Center for Advanced Multimodal Mobility Solutions and Education

USDOT Tier 1 University Transportation Center
Semi-Annual Progress Report #9

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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

As initially planned, the CAMMSE Call for Research Proposals for Year 6 (2021-2023) was developed and officially sent out to all CAMMSE Assistant Directors and researchers internally at UNC Charlotte and Associate Directors at all other member universities on May 31, 2021. The submission deadline for all project proposals was July 9, 2021, at 4:00 pm. Research proposals that were received and rigorous peer-reviews were then conducted. After examining the proposal evaluation comments and review ratings of all proposals, the CAMMSE Research Program Leadership Committee selected 15 of them for funding. The decision letters were sent to all PIs by August 20, 2021. The appendix contains the list of the funded projects (in Year 6) with respect to each member university. For all research projects that were selected for funding, the subcontracting process is currently ongoing. Relevant CAMMSE Project Information Forms have been posted on the CAMMSE website as well as on RiP as required by OST-R. All funded projects in the sixth year (i.e., in the year of 2021-2023) are expected to be completed within two years.

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 *Analytic Methods in Accident Research*, *ASCE Journal of Cold Regions Engineering, Future Transportation, Gases, International Journal of Engineering Science Invention (IJESI), International Journal of Environmental Research and Public Health, IEEE Transactions on Intelligent Transportation Systems*, *International*

Journal of Transportation Science and Technology, *Journal of Transportation Engineering, Part A: Systems, Journal of Transportation Safety & Security, Promet – Traffic & Transportation, Smart and Resilient Transportation, Sustainability, Traffic Injury Prevention, Transportation Planning and Technology, 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 NC Transportation Center of Excellence on Connected and Autonomous Vehicle Technology (NC-CAV) Seminar Series that was held at North Carolina A&T University, Graduate Research Symposium in the Department of Civil and Environmental Engineering at UNC Charlotte, Keynote Presentation for the 2021 Salt Symposium, TRB Resource Conservation and Recovery Committee (AMS20) Summer Workshop, Region 10 University Transportation Center PacTrans, Bridging Transportation Researchers (BTR) #3 Conference, and CAMMSE Graduate Seminar Series at UNC Charlotte.

In addition, CAMMSE has completed all 16 research projects of year 4 (2019-2021) during this reporting period. All final project reports of year 4 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

Representing the CAMMSE, Center Director Dr. Wei Fan used his expertise to serve on a National Science Foundation (NSF) Review Panel in June 2021. 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., Founding Editor-in-Chief *of Journal of Infrastructure Preservation and Resilience;* Handling Editor of *TRR Inaugural Editorial Board, Transportation Research Record;* Associate Editors of the *Accident Analysis and Prevention, ASCE Journal of Transportation Engineering, Part A: Systems*, *IEEE Transactions on Intelligent Transportation Systems*, *International Journal of Transportation Science and Technology;* Editorial boards of the *International Journal of Transportation Science and Technology* and *Journal of World Review of Intermodal Transportation Research,* and many professional committees (e.g., Co-Chair of World Transport Convention Connected and Autonomous Vehicles Section, and member of the ASCE Artificial Intelligence Committee, ASCE Connected & Autonomous Vehicles Impacts Committee, ASCE Public Transport Committee, ASCE Rail Transportation Committees, NCDOT Fully Autonomous Vehicle (FAV) Research Working Group Committee, NCSITE Scholarship Committee, PENC State Board, TRB Standing Committees (A0020C, ACP60, AP075, AHB60), World Transport Convention Shared Logistics and Transportation Systems Committee; Secretary of TRB Standing Committees (AP075); and Academic Outreach and Membership Officer of Chinese Overseas Transportation Association (COTA)), as well as several proposal and paper review committees (e.g., Luxembourg National Research Fund (LNR), Independent Research Fund Denmark, other USDOT Tier 1 UTCs, and TRB 101st 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 remotely. 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. CAMMSE'S Transportation Engineering Summer Camp

