, Texas Department of Transportation.  
Email: [Wade.Odell@txdot](mailto:Wade.Odell@txdot)

### **2.3. Have other collaborators or contacts been involved?**

Dr. Wei Fan, CAMMSE Director, has been making presentations, working and co-writing papers with faculty and researchers from North Carolina A&T University and North Carolina State University. A collaborative relationship has been successfully developed between these universities. Dr. Fan has been working with other researchers at UNC Charlotte on a research project entitled “Geo-FRIT: A Web-based Geospatial Analytics Tool for Quantifying Freight Risk and Resilience in Transportation”, which was sponsored by NCDOT. Dr. Fan also served as the lead principal investigator on the funded project entitled “Impact of Connected and Automated Vehicles on Work Zones” sponsored by NC-CAV/NCDOT.

TSU CAMMSE faculty members teamed up with professors from different universities to develop new UTC proposals. Collaborators were from the Virginia Polytechnic Institute and State University (Virginia Tech - VT), the University of Nevada Las Vegas (UNLV), the University of Texas Grand Rio Valley (UTGRV), Penn State Altoona, California State University Fresno (Fresno State), University of South Carolina, and Morgan State University, Prairie View A&M University, University of Nebraska-Lincoln, etc.

## 3. OUTPUTS

### 3.1. Journal publications, conference papers, and presentations

#### Journal publications

- [1] Hua, C. and Fan, W., Dynamic Speed Harmonisation for Mixed Traffic Flow on The Freeway Using Deep Reinforcement Learning, Accepted for Publication, *IET Intelligent Transport Systems*, September 2023.
- [2] Liu, S., Fan, W., Jiao, S. and Li, A., The Performance of Connected and Autonomous Vehicles with Trajectory Planning in a Fixed Signal Controlled Intersection, Accepted for Publication, *Promet - Traffic&Transportation*, July 2023.
- [3] Islam, M.M., Newaz, A., Song, L., Lartey, B., Lin, S-C, Fan, W., Hajbabaie, A., Khan, M.A., Partovi, A., Phuapaiboon, T., Homaifar, A., Karimodini, A., Connected Autonomous Vehicles: State of Practice, *Applied Stochastic Models in Business and Industry*, May 2023.
- [4] Omosebi, O., Azimi, M., Olowokere, D., Wanyan, Y., Zhao, Q. and Qi, Y., Investigating Runway Incursion Incidents at United States Airports, Accepted for publication, *Future Transportation*, September 2023.
- [5] Chen, C., Deng, Y., Li, M., and Shi, X., Key Climatic Factors Affecting Asphalt Pavement Roughness Differ in Different Climate Regions, *Transportation Research Part D: Transport and Environment*, in press, September 2023.
- [6] Deng, Y., Zhang, Y., and Shi, X., Feasibility of Determining Asphalt Pavement Condition from Falling Weight Deflectometer Test and Finite Element Model Updating, *Philosophical Transactions of the Royal Society A*, Volume 381, Issue 2254, July 2023.
- [7] Zhao, J., Lee, J. Y., Camenzind, D., Wolcott, M., Lewis, K., and Gillham, O., Multi-Component Resilience Assessment Framework for a Supply Chain System, *Sustainability*, Volume 15, No.7, 6197, April 2023.
- [8] Baumanis, C., Hall, J., Machemehl, R., and Wilkes, N., Perceptions of Bicycle Signal Faces and Associated Compliance: Results of an Online Survey, *Transportation Research Record*, June 2023.

#### Conference papers

- [1] Chen, Z. and Fan, W., Freeway Travel Time Prediction Based on Ensemble Learning Approaches, ASCE International Conference on Transportation and Development (ICTD) 2023, Austin, TX, June 2023.
- [2] Zhang, Y., Alsmadi, I., Qi, Y. and Li, Z., Trust Management and Attribute-based Access Control Framework for Protecting Maritime Cyber Infrastructure, International Conference on Software and Data Technologies (ICSOFT), Rome, Italy, July 2023.
- [3] Ma, F., and Lee, J. Y., An Integrated Framework for Wildfire Evacuation in a Damaged Transportation Network, Proceedings of the 14<sup>th</sup> International Conference on Applications of Statistics and Probability in Civil Engineering (ICASP14), Dublin, Ireland, July 2023.
- [4] Hall, J., Sabillion, C., and Machemehl, R., Equity as a Criterion for Transit Service Reduction During the COVID-19 Pandemic, ASCE International Conference on Transportation and Development (ICTD) 2023, Austin, TX, June 2023.
- [5] Hall, J., Baumanis, C., and Machemehl, R., Causal Analysis of COVID-19 Government Interventions in Reducing Transit Ridership, ASCE International Conference on Transportation and Development (ICTD) 2023, Austin, TX, June 2023.

