# Center for Advanced Multimodal Mobility Solutions and Education

# USDOT Tier 1 University Transportation Center
# Semi-Annual Progress Report #7

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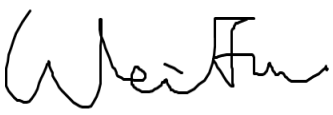
| **Signature of Submitting Official:** |  |

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# 1. ACCOMPLISHMENTS

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

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

**Research**

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

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

**Leadership**

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

**Education and Workforce Development**

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

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

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

**Technology Transfer**

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

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

**Collaboration**

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

**Diversity**

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

## 1.2. What was accomplished under these goals?

**Research**

As initially planned, the CAMMSE Call for Research Proposals for Year 5 (2020-2022) 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 June 1, 2020. The submission deadline for all project proposals was July 10, 2020, 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 10 of them for funding. The decision letters were sent to all PIs by August 21, 2020. The appendix contains the list of the funded projects (in Year 5) 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 fifth year (i.e., in the year of 2020-2022) 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 *Accident Analysis and Prevention*, *ASCE Journal of Cold Regions Engineering*, *ASCE Journal of Transportation Engineering, Part A: Systems*, *Canadian Journal of Civil Engineering, Environmental Monitoring and Assessment, IEEE Access*, *International Journal of Environmental Research and Public Health*, *Journal of Advanced Transportation*, *Journal of Civil Engineering Education*, *Journal of Computer Science, Journal of*

*Econometrics*, *Journal of Public Transportation*, *Journal of Safety Research, Journal of Traffic and Transportation Engineering*, *Journal of Transportation Safety & Security, Mathematical Problems in Engineering*, *Sustainability*, *Transportation Research Part C: Emerging Technologies*, *Transportation Research Record: Journal of the Transportation Research Board*, *and Transportmetrica A: Transport Science*.

During this reporting period, CAMMSE research results were also presented at many conferences on different occasions, which include the IEEE 23rd International Conference on Intelligent Transportation Systems (ITSC), the 33rd Annual Conference of International Chinese Transportation Professionals Association (ICTAP), the 2020 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), Virtual NCDOT/UTC Roundtable Meeting, USDOT CAMMSE UTC Webinar Series, ASCE Construction Research Congress, and University of Connecticut ENGR 1000: Orientation to Engineering.

In addition, CAMMSE has completed all 17 research projects of year 3 during this reporting period. All final project reports of year 3 that have been completed are in the processing of being posted on the CAMMSE's website and provided to Transportation Research Board, etc. These projects have resulted in valuable findings and advanced models, which will advance both the state of the art and state of the practice in respective fields.

**Leadership**

Representing the CAMMSE, Center Director Dr. Wei Fan used his expertise to serve as a proposal reviewer for "USDOT National Center for Transportation Infrastructure Durability and Life Extension" (TriDurLE) in the Missouri University of Science and Technology in April 2020. During this reporting period, Dr. Wei Fan also served as an affiliate faculty in the School of Data Science, UNC Charlotte since August 15, 2020, and a member of A0020C International Coordination Council (ICC) in the Transportation Research Board (TRB) since September 10, 2020.