was successfully held in the week of June 14-18, 2021 on the campus of UNCC, led by Dr. Martin Kane with help from Dr. Erika Weber and Linda Hargrove from the Department of Civil and Environmental Engineering. As a result of the COVID-19 pandemic, the campers' activities were limited in size and restricted to on-campus, socially distanced activities. There were five remote [Zoom] sessions throughout the week from Charlotte Area Transit System (CATS), Charlotte-Douglas Airport, Dr. Mei Sun, Michigan State University, and the City of Austin, Texas. We rotated between in-classroom activities and outside activities on the UNC Charlotte campus. All of the campers were engaged every day, especially when we went to see the differences in the bridges and the traffic observations. There were 19 campers enrolled [limit of 20] and all of the campers were curious and asked many questions about transportations. 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 2021 semester and the "Transportation Systems Analysis" course in the Fall 2021 semester to several graduate students who were in attendance. A total of six students have been involved in CAMMSE projects and all of them were directly supported by CAMMSE during this reporting period. During this reporting period, Shaojie Liu won the Third Place Award in the 2021 Graduate Research Symposium that was held by the Department of Civil and Environmental Engineering at UNC Charlotte on April 9, 2021. Li Song and Shaojie Liu were selected by the North Carolina Section of the Institute of Transportation Engineers (NCSITE) in May 2021 to receive the prestigious Don Blackburn Memorial Scholarship and the Roy D. Williams Memorial Scholarship, respectively in November, 2021. Besides, Dr. Kane organized the CLT Airport Webinar Presentations on April 22, 2021.

At WSU, one female engineering PhD student and one female undergraduate non-engineering student in the Department of Civil & Environmental Engineering at WSU have contributed to research activities. Olivia Rose Willis won the Emeritus Society Award for Excellence in Undergraduate Research and Scholarship for the Social, Economic and Behavioral Sciences, and the 2020-2021 Auvil Scholars Fellowship. Chuang Chen was awarded the Alfred Suksdorf Fellowship in the Voiland College of Engineering and Architecture at WSU. Yan Zhang won the University Transportation Center (UTC) Student of the Year award by the U.S. Department of Transportation.

At TSU, seven undergraduate-level and ten graduate-level transportation-related courses were taught by CAMMSE personnel (Drs. Yi Qi, Mehdi Azimi, Lei Yu, and Ms. Ursurla Williams). During this reporting period, there were a total of eight graduate students participated in and supported by CAMMSE research projects, including three male students and five female students. Two graduate students Jinli Liu and Mohammed Rahman graduated with a thesis directly supported by CAMMSE. Jinli's thesis title was "Severity analysis of the severity of large truck crashes - comparison between the regression modeling methods with machine learning methods". And Mohammed's thesis title was "Vessel-to-Rail intermodal connectivity analysis for the port of Houston".

At UT Austin, there were a total of four students involved in CAMMSE projects, including both female and male students.

Technology Transfer

CAMMSE faculty, staff, researchers, and students have been publishing many journal papers and making presentations at different meetings including the Department of Civil and Environmental Engineering Graduate Research Symposium at UNC Charlotte on April 9, 2021, NC Transportation Center of Excellence on Connected and Autonomous Vehicle Technology (NC-CAV) Seminar Series at North Carolina A&T University on May 28, 2021, and the Bridging Transportation Researchers (BTR) #3 Conference on August 3, 2021.

At WSU, Dr. Xianming Shi did several online presentations including the 2021 Salt Symposium on August 4, 2021, and the Region 10 University Transportation Center PacTrans on April 27, 2021.

At TSU, research findings discovered by the CAMMSE team were shared with students, transportation professionals, and the general public through published journal papers and technical reports. During the reporting period, TSU published six peer-reviewed journal papers and three technical reports.

At UT Austin, there are a total of four active projects sponsoring one master's student, three PhD students, 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, 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., NCA&T and NC State University) in co-writing proposals and/or papers. Dr. Kane also collaborated with CATS, Charlotte-Douglas Airport, City of Austin, City of Columbus, and Michigan State University for CAMMSE'S Transportation Engineering Summer Camp.

At WSU, during this reporting period, Dr. Xianming Shi continued to collaborate with Dr. Kakan Dey at West Virginia University to work on the CAMMSE 2020 Project 16. "Multimodal Connected Vehicle Pilot for Winter Travel". In addition, the research team led by Dr. Ji Yun Lee at WSU discussed the development of a hypothetical potato supply chain system with Washington State Potato Commission, including Chris Voigt (Executive Director), Matt Harris (Director of Government Affairs & Assistant Executive Director), and Matthew Blua (Director of Industry Outreach).

At TSU, Dr. Yi Qi and Dr. Mehdi Azimi collaborated with Texas A&M Transportation Institute and University of Houston to develop three proposals that were submitted to TxDOT and FHWA. By collaborating with Texas A&M Transportation Institute, they received a new research grant "Leveraging Artificial Intelligence (AI) Techniques to Detect, Forecast, and Manage Freeway Congestion" from TxDOT as CO-PI. During the reporting period, Dr. Lei Yu received a new research grant "Synthesis of Best Application and Verification Practices for Long-Life Pavement Markings" from TxDOT as CO-PI and he will continue to work closely with TxDOT. TSU officially signed an affiliation agreement with The International Association of Maritime and Port Executives (IAMPE). The IAMPE program is to advance the development of maritime and port education for professionals and students through a certification program (Educational Management Development of Port, Terminal, and Maritime).