#### Presentations

- [1] Fan, W., Analyzing Pedestrian Injuries in Pedestrian-Vehicle Crashes using Emerging Hotspots Analysis and XGBoost, Keynote Presentation, The 11th International Conference on Traffic and Logistic Engineering (ICTLE 2023), Macau, China, August 25, 2023.

- [2] Fan, W., Transportation Deep Decarbonization by 2050 in the U.S.: A Synthesis of Strategies and Pathways, Keynote Presentation, The 23rd COTA International Conference of Transportation Professionals (CICTP 2023), Beijing University of Technology, Beijing, China, July 16, 2023.
- [3] Fan, W., Using Emerging Hotspots Analysis and XGBoost to Analyze Pedestrian Injuries in Pedestrian-Vehicle Crashes: A Case Study of North Carolina, Invited Presentation, Chang'an University International Symposium, Chang'an University, Xi'an, China, July 12, 2023.
- [4] Fan, W. and Chen, Z., Freeway Travel Time Prediction Based on Ensemble Learning Approaches, Poster Presentation, ASCE International Conference on Transportation and Development (ICTD) 2023, Austin, TX, June 16, 2023.
- [5] Nazmus, A. and Azimi, M., Quantum Computing and Machine Learning for Optimizing Port Operations: A Path Towards Sustainable Marine Transportation System, 7th Biennial Conference on the Marine Transportation System Innovative Science and Technologies Toward Greater Sustainability, Washington, D.C., June 21, 2023.
- [6] Shi, X., Winter Road Maintenance Research Can Help Lower Salt Usage, PacTrans & WSDOT Summer High School Transportation Camp, Pullman, WA, July 29, 2023.
- [7] Deng, Y., Chen, C., and Shi, X., Prediction of Traffic Mobility Based on Historical Data and Machine Learning Approaches, Poster presentation, ASCE International Conference on Transportation and Development (ICTD) 2023, Austin, TX, June 15, 2023.
- [8] Deng, Y., Chen, C., and Shi, X., Key Climatic Factors Affecting Asphalt Pavement Roughness Differ in Different Climate Regions: Exploratory Analyses, Poster presentation, ASCE International Conference on Transportation and Development (ICTD) 2023, Austin, TX, June 16, 2023.
- [9] Hall, J., Baumanis, C., and Machemehl, R., Causal Analysis of COVID-19 Government Interventions in Reducing Transit Ridership, Poster Presentation, ASCE International Conference on Transportation and Development (ICTD) 2023, Austin, TX, June 14-17, 2023.
- [10] Hall, J., Sabillion, C., and Machemehl, R., Equity as a Criterion for Transit Service Reduction During the COVID-19 Pandemic, Poster Presentation, ASCE International Conference on Transportation and Development (ICTD) 2023, Austin, TX, June 14-17, 2023.

### **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**

Nothing to report.

### **3.5. Other outputs**

#### **CAMMSE Graduate Seminar Series @ UNCC, Sponsored by CAMMSE**

- [1] "Introduction to Proximal Policy Optimization", presented by Mr. Tianjia Yang (CAMMSE INES Ph.D. research assistant), 9-10am, April 5, 2023, EPIC CEE Conference Room 3344.
- [2] "Transit Signal Priority Control with Connected Vehicle Technology: Deep Reinforcement Learning Approach", presented by Mr. Tianjia Yang (CAMMSE INES Ph.D. research assistant), 9-10am, April 19, 2023, remotely via Zoom.
- [3] "Dynamic speed harmonization (DSH) and synergistic performance evaluation in a connected automated vehicle environment", presented by Mr. Chengying Hua (CAMMSE INES Ph.D. research assistant), 9-10am, April 26, 2023, EPIC CEE Conference Room 3344.