During this reporting period, CAMMSE Center Director and Associate Directors have been actively serving on many editorial boards (e.g., Guest Editor-in-Chief of *Journal of Advanced Transportation*; Lead Guest Editor of *Journal of Entropy,* and *Mathematical Problems in Engineering*; Handling Editor of *Transportation Research Record Inaugural Editorial Board*; Associate Editor of the *ASCE Journal of Transportation Engineering, Part A: Systems*, *IEEE Transactions on Intelligent Transportation Systems*, *International Journal of Transportation Science and Technology*, and *Journal of Transportation of the Institute of Transportation Engineers;* Founding Editor-in-Chief of the *Journal of Infrastructure Preservation and Resilience;* Editorial boards of *Accidents and Civil Infrastructure, Asian Transport Studies, Current Trends in Civil & Structural Engineering, Institute of Transportation Engineers, International Journal of Natural Disaster, International Journal of Revenue Management*, *International Journal of Transportation*, *International Journal of Transportation Science and Technology, Journal of Infrastructure Preservation and Resilience, Journal of Transportation Research Part D, Journal of World Review of Intermodal Transportation Research, Transportation Letters,* and *Transportmetrica A: Transport Science)*, and many professional committees (e.g., member of the ASCE Connected & Autonomous Vehicles Impacts Committee, ASCE Advanced Technologies Committee, ASCE Public Transport Committee, ASCE Rail Transportation Committees, NCDOT Fully Autonomous Vehicle (FAV) Research Working Group Committee, NCSITE Scholarship Committee, Sustain Charlotte Transportation Choices Alliance Advisory Council, World Transport Convention Shared Logistics and Transportation Systems Committee, NCSITE Scholarship Committee, PENC State Board, TRB Standing Committees (AHB60, AHD60, AP025, ADB10, ABR10, ABJ70, AFN30, ADC20, ADC60, AFP40, AT050, AW010, AW010(2), AW010(3), and AW020), Co-Chair of Connected Autonomous Vehicles Section for the World Transport Convention, Chair of the asset management subcommittee of TRB's Traffic Signal Systems Committee, Session Chair of the INFORMS, Chair of the 2020 CAMMSE Research Symposium, Outreach subcommittee of the Lone Star Harbor Safety Committee (LSHSC), Academic Outreach and Membership Officer, board member of Chinese Overseas Transportation Association (COTA), member of the Maritime Education, Training, and Outreach Subcommittee of the Lone Star Harbor Safety Committee (LSHSC), and at large member of PENC state board, as well as several proposal and book review committees (e.g., NCHRP). At WSU, Dr. Xianming Shi has also been named Fellow of the American

Society of Civil Engineers, a prestigious honor held by only 3% of ASCE members. ASCE Fellows have made celebrated contributions and developed creative solutions that change lives around the world.

**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, David Weggel, and Martin Kane) 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. In particular, Dr. Martin Kane conducted educational outreach activities for CAMMSE to the North Carolina State Extension's Annual 4-H Congress on July 21, and Rowan County Driver Ed classes on August 5, 2020. CAMMSE and ITE Student Chapter at UNCC invited Ms. Megan Corkery, the Assistant Director and Career Coach of the University Career Center at UNC Charlotte, to give an online speech for "Tips for a post-COVID-19 job search and ways to navigate new normal living" on September 22, 2020. 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, Dr. Wei Fan taught the "Urban Transportation Networks: Operations & Optimization" course in the Spring 2020 semester and the "Connected and Autonomous Vehicles" course in the Fall 2020 semester to several graduate students who were in attendance. A total of seven students have been involved in CAMMSE projects and six of them were directly supported by CAMMSE during this reporting period.

At WSU, the undergraduate research assistant Olivia Rose Willis was awarded the 2020-2021 Auvil Scholars Fellowship from Office of Undergraduate Research in WSU. Ms. Cheryl A. Reed (outreach coordinator) worked with Olivia R. Willis and conducted more outreach activities for middle schools and high schools through a targeted online program. The detailed outreach program and results are summarized in the Final Report of the CAMMSE 2019 Project 15 titled "Multimodal Transportation Engineering Curriculum for Middle and High School Students".

At TSU, two undergraduate-level and seven graduate-level transportation-related courses were taught by CAMMSE personnel (Drs. Yi Qi, Mehdi Azimi and Lei Yu). During the reporting period, four master students and two Ph.D. students have participated in CAMMSE funded research projects. CAMMSE funded students have received notable national, local, and university awards. Master student Jili Liu received the Helene M. Overly Memorial Scholarship, Enamul Fayek received Transportation Clun of Houston Scholarship, Mohammed Rahman received Council of University Transportation Center (CUTC) Outstanding Student of the Year. Ph.D. student Tao Tao received TSU Travel Award and TSU university scholarship. In addition, CAMMSE supported student Tao Tao is pursuing his Ph.D. study at Urban Planning with an emphasis on Transportation Planning. Hasin Jinna and Qiao Sun both found jobs working as traffic engineer interns after graduation.

At UT Austin, there were a total of seven students involved in CAMMSE projects, including both female and male students. Two students (Suyash Vishnoi and Abduallah Mohamed) have obtained their MS degree with support from this project.