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. One of the UT-Austin principal investigators has internally collaborated with Professor Wang of the ECE department at UT Austin on the Skeleton-Graph project.

UConn has collaborated with the CT Transit and Connecticut Department of Transportation.

Diversity

Several Ph.D. students from underrepresented groups have been hired to conduct CAMMSE's research during this reporting period. For example, at UNCC, six international graduate students (including Mr. Bo Qiu, Mr. Shaojie Liu, Mr. Li Song, Mr. Tianjia Yang, Mr. Chengying Hua, and Ms. Yang Zhao, all of whom came from P.R.China) joined the INES Ph.D. program and they have been working as CAMMSE research assistants. A master student, Mr. Kiavash Riahipour, from Iran, is currently being advised by Dr. Wei Fan to conduct his thesis research.

At WSU, two female engineers, Dr. Ji Yun Lee and one female PhD student she is advising, are involved in a CAMMSE sponsored research project. Furthermore, one female Outreach Coordinator (Cheryl A. Reed, WSU) is actively involved in getting the CAMMSE 2019 Project 15 findings published, which also involved one female undergraduate student (Olivia Willis)."

At TSU, most students supported by CAMMSE fund are minority students. During the reporting period, TSU CAMMSE supported eight graduate students with different backgrounds, such as female students and African American students.

At UT Austin, the CAMMSE funds have supported several undergraduate and graduate students from various countries including Egypt, India and China. These funds have also supported both male and female students.

The UConn School of Engineering announced the creation of the Vergnano Institute for Inclusion, an endowed Institute funded by a generous gift from two UConn alumni, that will drive increased diversity, equity, and inclusion (DEI) within the engineering field by providing underrepresented students with access to scholarships, coaching and mentorship opportunities, training, and other critical career development resources within the school.

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 WSU, the four presentations that were made by Dr. Shi (as mentioned earlier) provided some professional development for the audience. In addition, the research activities at WSU have been performed as part of one PhD student's dissertation research.

At TSU, CAMMSE funding provided research assistantships to students and gave them opportunities to participate in CAMMSE research projects and work closely with faculty members. The professional training they received will help their career development in the future. During the reporting period, TSU CAMMSE continued to host transportation webinar series. On August 11, 2021, Ms. Qun presented her research of "Countermeasures for Post-COVID Public Transit Service Recovering".

At UT Austin, during this reporting period, CAMMSE students from UT Austin submitted papers to the TRB Annual Meeting. Attending this conference will provide 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. 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 50 students each spring semester and he discusses all the CAMMSE research efforts during his lectures. Most of these students (about 85 percent) graduated in May 2021 becoming new engineers who bring with them the results of the CAMMSE research projects.

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. At TSU, CAMMSE research results were published in peer-reviewed journals and technical reports. 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, two papers were accepted to the 101st Transportation Research Board meeting in January 2022. Results have also been published in the Journal of Computer Science. Manuscripts have been published in Transportation Research Part C and Transportation Research Part E. The results of the Skeleton-Graph project have been published at the 2021 International Conference on Computer Vision (ICCV).

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) Present papers based on CAMMSE's research on different occasions including the North Carolina Department of Transportation Research & Innovation Summit from October 5-6, 2021. North Carolina Section Institute of Transportation Engineers (NCSITE) Annual Meeting on November 18, 2021, and the TRB 101th Annual Meeting from January 9-13, 2022.
  (2) The Fourth Annual CAMMSE Virtual Research Symposium will be held from November 4-5, 2021.
  (3) Despite the constraints posed by COVID-19, all CAMMSE partner institutions will take on the challenges and continue working hard to resolve all relevant issues.
  (4) In particular, UT Austin participants will present papers at the TRB Annual Meeting and Conference for presentation and publication. WSU researchers will continue their activities in journal article submission/revision and presentations when suitable, while making progress on addressing other CAMMSE objectives. One journal paper regarding the effect of CAVs on supply chain performance will be submitted to *Transportation Research Part C: Emerging Technologies* by the end of October. Dr. Ji Yun Lee and her PhD student will present the research results at the 2021 CAMMSE Research Symposium.

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
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 Department of Transportation	Government /CT				X	
CT Transit	Transit Operator				X	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	
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	
Oregon State University	University/OR				X	
PacTrans	UTC/WA				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		
University of Houston	University /TX				X	
University of Connecticut	University /CT	X	X	X		
University of North Carolina at Charlotte	University /NC	X	X	X		
University of Queensland				X		
University of Texas at Austin	University /TX	X	X	X		
UT's Center for Transportation Research (UT Austin)	University /TX		X	X		

University of Washington	University /WA				X	
Washington Department of Transportation	Government /WA				X	
Washington State University	University /WA	X	X	X		
West Virginia University (WSU)	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 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.