- [4] "Transferability of Deep Reinforcement Learning-Based Variable Speed Limit Control", presented by Mr. Chengying Hua (CammSE INES Ph.D. research assistant), 9-10am, May 3, 2023, EPIC CEE Conference Room 3226.
- [5] "Enhancing Robustness of DRL-Based Traffic Signal Controllers in Mixed Traffic Environments through Data Fusion and Multi-Discrete Actions", presented by Mr. Tianjia Yang (CammSE INES Ph.D. research assistant), 9-10am, August 30, 2023, EPIC CEE Conference Room 3344.
- [6] "Surrogate safety measures (SSM) in CAVs safety modeling: What? Why? How?", presented by Mr. Chengying Hua (CammSE INES Ph.D. research assistant), 9-10am, September 6, 2023, EPIC CEE Conference Room 3344.
- [7] "Decentralized Signal Control for Multi-Modal Traffic Network: A Deep Reinforcement Learning Approach", presented by Mr. Tianjia Yang (CammSE INES Ph.D. research assistant), 9-10am, September 13, 2023, EPIC CEE Conference Room 3344.
- [8] "Extended Variable Speed Limit control using Multi-agent Reinforcement Learning", presented by Mr. Chengying Hua (CammSE INES Ph.D. research assistant), 9-10am, September 20, 2023, EPIC CEE Conference Room 3344.
- [9] "Mastering Arterial Traffic Signal Control with Multi-Agent Attention-Based Soft Actor-Critic Model", presented by Mr. Tianjia Yang (CammSE INES Ph.D. research assistant), 9-10am, September 27, 2023, EPIC CEE Conference Room 3344.

#### **ITE Seminar Series @ TSU, Co-organized and sponsored by TSU ITE Student Chapter and CammSE**

- [1] "Houston Ship Channel Project Expansion", lectured By Leia Wilson and Amanda Hamrick, Ship Channel Operation Manager and Channel Development Project Manager, Port Houston, April 27, 2023.
- [2] Training Session - Invited an instructor from the industry to present PTV VISTRO training for the members, April 21, 2023.

#### **Summer Maritime Academy (SMA) @ TSU, Co-organized and sponsored by TSU Department of Transportation Studies and CammSE, June 20-22, 2023.**

Summer Maritime Academy (SMA) is a one-week non-residential program designed to introduce high school students to the maritime industry. The program also introduces students to the Maritime Transportation Management and Security degree program and scholarship opportunities at TSU. During the week, the topics of logistics, security, and the environment (vehicle emissions) were covered and students enjoyed field trips to the Port of Houston Authority and the U.S. Coast Guard facility. U.S. Customs and Border Protection Agency officials also visited with students and demonstrated cargo screening techniques to detect contraband items in cargo. Students also learned transferable skills through sessions on Leadership, Dealing with Change, and Effective Communication Strategies.

#### **Young Transportation Member Workshop Presentation @ UT Austin, Sponsored by CammSE**

- [1] Hall, J., Bagabaldo, A., Liu, C., Shi, H., Pu, C., Ricord, S., Ma, S., and Wang, Y., Research Highlights for PhD Students in AI., Young Transportation Member Workshop Presentation, ASCE International Conference on Transportation and Development (ICTD) 2023, Austin, TX, June 14, 2023.

#### **Interviews & Media Events/Mentions**

- [1] Dr. Wei Fan was interviewed by a "Banking, Finance, Tech, Startups, and Entrepreneurship Reporter" Staff Writer Ms. Symone Graham from Charlotte Business Journal on Self-Driving Vehicles, August 23, 2023. [UNC Charlotte researchers talk pros, cons of self-driving vehicles as Cruise hits local streets](#)

#### **Technical Reports**

- [1] Das, S., Tsapakis, I., Khan, M.N., Liu, J., Mills, D., Miller, M., Balke, K., Wu, J., Azimi, M., and Qi, Y., *Leveraging Artificial Intelligence (AI) Techniques to Detect, Forecast, and Manage Freeway Congestion*, Technical Report No. FHWA/TX-23/0-7131-R1, Texas Department of Transportation (TxDOT), September 2023.

- [2] Li, T. and Machemehl, R., *Developing Robust Smart Traffic Signal Control*, Technical Report for CAMMSE Research 2022 Project 07, U.S. Department of Transportation, September 2023.
- [3] Mantri, S., Lownes, N., and Bergman, D., *Prioritizing People-Mixed Equilibrium Assignment for AV Based on Occupancy (Phase II)*, Technical Report for CAMMSE Research 2022 Project 08, U.S. Department of Transportation, September 2023.
- [4] Lownes, N., Rezwana, S., Shaon, R., Razaur, M., and Jackson, E., *Pedestrian Behavior and Interaction with Autonomous Vehicles (Phase II)*, Technical Report for CAMMSE Research 2022 Project 09, U.S. Department of Transportation, September 2023.