**Technology Transfer**

CAMMSE faculty, staff, researchers and students have been making presentations at different meetings including the IEEE 23rd International Conference on Intelligent Transportation Systems (ITSC) on

September 20-23, 2020, in Rhodes, Greece; the 33rd Annual Conference of International Chinese Transportation Professionals Association (ICTAP) on May 27-30, 2020, in Shanghai, China; the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR) on June 16-18, 2020, in Seattle, United States; ASCE Construction Research Congress Poster Presentation in Tempe, Arizona; Virtual NCDOT/UTC Roundtable Meeting on July 1, 2020; and three 2020 USDOT CAMMSE UTC Webinar Series remotely via WebEx.

At TSU, CAMMSE faculty and students published research findings in peer-reviewed journals, including the Environmental Monitoring and Assessment, IEEE Access, International Journal of Environmental Research and Public Health, Journal of Advanced Transportation, Journal of Safety Research, Journal of Traffic and Transportation Engineering, and Mathematical Problems in Engineering. In addition, CAMMSE research result was presented at the 33rd Annual Conference of International Chinese Transportation Professionals Association (ICTAP).

At UT Austin, there are a total of four active projects sponsoring one master's student, five Ph.D. students, three 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. 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. Additionally, Year 3 final reports have been completed and submitted. In addition, for 2019 Project 07. "Assessment of Parcel Delivery Systems Using Unmanned Aerial Vehicles (Phase II)", they developed two optimization formulations for drone logistics involving an electric vehicle and a drone to assist with deliveries, one deterministic and the other stochastic using fixed recourse. They also developed custom heuristics for these challenging optimization problems and presented results on benchmark instances. For 2019 Project 08. "Deep-Learning Based Trajectory Forecast for Safety of Intersections with Multimodal Traffic (Phase II)", a novel pedestrian forecast flow model has been derived. This model was based on a combination of graph theory and artificial neural networks and used considerably fewer model parameters than classical models. It also predicted future paths faster than other reported algorithms. For 2019 Project 06. "Corridor Level Adaptive Signal Control (Phase II)", they developed an adaptive signal control algorithm based on queueing theory to optimize signal timing for an isolated intersection under low traffic volume conditions. Lastly, for 2019 Project 05. "Forecasting Bicycle Facility Demand to Estimate Societal Impacts (Phase II)", they developed statistical models that connect bicycle facility counts to time, demographic data, and weather data to better predict bicycle facility usage.

The CAMMSE-supported students that have graduated during this reporting period will carry the new technology that they have helped develop with them for the rest of their careers. This new technology will be used in their new jobs, and they will 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.

**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, NC State University, and Tongji University) in co-writing proposals and/or papers. Dr. Kane also participated in the Charlotte Area Transit Authority Groundwork for the Summer Camp.

At WSU, during this time period, Dr. Xianming Shi collaborated with Oregon State University and University of Washington for a Connected Vehicle research project. His team also collaborated with Dr.

Kakan Dey at West Virginia University to start the work on the CAMMSE 2020 Project 16. “Multimodal Connected Vehicle Pilot for Winter Travel”.

At TSU, Drs. Yi Qi, Mehdi Azimi, and Lei Yu collaborated with University of Alabama, Clemson University, Mississippi State University, University of Central Florida, Pennsylvania State University, and University of Louisville to develop new proposals. In addition, Dr. Mehdi Azimi also partnered with Houston Bike Share and City of Houston on his ongoing 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. One of the UT-Austin principal investigators is also collaborating with the National Science Foundation (NSF) on 2019 Project 08. “Deep-Learning Based Trajectory Forecast for Safety of Intersections with Multimodal Traffic”.

**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 (Mr. Yang Li, Ms. Zijing Lin, Mr. Pengfei Liu, Mr. Bo Qiu, Mr. Shaojie Liu, and Mr. Li Song all 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, one female Outreach Coordinator (Cheryl A. Reed, WSU) is actively involved in the CAMMSE 2019 Project 15. One female minority undergraduate (Olivia Willis) was involved in CAMMSE 2019 Project 15. One international graduate student (Mr. Chuang Chen, from P.R. China) worked on CAMMSE projects, especially the 2019 Project 16 “Effects of Incorporating Connected Vehicle Technologies into No-Notice Emergency Evacuation during Winter Weather”.