At WSU, the research team had a meeting with Washington State Potato Commission, including Chris Voigt (Executive Director), Matt Harris (Director of Government Affairs & Assistant Executive Director), and Matthew Blua (Director of Industry Outreach) to get data and seek their advice in developing a hypothetical potato supply chain system.

TSU CAMMSE teamed up with the University of Houston and Texas A&M Transportation Institute to develop several new proposals.

At UT Austin, CAMMSE researchers collaborated with Professor Want who is a faculty member of ECE at UT Austin, and Warren Vu who is with the University of Washington.

3. OUTPUTS

3.1. Journal publications, conference papers, and presentations

Journal publications

[1] Chen, Z. and Fan, W., A Freeway Travel Time Prediction Method Based on an XGBoost Model, *Sustainability*, Volume 13, Issue 15, pp. 8577: 1-15, July 2021.

[2] Liu, S., Lin, Z. and Fan, W., Investigating Contributing Factors to Injury Severity Levels in Crashes Involving Pedestrians and Cyclists Using Latent Class Clustering Analysis and Mixed Logit Models, *Journal of Transportation Safety & Security*, pp.1-28, July 2021.

[3] Song, L., Fan, W. and Li, Y., Time-of-day Variations and the Temporal Instability of Multi-vehicle Crash Injury Severities under the Influence of Alcohol or Drugs after the Great Recession, *Analytic Methods in Accident Research*, Volume 32, pp. 100183: 1-17, December 2021.

[4] Qiu, B. and Fan, W., Machine Learning Based Short-Term Travel Time Prediction: Numerical Results and Comparative Analyses, *Sustainability*, Volume 13, Issue 13, pp. 7454: 1-19, July 2021.

[5] Qiu, B. and Fan, W., Travel Time Forecasting on a Freeway Corridor: a Dynamic Information Fusion Model based on the Random Forests Approach, Accepted for Publication, *Smart and Resilient Transportation*, June 2021.

[6] Li, Y. and Fan, W., Bi-Level Optimization of Long-Term Highway Work Zone Scheduling Considering Elastic Demand, Accepted for Publication, *Smart and Resilient Transportation*, June 2021.

[7] Song, L., Li, Y., Fan, W. and Liu, P., Mixed Logit Approach to Analyzing Pedestrian Injury Severity in Pedestrian-Vehicle Crashes in North Carolina: Considering Time-of-day and Day-of-week, *Traffic Injury Prevention*, Volume 22, Issue 7, pp. 524-529, July 2021.

[8] Qiu, B. and Fan, W., Mixed Logit Models for Examining Pedestrian Injury Severities at Intersection and Non-Intersection Locations, *Journal of Transportation Safety & Security*, pp.1-25, June 2021.

[9] Liu, P. and Fan, W., Extreme Gradient Boosting (XGBoost) Model for Vehicle Trajectory Prediction in Connected and Autonomous Vehicle Environment, *Promet - Traffic&Transportation*, Vol. 33, No. 5, pp. 767-774, 2021.

[10] Song, L., Fan, W. and Liu, P., Exploring the Effects of Connected and Automated Vehicles at Fixed and Actuated Signalized Intersections with Different Market Penetration Rates, *Transportation Planning and Technology*, Volume 44, Issue 6, pp. 577-593, June 2021.

[11] Liu, S. and Fan, W., Investigating Operational Performance of Connected and Autonomous Vehicles on Signalized Superstreets, *Transportation Planning and Technology*, Volume 44, Issue 6, pp. 594-607, June 2021.

[12] Azimi, M., Oyelade, I., Aremu, A. M., Balal, E., Cheu, R. L., and Qi, Y., Selection and Implementation of Intelligent Transportation Systems for Work Zone Construction Projects, *Future Transportation*, Volume 1, Issue 2, pp. 169-187, July 2021.

[13] Du, J., Qiao, F., Yu, L., and Lv, Y., Impact of Managed Lane Pricing Strategies on Vehicle-Sourced NOx and HC Emissions, *Gases*, Volume 1, Issue 2, pp. 117-132, June 2021.

[14] Du, J., Qiao, F., Wang, H., Zhang, Y., and Yu, L., Frequent Pattern Analysis of the Roadside Safety Devices Related On-road Crashes, *International Journal of Engineering Science Invention (IJESI)*, Volume 10, Issue 5, Series I, pp. 35-46, May 2021.