## 4. OUTCOMES

### 4.1. Increased understanding and awareness of transportation issues

TSU's research project, "Investigate Age Impacts on Controlled Flight into Terrain (CFIT) Crashes in General Aviation", regarding pilot-related factors on Controlled Flight into Terrain (CFIT) crash, yielded significant findings. CFIT crashes are more likely to result in irreversible damage to the aircraft leading to a higher likelihood of serious, and fatal injuries. Accidents from the sample size show higher percentages of Private Pilots Licenses and Commercial Pilot Licenses operating under Visual Flight Rules. CFIT accidents historically have a higher percentage rate of occurring by pilots unintentionally transitioning from Visual Flight Rules to Instrument Flight Rules and during high task-saturated phases of flight. There were significant findings from pilots' descriptive information that the accidents were caused by pilots over 50 years of age and holding a 3<sup>rd</sup> Class Medical.

TSU's research project, "Investigating the Impact of COVID-19 Pandemic Outbreak on Bike Share Usage and Ridership", studied bike-share systems and can provide a wealth of data and insights to raise awareness of transportation issues, promote sustainable transportation alternatives, inform policy decisions, and ultimately contribute to more efficient, equitable, and environmentally friendly transportation systems. The study on bike-share systems during a pandemic particularly provides valuable insights into transportation issues during times of crisis increases awareness of the importance of adaptable and sustainable transportation options and informs policies and investments that enhance transportation resilience and equity.

The outcomes of UT Austin research studies contribute to an increased understanding and awareness of transportation issues related to public transit systems and e-scooters. By examining the impact of reduced and canceled bus routes on essential workers, the research shed light on equity issues within public transit systems. The e-scooter project highlights the issue of e-scooter injuries, specifically focusing on incidents occurring along roadways leading to multiple abrasions or head injuries. This emphasizes the safety concerns associated with e-scooter usage, particularly in densely populated urban areas where e-scooters are commonly used.

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

Nothing to report.

### 4.3. Increases in the body of knowledge

In TSU's research project "Investigating the Impact of COVID-19 Pandemic Outbreak on Bike Share Usage and Ridership", the analysis uncovered compelling insights into bike trips in Houston during 2020. Notably, there was a remarkable 30.6% surge in the total number of bike trips compared to the preceding year. The COVID-19 pandemic left a pronounced imprint on the duration and timing of these trips, as we observed a prevalence of longer journeys in 2020 while mid-duration trips became less frequent. Remarkably, total trip durations escalated by a substantial 73.52% during that year. Furthermore, travel patterns underwent a transformation during the pandemic, with a notable shift towards off-peak hours and a decline in morning and evening peak-period travel. While the number of member trips held steady throughout the pandemic, there was a substantial uptick in non-member trips during 2020. Also, it was evident that rainy days correlated with a substantial reduction in bike-share ridership.

In TSU's research project "Countermeasures for Maintaining Safe and Effective Public Transit Service in the Post-COVID-19 Era", the TSU CAMMSE team develops a model to quantitatively evaluate the infection risk of COVID by riding public transit. Model results show that face masking, social distancing, and vaccination can all reduce the infection risk for passengers. It also indicates that face masking can

significantly reduce the infection risk and is more effective than the current vaccination. To add the practical value of this research, interviews with a lead transit planner and a bus operator at Houston Metro were also conducted. Both interviewees also highlighted the importance of wearing masks on buses.

The UT Austin research studies contribute to the body of knowledge in transportation by introducing advanced analytical methods, exploring micro-mobility safety issues, highlighting equity concerns in public transit, and emphasizing the impact of government policies on transit ridership. These contributions expand the toolkit of methodologies and deepen our understanding of the multifaceted challenges and solutions in the realm of urban transportation. This knowledge is valuable for urban planners/transportation engineers, policymakers, and researchers working on sustainable transportation solutions. UT Austin used causal mediation analyses to investigate the causal relationship between 1) geofencing technologies (specifically parking restriction geofences) and reduced e-scooter injuries and 2) government interventions on public transportation ridership. This methodology provides an analytical framework for studying the impact of specific interventions in transportation safety.