At TSU, students supported by CAMMSE fund have different backgrounds. Among the six students, two are female. In addition, TSU is one of the nation’s largest historically black university, and the majority of students are minority students.

UT Austin students sponsored by CAMMSE come from all sorts of diverse backgrounds. Specifically, UT Austin supported two females (Ms. Jennifer and Ms. Carolina) and five males (Mr. Hao, Mr. Abdullah, Mr. Kun, Mr. Suyash, and Mr. Tengkuo) through 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 WSU, some online training (introduction to transportation engineering) was provided to more than 100 high school and middle school students as summarized in the Final Report of the CAMMSE 2019 Project 15 titled “Multimodal Transportation Engineering Curriculum for Middle and High School Students”. Furthermore, the presentations of the research projects provided some professional development for the audience.

At TSU, CAMMSE funding provided research assistantships to our graduate students and gave them opportunities to participate in CAMMSE research projects. In addition, TSU CAMMSE regularly organized Transportation Seminar Series. During the reporting period, two online seminars were held, which were “Theoretical Examination of Passing Sight Distance with Application to Marking” by Dr. Mehdi Azimi and “Transportation Opportunities Q&A” by Ms. Heather Richardson from the Volpe National Transportation Systems Center.

At UT Austin, CAMMSE students from UT Austin submitted papers to the TRB Annual Meeting. Attending this conference provided students the opportunity to network with practitioners, alumni, and academic professionals during this reporting period. 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 made many presentations both nationally and internationally. At TSU, CAMMSE research results were published in peer-reviewed journals and conference proceedings. TSU also presented research findings through technical reports. UT Austin has presented the results through published papers, technical reports, technical presentations, and website in: http://sboyles.github.io/, https://sites.utexas.edu/machemehl/ and http://www.mass-lab-ut.com/. Results have been published in the high reputation journals such as Transportation Research Part C and Journal of Computer Science. Manuscripts reporting these results are also currently under peer review in high reputation journals such as Transportation Research Part C and Transportation Research Part E.

### 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 that have been completed for year 3 (2018-2020) 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 Department of Transportation Research & Innovation Summit on October 13, 2020, North Carolina Section Institute of Transportation Engineers (NCSITE) Annual Meeting on November 16, 2020, and the TRB 100$^{th}$ Annual Meeting on January 11-15, 2021.

(3) The Third Annual CAMMSE Virtual Research Symposium will be held from November 5-6, 2020.

(4) 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.

(5) In particular, UT Austin will explore constraint programming as a more efficient solution method for optimization problems. They will consider robust optimization as an alternative formalization for uncertainty in customer demand. They will also continue working on the trajectory prediction problem, with partial human control. In this problem, they assume that the users should furthermore follow a certain path and use this information to improve the path prediction (and compute deviations with respect to the assigned path).

# 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 | | |
| Case Western Reserve University | University /OH | | | | X | |
| Centralina Council of Governments | MPO /NC | | X | | | |
| Charlotte Area Transit System | Government /NC | | X | | | |
| City of Austin | Government /TX | | X | X | X | |
| City of Charlotte | Government /NC | | X | | | |
| City of Houston | Government /TX | | | | X | |
| Connecticut Department of Transportation | Government /CT | | | | X | |
| CTTransit | Transit Operator | | | | X | X |
| Harbin Institute of Technology | University /China | | | | X | |
| Houston Bike Share | Non-profit /TX | | | | X | |
| Houston-Galveston Area Council | Non-profit /TX | | | | 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 | |
| Partnership for Strong Communities | Non-profit /CT | | | | X | |
| PacTrans | UTC /WA | | | | X | |
| Propeller Club Port of Houston | | | | | X | |
| Texas Department of Transportation | Government /TX | | X | X | | |
| Texas Southern University | University /TX | X | X | X | | |
| Tongji University | University /China | | | | X | |
| University of Houston | University /TX | | | | X | |
| University of Connecticut | University /CT | X | X | X | | |
| University of North Carolina at | University | X | X | X | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Charlotte | /NC | | | | | |
| University of Texas at Austin | University /TX | X | X | X | | |
| UT's Center for Transportation Research (UT Austin) | University /TX | | X | X | | |
| University of Texas at El Paso | University /TX | | | | 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, co-writing and publishing papers with faculty and researchers from the Key Laboratory of Road and Traffic Engineering, Ministry of Education and College of Transportation Engineering at Tongji University in Shanghai, P.R.China. A collaborative relationship has been successfully developed between two universities.