[15] Wang, X., Song, G., Zhai, Z., Wu, Y., Yin, H., and Yu, L., Effects of Vehicle Load on Emissions of Heavy-Duty Diesel Trucks: A Study Based on Real-World Data, *International Journal of Environmental Research and Public Health*, Volume 18, Issue 8, pp. 3877: 1-17, April 2021

[16] Qu, W., Liu, S., Zhao, Q., and Qi, Y., Development of a Progression-Based, Signal-Timing Strategy for Continuous Flow Intersections, *Journal of Transportation Engineering, Part A: Systems*, Volume 147, Issue 3. pp. 04021002: 1-11, April 2021.

[17] Meng, D., Song, G., Wu, Y., Zhai, Z., Yu, L., & Zhang, J., Modification of Newell's car-following model incorporating multidimensional stochastic parameters for emission estimation, *Journal of Transportation Research Part D*, Volume 91, pp. 102692: 1-20, April 2021.

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[20] He, Y., Akin, M., Yang, Q., and Shi, X., Conceptualizing How Agencies Could Leverage Weather-related Connected Vehicle Application to Enhance Winter Road Services, *ASCE Journal of Cold Regions Engineering*, Volume 35 Issue 3, pp. 04021011: 1-13, September 2021.

Conference papers
Nothing to report.

Presentations
[1] Fan, W., Mitigating Freeway Congestion at Bottlenecks through Variable Speed Limit Control in Connected Autonomous Vehicle Environment, NC Transportation Center of Excellence on Connected and Autonomous Vehicle Technology (NC-CAV) Seminar Series, North Carolina A&T University, Greensboro, NC, May 28, 2021.

[2] Song, L. and Fan, W., Impacts of CAVs on Transfer-Based DQN Controlled Signal Intersections, Department of Civil and Environmental Engineering Graduate Research Symposium, UNC Charlotte, April 9, 2021.

[3] Liu, S. and Fan, W., The Impact of Connected and Autonomous Vehicles on the Performance of Superstreets, Department of Civil and Environmental Engineering Graduate Research Symposium, UNC Charlotte, April 9, 2021.

[4] Qiu, B. and Fan, W., Travel Time Prediction on a Freeway Corridor: a Dynamic Information Fusion Model based on the Machine Learning Approach, Department of Civil and Environmental Engineering Graduate Research Symposium, UNC Charlotte, April 9, 2021.

[5] Joshi, P., Ivan, J., and Burnicki, A., Effects of Traffic Conflicts on Pedestrian Crossing Volume Considering Geospatial & Other Location Data, Bridging Transportation Researchers (BTR) #3 Conference, August 3, 2021.

[6] Shi, X., Winter Road Maintenance Research Can Help Lower Salt Usage, Keynote Presentation for the 2021 Salt Symposium, August 4, 2021.

[7] Shi, X., Value-added Renewable Additives for More Sustainable Anti-icing Operations on Roadways, An online presentation at the TRB Resource Conservation and Recovery Committee (AMS20) Summer Workshop, July 29, 2021.

[8] Shi, X., and Pu. Z., Exploring Weather Related Connected Vehicle Applications for Improved Winter Travel, PacTrans - Region 10 University Transportation Center, April 27, 2021.

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/. Script written by UConn for implementing the mixed traffic equilibrium assignment can be found in this link: https://github.com/sruthimantri/Mixed-Equilibrium-Traffic-Assignment.

3.3. Technologies or techniques

UT Austin has developed a novel computational framework for prediction trajectories of pedestrians around intersections, through a graph theoretic neural network model. The model requires considerably less parameters than other models reported in the literature (10 to 100x less), and is faster, for the same level of performance.

3.4. Inventions, patent applications, and/or licenses

Nothing to report.

3.5. Other outputs

USDOT CAMMSE UTC Webinar Series, Sponsored by CAMMSE
[1] "Countermeasures for Post-COVID Public Transit Service Recovering", presented by Ms. Qun Zhao (Research Associate, TSU), 3-4 pm, August 11, 2021.