#### **4.4. Improvement of existing techniques, practices, technologies**

In TSU's research project "Countermeasures for Maintaining Safe and Effective Public Transit Service in the Post-COVID-19 Era", a new model was developed to quantitatively evaluate the infection risk of COVID by riding public transit. Since the developed model considers various factors that affect the infection risk, including social distance, ventilation rate, air distribution effectiveness, masking, vaccination, and exposure time, it can be used for assessing the effectiveness of different countermeasures and operational strategies that aim at reducing the COVID-19 infection risk of riding public transit.

In prior research, various factors affecting bike-sharing ridership have been explored. Some studies have employed surveys to gather insights into user behavior, while others have conducted observations and experiments in specific locales. However, these approaches often fell short of providing a comprehensive view of bike-sharing activities across an entire system. In Project 12 (Investigating the Impact of COVID-19 Pandemic Outbreak on Bike Share Usage and Ridership), we adopted a Negative Binomial regression model to discern the specific influence of the COVID-19 pandemic on the average daily ridership of a bike-sharing system. The motivation behind this research stemmed from a recognized gap in our understanding: there was a notable lack of comprehensive knowledge regarding how the COVID-19 pandemic affected the utilization of the Houston bike-share system.

#### **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?**

TSU's research project, "Countermeasures for Maintaining Safe and Effective Public Transit Service in the Post-COVID-19 Era", developed a model that can be used for assessing the effectiveness of different countermeasures and operational strategies that aim at reducing the COVID-19 infection risk of riding public transit. Thus, it will help public transit agencies maintain safe and effective public transit services during the post-COVID-19 era.

The research conducted at UT Austin suggests that implementing parking restriction geofences can enhance e-scooter safety, but reductions and cancellations of bus routes during emergencies can negatively affect equity in public transit. Additionally, state-level policy changes have a direct impact on public transit ridership, highlighting the importance of government interventions in shaping transportation system effectiveness.

### **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?**

The results of TSU's research project, "Investigate Age Impacts on Controlled Flight into Terrain (CFIT) Crashes in General Aviation", will help determine higher risk factors in general aviation and develop new policies and practices for improving the flight instructors' training and bi-annual flight reviews.

The research 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?**

UNCC organized several transportation seminars which provided students opportunities to communicate with professors and industry experts. What they have learned through these seminars could be of great value for their future works as transportation professionals. In addition, CAMMSE funding provided research assistantships. By participating CAMMSE research, students gained hands-on experience.

At TSU, CAMMSE offers research assistantships to students. By participating in CAMMSE research projects and being mentored by CAMMSE faculty members, students learned first-hand technologies and new methods on how to analyze transportation-related problems. What they learned from their research project will help them in their future work. In addition, CAMMSE sponsored workshop or seminar provides great opportunities for students to communicate with experts from both industry and academia. It will help them build their future careers.

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

Nothing to report.

### 6.3. Changes that have a significant impact on expenditures

CAMMSE's work has been significantly impacted by COVID-19, which set several projects back. At UNC Charlotte, we have significant delays in two projects 2022 Project 16 "Dynamic Coordinated Speed Control and Synergistic Performance Evaluation in Connected and Automated Vehicle Environment" and 2022 Project 17 "Transit Signal Priority Control with Connected Vehicle Technology: Deep Reinforcement Learning Approach". We are currently developing advanced algorithms, conducting simulations, and working on developing publications once the results have been finalized.

At TSU, we have had three projects that were impacted: 1. For Project 12 "Investigating the Impact of COVID-19 Pandemic Outbreak on Bike Share Usage and Ridership: A Case Study in Houston", we had a delay in receiving the required data from the Houston BCycle and a delay in communication due to the change in the staff and organization of this bikeshare program; 2. For Project 13 "Countermeasures for Maintaining Safe and Effective Public Transit Service in the Post-COVID-19 Era", the key investigator Ms. Qun Zhao had been on maternity leave since May 9, 2023, which affected the development of a final report; 3. For Project 14 "Investigate Age Impacts on Controlled Flight into Terrain (CFIT) Crashes in General Aviation", several personal matters occurred that significantly impacted its research progress.

At UT Austin, we have the following projects underway: 1. 2022 Project 05. Impacts of Speed on Dockless Electric Scooter Crashes (Phase II); and 2. 2022 Project 06. Optimizing Type and Location of Pedestrian Crossing Signs at Non-signalized Intersections (Phase II). COVID-19 was a significant factor in the sense that people were not using scooters very much since classes were remote for a long time, therefore we didn't have any injury data to review from the pandemic. We had to wait until activity came back to normal in order to get some data. We are still conducting analysis for these two projects, and will work on developing publications once the results have been finalized.