TSU also partnered with the following universities for collaborative research: University of Alabama, Clemson University, Mississippi State University, University of Central Florida, Pennsylvania State University, and University of Louisville.

The research of Abduallah Mohamed and Kun Qian from UT Austin has also been supported by the National Science Foundation (CPS: Medium: Collaborative Research: Synergy: Augmented reality for control of reservation-based intersections with mixed autonomous-non autonomous flows).
At UConn, the collaborators have been involved in the CAMMSE related activities mainly by contributing domain knowledge or exchanging the latest information on connected vehicle technologies. The PacTrans: Region 10 UTC has been involved by sharing the interests in exploring CV technologies for better winter road maintenance operations. West Virginia University has been involved as subcontractor on one of the CAMMSE projects. North Carolina State University has also been involved due to the transition of Dr. Ali Hajababaie from WSU to NCSU.

# 3. OUTPUTS

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

**Journal publications**


[1] Li, Y. and Fan, W., Mixed Logit Approach to Modeling the Severity of Pedestrian-Injury in Pedestrian-Vehicle Crashes in North Carolina: Accounting for Unobserved Heterogeneity, Accepted for Publication, *Journal of Transportation Safety & Security*, pp.1-22, September 2020.

[2] Liu, P. and Fan, W., Analyzing Injury Severity of Rear-End Crashes involving Large Trucks Using a Mixed Logit Model: A Case Study in North Carolina, Accepted for Publication, *Journal of Transportation Safety & Security*, pp.1-14, August 2020.

[3] Liu, S. and Fan, W., Investigating Factors Affecting Injury Severity in Vehicle-Cyclist Crashes: A Day-of-Week Analysis with Partial Proportional Models, Accepted for Publication, *Canadian Journal of Civil Engineering*, August 2020.

[4] Huang, Z., Fan, W., Xu, R.H., Lee, D.H. and Zhu, W., Reliability Measure-Based Data Analytics Approach to Identifying and Ranking Recurrent Bottlenecks in Urban Rail Transit Networks, *ASCE Journal of Transportation Engineering, Part A: Systems,* Volume 146, Issue 9, pp.04020103, September 2020.

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**Conference papers**

[1] Niroumand R. and A. Hajbabaie. The Effects of the "White Phase" on Intersection Performance with Mixed-Autonomy Traffic Stream. The IEEE 23rd International Conference on Intelligent Transportation Systems (ITSC), Rhodes, Greece, September 20-23, 2020.
[2] Mohebifard R. and A. Hajbabaie. Effects of Automated Vehicles on Traffic Operations at Roundabouts. The IEEE 23rd International Conference on Intelligent Transportation Systems (ITSC), Rhodes, Greece, September 20-23, 2020.
[3] Qiao, F., S. Liu, Q. Li, J. Du, and L. Yu. Implication of Eco-Driving at a Single Lane Roundabout. Proceedings of the 33rd Annual Conference of International Chinese Transportation Professionals Association (ICTAP), Shanghai, China, May 27-30, 2020.
[4] Abduallah Mohamed, Kun Qian, Mohamed Elhoseiny, Christian Claudel, Social-STGCNN: A Social Spatio-Temporal Graph Convolutional Neural Network for Human Trajectory Prediction, The IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), Seattle, United States, June 16-18, 2020.

**Presentations**

[1] Fan, W., CAMMSE's Updates and Recent Activities, Virtual NCDOT/UTC Roundtable Meeting, July 1, 2020.
[2] Fan, W., Developing A Systematic Method for Identifying, Ranking, Examining, and Mitigating Freeway Bottlenecks, USDOT CAMMSE UTC Webinar Series, Charlotte, NC, remotely via Webex, April 17, 2020.
[3] Niroumand R. and A. Hajbabaie. The Effects of the "White Phase" on Intersection Performance with Mixed-Autonomy Traffic Stream. The IEEE 23rd International Conference on Intelligent Transportation Systems (ITSC), September 2020.