CAMMSE Graduate Seminar Series @ UNCC, Sponsored by CAMMSE
[1] "Identify Potential Intersections and Design Scenarios for CAV Simulation", Presented by Mr. Li Song, remotely via WebEx, 9-10am, April 7, 2021.
[2] "Optimal Control for Trajectory Planning: The Hanmiltonian Function and Pontryagin Maximum Principle", Presented by Mr. Shaojie Liu, remotely via WebEx, 9-10am, April 14, 2021.
[3] "Discussion on Reinforcement Learning Controlled Variable Speed Limit", Presented by Mr. Li Song, remotely via WebEx, 9-10am, April 21, 2021.
[4] "A Comparative Analysis of Ensemble Learning Approaches", Presented by Mr. Bo Qiu, remotely via WebEx, 9-10am, April 28, 2021.
[5] "Current Research Status on Trajectory Planning", Presented by Mr. Shaojie Liu, remotely via WebEx, 9-10am, May 5, 2021.
[6] "Differential Variable Speed Llimits Control via DRL", Presented by Mr. Li Song, remotely via WebEx, 9-10am, May 12, 2021.
[7] "CAMMSE Graduate Students Research Group Meeting: Discuss Recent Research Progress and Plans", Presented by all CAMMSE INES Ph.D. research assistants, 9-10am, June 25, 2021, remotely via WebEx.
[8] "CAMMSE Graduate Students Research Group Meeting: Discuss Recent Research Progress and Plans", Presented by all CAMMSE INES Ph.D. research assistants, 9-10am, July 21, 2021, remotely via WebEx.
[9] "Impacts of Mixed Traffic on Transfer-based DQN Controlled Signal Intersection", Presented by Mr. Li Song, EPIC CEE Conference Room 3344, 9-10am, August 25, 2021.
[10] "An Introduction of SUMO and the Performance of CAVs in Superstreet Considering Platooning", Presented by Mr. Shaojie Liu, EPIC CEE Conference Room 3344, 9-10am, September 1, 2021.
[11] "Travel Time Forecasting on a Freeway Corridor: a Dynamic Information Fusion Model based on Long Short-Term Neural Network with Attention Mechanism", Presented by Mr. Bo Qiu, EPIC CEE Conference Room 3344, 9-10am, September 8, 2021.
[12] "Intersection Capacity Analysis under Different MPRs of CAVs", Presented by Mr. Li Song, EPIC CEE Conference Room 3344, 9-10am, September 15, 2021.
[13] "Trajectory Planning of CAVs and Preliminary Performance Analysis in Superstreets", Presented by Mr. Shaojie Liu, EPIC CEE Conference Room 3344, 9-10am, September 22, 2021.
[14] "A Comprehensive Analysis of LSTM and Attention Mechanism Approach", Presented by Mr. Bo Qiu, EPIC CEE Conference Room 3344, 9-10am, September 29, 2021.

ITE Seminar Series @ UNCC, Co-organized and sponsored by UNCC ITE Student Chapter and CAMMSE
[1] "UNCC-ITE Career Development Seminar", lectured by Ms. Stacie L. Phillips, PE, from Kimley-Horn, Inc, remotely via WebEx, April 21, 2021.
[2] "Prepare Your Job and Career Development", lectured by Ms. Megan Corkery, the Assistant Director and Career Coach of the University Career Center at UNC Charlotte, remotely via Zoom, September 15, 2021.

Lunch and Learn Series @ TSU, Co-organized and sponsored by CAMMSE
[1] "Career Opportunities for Uniform and Non-uniform Professionals with the Federal Agency", presented by Ms. Ximena Cavazos (Recruiter) and Ms. Susan Lowery (Public Affairs), from U.S. Customs and Border Protection, April 28, 2021.

[2] "Career as a US Coast Guard officer", presented by Mr. Timothy Tilghman, from USCG, April 21, 2021.

Technical Reports
[1] Fan, W. and Qiu, B., *Travel Time Forecasting on a Freeway Corridor: a Dynamic Information Fusion Model Based on the Random Forests Approach*, Technical Report for CAMMSE Research 2020 Project 01, U.S. Department of Transportation, September 2021.

[2] Fan, W. and Li, Y., *Optimization of Long-Term Highway Work Zone Scheduling*, Technical Report for CAMMSE Research 2020 Project 02, U.S. Department of Transportation, September 2021.

[3] Fan, W. and Liu, S., *Impact of Connected and Autonomous Vehicles on Nontraditional Intersection Design: Superstreets*, Technical Report for CAMMSE Research 2020 Project 03, U.S. Department of Transportation, September 2021.

[4] Fan, W. and Liu, P., *Machine Learning-based Trajectory Optimization of Connected and Autonomous Vehicles*, Technical Report for CAMMSE Research 2020 Project 04, U.S. Department of Transportation, September 2021.

[5] Fan, W., Lin, Z., Liu, S., Searcy, S. and Carter, B., *Bicycle Volume: Counting Machine Validation & Correction, Estimating & Forecasting, and Analysis of Injury Risk*, Technical Report for Research Project 2020-43, North Carolina Department of Transportation (NCDOT), FHWA/NC/2020-43, September 2021.