### 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

Nothing to report.

### 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
<b>University of North Carolina at Charlotte</b>	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
<b>University of Texas at Austin</b>	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
<b>University of Connecticut</b>	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
<b>Washington State University</b>	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
<b>Texas Southern University</b>	Yi Qi Mehdi Azimi Qun Zhao	Applied Research	Determination of Freeway Acceleration Lane Length for Smooth and 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
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CAMMSE @ UNC Charlotte Funded Projects, 2018-2020 (Year 3), All Completed

University	Principle Investigator(s)	Category	Title of the Funded Project
<b>University of North Carolina at Charlotte</b>	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
<b>University of Texas at Austin</b>	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)
<b>University of Connecticut</b>	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
<b>Washington State University</b>	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
<b>Texas Southern University</b>	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
<b>University of North Carolina at Charlotte</b>	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
<b>University of Texas at Austin</b>	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)
<b>University of Connecticut</b>	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
<b>Washington State University</b>	Xianming Shi	Applied Research	Multimodal Connected Vehicle Pilot for Winter Travel
<b>Texas Southern University</b>	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

<b>University</b>	<b>Principle Investigator(s)</b>	<b>Category</b>	<b>Title of the Funded Project</b>
<b>University of Texas at Austin</b>	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
<b>University of Connecticut</b>	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
<b>Washington State University</b>	Ji Yun Lee	Advanced Research	Effect of Connected and Autonomous Vehicles on Supply Chain Performance
<b>Texas Southern University</b>	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
<b>University of North Carolina at Charlotte</b>	Wei Fan	Applied Research	Evaluating and Comparing the Impact of Connected and Autonomous Vehicles on Conventional Intersections and Superstreets (completed)
	Wei Fan	Advanced Research	Real-Time Freeway Speed Prediction Based on Deep Learning in Connected and Autonomous Vehicles Environment (completed)
	Wei Fan	Advanced Research	Online Cooperative Lane-changing Model of Connected and Autonomous Vehicles (completed)
	Wei Fan	Applied Research	Impact of Connected and Autonomous Vehicles on Signalized Intersections with Transit Signal Priority (completed)
	Wei Fan	Advanced Research	Dynamic Coordinated Speed Control and Synergistic Performance Evaluation in Connected and Automated Vehicle Environment (ongoing)
	Wei Fan	Advanced Research	Transit Signal Priority Control with Connected Vehicle Technology: Deep Reinforcement Learning Approach (ongoing)
<b>University of Texas at Austin</b>	Randy Machemehl	Applied Research	Impacts of Speed on Dockless Electric Scooter Crashes (Phase II) (ongoing)
	Randy Machemehl	Applied Research	Optimizing Type and Location of Pedestrian Crossing Signs at Non-signalized Intersections (Phase II) (ongoing)
	Randy Machemehl	Applied Research	Developing Robust Smart Traffic Signal Control (completed)
<b>University of Connecticut</b>	Nicholas Lownes	Advanced Research	Prioritizing People - Mixed Equilibrium Assignment for AV Based on Occupancy (Phase II) (completed)
	Nicholas Lownes	Advanced Research	Pedestrian Behavior and Interaction with Autonomous Vehicles (Phase II) (completed)
	Jin Zhu	Applied Research	Disaster Resilience through Diverse Evacuation and Emergency Transportation Systems (Phase II) (completed)
	John Ivan Amy Burnicki	Applied Research	Estimation of Pedestrian Compliance at Signalized Intersections Considering Demographic and Geographic Factors (Phase II) (completed)
<b>Washington State University</b>	Xianming Shi	Applied Research	Prediction of Traffic Mobility Based on Historical Data and Machine Learning Approaches (completed)
<b>Texas Southern University</b>	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 (ongoing)

	Yi Qi Mehdi Azimi Qun Zhao	Applied Research	Countermeasures for Maintaining Safe and Effective Public Transit Service in the Post-COVID-19 Era (ongoing)
	Yi Qi Qun Zhao Mehdi Azimi	Applied Research	Investigate Age Impacts on Controlled Flight into Terrain (CFIT) Crashes in General Aviation (ongoing)



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