[4] Mohebifard R. and A. Hajbabaie. Effects of Automated Vehicles on Traffic Operations at Roundabouts. The IEEE 23rd International Conference on Intelligent Transportation Systems (ITSC), September 2020.
[5] Azimi, M. Theoretical Examination of Passing Sight Distance with Application to Marking No-Passing Zones. USDOT CAMMSE UTC Webinar Series, remotely via Webex, April 3, 2020.
[6] Patrick T. Toman. Predictive Modeling of Shared Ride Modes in New York City: A Case Study Using Dynamic Compositions of Time Series, Quality and Productivity Research Conference, American University, Washington DC, 2019.
[7] Zhu, J., Zhang, L., and Ren, Z. (2020). A Conceptual Framework for Understanding the Relationships between Transportation Infrastructure and Human Resilience. ASCE Construction Research Congress Poster Presentation, Tempe, AZ, 2020.
[8] Zhu, J. Civil Infrastructure and Human Well-being. University of Connecticut ENGR 1000: Orientation to Engineering. Storrs. CT. 2020.
[9] Claudel, C. Social-STGCNN: A Social Spatio-Temporal Graph Convolutional Neural Network for Human Trajectory Prediction, USDOT CAMMSE UTC Webinar Series, remotely via Webex, July 31, 2020.

### 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

TSU developed a systematic method for determining the length of Contraflow Left-turn Lane (CLL) and the signal timing plan for implementing CLL at signalized intersections. TSU team also developed a signal timing strategy for displaced left turn intersections.

UConn developed a disaster resilience through diverse evacuation and emergency transportation systems. The project starts on Oct 1, 2019. In the past year, the research team focused on task 1 of the proposed study: quantifying transportation system diversity. The research team has developed an entropy-based method to quantify the level of diversity of a multimodal transportation system from both infrastructure and travel behavior perspectives. The proposed method was tested in a case study of Hartford, CT.

UT Austin 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 performance.

### 3.4. Inventions, patent applications, and/or licenses

Nothing to report.

### 3.5. Other outputs

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

[1] “Coordination of Connected and Automated Vehicles at Intersections: Optimization Methods for Centralized Control”, Presented by Mr. Li Song (CAMMSE INES Ph.D. research assistant), 9-10am, April 1, 2020, remotely via WebEx.
[2] “Modeling Cooperative Adaptive Cruise Control (CACC) Vehicles”, Presented by Mr. Shaojie Liu (CAMMSE INES Ph.D. research assistant), 9-10am, April 8, 2020, remotely via WebEx.
[3] “GSIM Datasets and Applications in Trajectory Prediction”, Presented by Mr. Pengfei Liu (CAMMSE INES Ph.D. research assistant), 9-10am, April 15, 2020, remotely via WebEx.