[6] Mantri, S., Lownes, N., and Bergman, D, *Prioritizing People – Mixed Equilibrium Assignment for AV Based on Occupancy*, Technical Report for CAMMSE Research 2020 Project 09, September 2021.

[7] Becker, T. and Lownes, N., *Using Computational Biology to Mitigate Path Overlap in Transit Assignment*, Technical Report for CAMMSE Research 2020 Project 10, September 2021.

[8] Zhu, J., Ren, Z., and Chowdhury, S., *Disaster Resilience through Diverse Evacuation and Emergency Transportation Systems*, Technical Report for CAMMSE Research 2020 Project 11, September 2021.

[9] Ivan, J., Burnicki, A., and Joshi, P., *Estimation of Pedestrian Volume Using Geospatial and Traffic Conflict Data*, Technical Report for CAMMSE Research 2020 Project 12, September 2021.

[10] Qi, Y., Azimi, M., and Zhao, Q., *A New Method for Estimating Truck Queue Length at Marine Terminal Gates*, Technical Report for CAMMSE Research 2020 Project 13, September 2021.

[11] Azimi, M., and Qi, Y., *Analysis of Intermodal Vessel-To-Rail Connectivity*, Technical Report for CAMMSE Research 2020 Project 14, September 2021.

[12] Azimi, M., and Qi, Y., *Exploring the Impact of Infrastructure on Bike Sharing System Performance in Houston City*, Technical Report for CAMMSE Research 2020 Project 15, September 2021.

[13] Dey, K., Ashraf, Md T., Shi, X., *Multimodal Connected Vehicle Pilot for Winter Travel*. Final report for CAMMSE Research 2020 Project 16, August 2021.

[14] Shi, X., Bergner, D., Du, S., Keep, D., Reed, C., *Review and Summary of Pre-wet Methods and Procedures*. Final Report for the Clear Roads Pooled Fund and Minnesota Department of Transportation, June 2021.

Interviews & Media Events/Mentions
[1] Inside UNC Charlotte: Niner Insider: Bikes, Trains and Automobiles: How UNC Charlotte Research Keeps Traffic - and People - Moving, https://inside.charlotte.edu/news-features/2021-07-29/uncc-transportation-engineering-CAMMSE, July 29, 2021. UNC Charlotte Twitter and UNC Charlotte Facebook, August 2, 2021.

[2] Interviewed by UNCC's Freelance Writer Ms. Yen Duong - CAMMSE's story, June 1, 2021.

4. OUTCOMES

4.1. Increased understanding and awareness of transportation issues

TSU's research project "Exploring the Impact of Infrastructure on Bike Sharing System Performance in Houston City" identified how the bike infrastructure, especially bike lane investment, benefits the bike-sharing system.

The direct impact of UT Austin's projects is a better understanding of how to improve multi-modal mobility (i.e., vehicles, cyclists, transit) and safety (i.e., considering human body cues to predict vehicle trajectories).

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

Nothing to report.

4.3. Increases in the body of knowledge

UT Austin has formulated new versions of familiar logistics problems that encompass the possibilities of unmanned aerial vehicle technology. These problems are intractable (NP-hard) but we have developed tailored heuristics that exploit problem structure, producing reasonable solutions in an acceptable amount of time.

TSU's research project "Analysis of Intermodal Vessel-To-Rail Connectivity" identified the critical components of a vessel-rail intermodal system, analyzed the significance of each of them, compared the competitiveness of the Port of Houston among the similar ports by collecting information from the port officials and the public database, pinpointed the gap between the existing condition of the POH and state of the art practices.

While the effects of CAVs on transportation systems have been well investigated, the benefits that CAVs can present to supply chain operation and management have not been explored and quantified. Quantitative assessment of the impact of CAVs on a supply chain system is necessary for finding optimal supply chain design and management, as the optimization process requires quantitative/objective information. The WSU's research project (2021 Project 10) will fill this research gap and improve knowledge of the effects of CAVs on supply chain performance.

4.4. Improvement of existing techniques, practices, technologies

At UT Austin, the research team included COVID-19 metrics to help improve bicycle facility demand forecasting models. These models have also been updated to include machine learning techniques such as LASSO, which improve prediction ability and decrease the number of variables required. Meanwhile, the Skeleton-Graph algorithm significantly improved the performance of trajectory prediction over state-of-the-art algorithms. The results show an FDE (final displacement error) improvement of at least 27% and an ADE (average displacement error) of 4% on both the GTA-IM and PROX datasets respectively in comparison with prior works. Also, this method is 88% and 93% less divergence on the long-term motion prediction in comparison with prior works on both GTA-IM and PROX datasets. Moreover, from the Adaptive Signal Control Project that was conducted by UT-Austin, this research has improved existing technologies that will allow people to have less delay, resulting in decreased emissions and better quality of life.