[4] “Investigating Cycling Behaviour Considering Different Temporal Characteristics Using Crowdsourced Bicycle Data”, Presented by Ms. Zijing Lin (CAMMSE INES Ph.D. research assistant), 9-10am, April 22, 2020, remotely via WebEx.
[5] “Applications of Major Boosting (Machine Learning) Methods in Pedestrian Injury Severity Data Analysis”, Presented by Mr. Yang Li (CAMMSE INES Ph.D. research assistant), 9-10am, April 29, 2020, remotely via WebEx.
[6] “Pedestrians Injury Severity Analysis with Mixed-logit Models at Intersections and Non-intersection Locations”, Presented by Mr. Bo Qiu (CAMMSE INES Ph.D. research assistant), 9-10am, May 6, 2020, remotely via WebEx.
[7] “An Introduction to Open Source Traffic Simulation Platforms”, Presented by Mr. Li Song (CAMMSE INES Ph.D. research assistant), 9-10am, May13, 2020, remotely via WebEx.
[8] “Exploring underlying Factors in Cyclists' Crashes at Intersections - A Preliminary Analysis with Association Rules”, Presented by Mr. Shaojie Liu (CAMMSE INES Ph.D. research assistant), 9-10am, May 20, 2020, remotely via WebEx.
[9] “CAMMSE Graduate Students Research Group Meeting: Discuss Recent Research Progress and Plans”, Presented by all CAMMSE INES Ph.D. research assistants, 9-10am, July 8, 2020, remotely via WebEx.
[10] “CAMMSE Graduate Students Research Group Meeting: Discuss Recent Research Progress and Plans”, Presented by all CAMMSE INES Ph.D. research assistants, 9-10am, August 12, 2020, remotely via WebEx.
[11] “Emerging Hotspot & XGBoost for Analyzing Pedestrian Severities – A Brief Result Presentation Based on a Case Study Conducted In NC”, Presented by Mr. Yang Li (CAMMSE INES Ph.D. research assistant), 9-10am, September 9, 2020, remotely via WebEx.
[12] “Bicyclist Injury Risk Analysis”, Presented by Ms. Zijing Lin (CAMMSE INES Ph.D. research assistant), 9-10am, September 16, 2020, remotely via WebEx.
[13] “Trajectory Optimization of CAVs at Signalized Intersections”, Presented by Mr. Pengfei Liu (CAMMSE INES Ph.D. research assistant), 9-10am, September 23, 2020, remotely via WebEx.
[14] “Travel Time forecasting: Comprehensive Numerical Results”, Presented by Mr. Bo Qiu (CAMMSE INES Ph.D. research assistant), 9-10am, September 30, 2020, remotely via WebEx.

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

[1] “Tips for a post-COVID-19 job search and ways to navigate new normal living” lectured By Ms. Megan Corkery, the Assistant Director and Career Coach of the University Career Center at UNC Charlotte. September 22, 2020, remotely via WebEx.

**Online Seminar Series @ TSU, Sponsored by CAMMSE**

[1] “Theoretical Examination of Passing Sight Distance with Application to Marking No-Passing Zones”, presented by Dr. Mehdi Azimi (CAMMSE assistant professor), 11am-12pm, April 3, 2020. Online seminar.
[2] “Transportation Opportunities Q&A”, presented by Ms. Heather Richardson (Volpe National Transportation Systems Center of U.S. Department of Transportation), 4-5pm, April 30, 2020. Online seminar.

**Technical Reports**

[1] Fan, W. and Chen, Z, *Predicting Travel Time on Freeway Corridors: Machine Learning Approach*, Technical Report for CAMMSE Research 2019 Project 01, U.S. Department of Transportation, September 2020.
[2] Fan, W. and Li, Y, *Optimizing Transit Equity and Accessibility by Integrating Relevant GTFS Data Performance Metrics*, Technical Report for CAMMSE Research 2019 Project 02, U.S. Department of Transportation, September 2020.
[3] Fan, W. and Lin, Z., *Analyzing Cycling Behavior During Different Time Periods Using Crowdsourced Bicycle Data*, Technical Report for CAMMSE Research 2019 Project 03, U.S. Department of Transportation, September 2020.