TSU's research project "Exploring the Impact of Infrastructure on Bike Sharing System Performance in Houston City" developed a longitudinal model to investigate the relationship between the number of the added bike lane miles and the bike-share ridership.

At WSU, the research team utilized the existing quantitative models for assessing the effects of CAVs on transportation systems and improved supply chain analysis to capture systematic propagation of CAV-impacted variables.

4.5. Enlargement of the pool of trained transportation professionals

At UConn, one undergraduate student and seven graduate students received training and experience in transportation analysis. Skills gained include GIS, python scripting, technical writing, technical presentations, and the transportation planning process.

TSU CAMMSE supported student Jinli Liu graduated in June 2021 and is now pursuing her Ph.D. degree at Texas State University. Another CAMMSE supported student Enamul Karim Fayek also graduated in June 2021 and now is working as a Transportation Intern at HNTB.

4.6. Incorporation of new techniques, practices, technologies

At UT Austin, since the bicycle signal technology is being jointly field tested by CAMMSE researchers and the City of Austin, once testing is complete, implementation will be a simple matter. As a joint sponsor, the City will be ready and able to implement rapidly.

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?

At UT Austin, the statistical models developed in 2020 Project 05 connect bicycle facility counts to time, demographic data, and weather data to better predict bicycle facility usage. There has been some work done in estimating the impacts of bicycle facilities, but very little has been done to examine the impacts upon minorities or other specific population segments. Estimating bicycle facility usage is the first step in estimating the positive impacts of bicycle facility implementation. Models that consider COVID-19 metrics have also been developed for predicting bicycle facility demand. In addition, the researchers also worked on another project in which electric vehicles and drones have the potential to improve the efficiency of freight delivery, and to reduce emissions associated with the transportation system.

TSU's research project "Analysis of Intermodal Vessel-To-Rail Connectivity" found that the main parameters to evaluate the efficiency of the vessel-to-rail intermodal system are drayage cost, on-dock rail intermodal yard, terminal location, its capacity, and operational equipment facility cranes. To cope with the containerized traffic in the future, the port should improve its terminal capacity and initiate new terminals at convenient locations with optimum infrastructural facilities. The research findings help improve the effectiveness of intermodal transportation.

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?

At UT Austin, the research is performed by students and faculty supervisors who work closely with industry and government entities. As with the signal re-timing 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.

At TSU, the CAMMSE team worked closely with industry or government partners, such as TxDOT and Houston Bicycle, which helps the technology transfer. In addition, CAMMSE students will carry the skills to their future employers.

At WSU, the research team of CAMMSE 2021 Project 10 will publicly share the quantitative model and the Python codes developed as part of the research activities so that supply chain managers or grocery delivery companies (dealing with perishable or semi-perishable products) can use it in their preliminary supply chain analyses to design or re-optimize their systems. Given that online grocery shopping and delivery have received great attention especially during the COVID-19 situation (and assuming that this will be a new normal), research outcomes may have broader impacts on society.

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

At UT Austin, 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.

By working on CAMMSE supported research projects, the TSU team developed new methods and gained a better understanding of transportation issues.

At WSU, the proposed model from CAMMSE 2021 Project 10 will improve understanding of the direct and indirect effects of CAVs on supply chain performance (especially involving fresh or perishable products).

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 UT Austin, 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.

During the reporting period, TSU CAMMSE faculty members have been teaching seven undergraduate-level courses and ten graduate-level courses, as well as conducting cutting-edge research. Both CAMMSE supported students and non-CAMMSE supported students benefit from their classes. In addition, TSU continues hosting transportation webinar series to provide students the opportunities to learn new methods or techniques.

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

The COVID pandemic set several projects back and eliminated some presentation opportunities for CAMMSE researchers at all CAMMSE partner institutions. As we adapt to the new circumstances, it is anticipated that these issues will be mitigated. Both UCONN and WSU mentioned that the COVID-19 pandemic has caused some delays in their CAMMSE project activities. WSU's plan to resolve the aforementioned problems will be to catch up some lost time during the next reporting period.

In short, despite the constraints posed by COVID-19, all CAMMSE partner institutions will take on the challenges and continue working hard to resolve all relevant issues.

6.3. Changes that have a significant impact on expenditures

The COVID pandemic brought many challenges to all CAMMSE partner institutions. For example, due to the COVID pandemic, UNCC was not able to recruit any new students and have them physically join UNCC as we used to in the past. Because of such special circumstances, UNCC could not develop any new research proposals in year 5 due to the unavailability of new students.

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 are 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

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), Ongoing

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

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
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