[4] Fan, W. and Liu, P., *Trajectory Optimization of Connected and Autonomous Vehicles (CAVs) at Signalized Intersections*, Technical Report for CAMMSE Research 2019 Project 04, U.S. Department of Transportation, September 2020.
[5] Hall, J, R. Machemehl, and C. Baumanis, *Forecasting Bicycle Facility Demand to Estimate Societal Impacts (Phase II)*, Technical Report for CAMMSE Research 2019 Project 05, August 2020.
[6] Liu, H. and R. Machemehl, *Corridor Level Adaptive Signal Control (Phase II)*, Technical Report for CAMMSE Research 2019 Project 06, August 2020.
[7] Boyles, S. D. and T. Zhu, *Assessment of Parcel Delivery Systems Using Unmanned Aerial Vehicles*, Technical Report for CAMMSE Research 2019 Project 07, August 2020.
[8] Mohamed, A. and C. Claudel, *Deep-Learning Based Trajectory Forecast for Safety of Intersections with Multimodal Traffic (Phase II*), Technical Report for CAMMSE Research 2019 Project 08, August 2020.
[9] Cohen, J. and Lownes, N., *Highways and Wealth Distribution: A Geospatial Analysis*, Technical Report for CAMMSE Research 2019 Project 09, U.S. Department of Transportation, September 2020.
[10] Konduri, K.C. and Ravishanker, N., *Are Transportation Network Companies Synergistic with Other Shared Ride Mode Offerings? An Exploratory Analysis of Demand Data from NYC Utilizing High Resolution Spatiotemporal Models*, Technical Report for CAMMSE Research 2019 Project 10, U.S. Department of Transportation, September 2020.
[11] Garrick, N. and Atkinson-Palombo, C*., Understanding the Surprising and Oversized Use of Ridesourcing Services in Poorer Neighborhoods in NYC*, Technical Report for CAMMSE Research 2019 Project 11, U.S. Department of Transportation, September 2020.
[12] Qi, Y., Zhao, Q., Liu, J., and Liu, S., *Development of Guidelines for Implementation of Contraflow Left-Turn Lanes at Signalized Intersections*, Technical Report for CAMMSE Research 2019 Project 12, U.S. Department of Transportation, September 2020.
[13] Qi, Y., Zhao, Q., Liu, S., and Azimi, M. *Signal Timing Strategy for Displaced Left Turn Intersections,* Technical Report for CAMMSE Research 2019 Project 13, U.S. Department of Transportation, September 2020.
[14] Azimi, M. Lan, L., Rahman, M. and Qi, Y. *Impacts of Bicycling Corridor Improvements on Users' Behaviors in Large Cities,* Technical Report for CAMMSE Research 2019 Project 14, U.S. Department of Transportation, September 2020.
[15] Willis, O., Reed, C., Zhang, Y., Shi, X. *Multimodal Transportation Engineering Curriculum for Middle and High School Students*. Technical Report for CAMMSE Research 2019 Project 15, U.S. Department of Transportation, September 2020.
[16] Chen, C., Shi, X. *Effects of Incorporating Connected Vehicle Technologies into No-Notice Emergency Evacuation During Winter Weather (Phase I)*. Technical Report for CAMMSE Research 2019 Project 16, U.S. Department of Transportation, September 2020.
[17] Hajbabaie, A. and Tajalli, M., *Dynamic Speed Harmonization in Connected Urban Street Networks: Improving Mobility*, Technical Report for CAMMSE Research 2019 Project 17, U.S. Department of Transportation, September 2020.

# 4. OUTCOMES

## 4.1. Increased understanding and awareness of transportation issues

TSU's research project "Investigating the Impact of Different Attributes on Bicycling Mode Share as A Multimodal Connectivity Strategy in Large Cities: A Case Study in Houston" increased the understanding of the role of cycling in city transportation systems, as well as the impact of different attributes on bicycling mode share as a multimodal connectivity strategy in Houston. Also, the direct outcome 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

TSU's research project "Development of Guidelines for Implementation of Contraflow Left-Turn Lanes (CLL) at Signalized Intersections" developed a systematic method for determining the length of CLL and the signal timing plan for implementing CLL at signalized intersections. The method proposed by this study can provide useful tools and design guidelines to the traffic engineers. Also, 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 they have developed tailored heuristics that exploit problem structure, producing reasonable solutions in an acceptable amount of time.

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

UCONN has developed "Disaster Resilience through Diverse Evacuation and Emergency Transportation Systems". The proposed method enables quantifying the level of diversity of transportation systems in different regions. Transportation planner and decision makers can use the quantification method to assess the current level of diversity and identify gaps and needs in order to enhance diversity and equity in transportation systems. From the Adaptive Signal Control Project that was conducted by UT-Austin, we have improved existing technologies that will allow people to have less delay, resulting in decreased emissions and better quality of life.

## 4.5. Enlargement of the pool of trained transportation professionals

At UNCC, Zhen Chen graduated with a Ph.D. degree and is currently pursuing a transportation career in Parsons Corporation. Three CAMMSE sponsored master students graduated at TSU. During their studies in TSU, they participated in CAMMSE research. The education they received at TSU and CAMMSE makes them trained transportation professionals. Student Tao Tao choses to continue his study at Urban Planning with an emphasis on Transportation Planning. Students Qiao Sun and Hasin Jinna started to work as traffic engineer interns after graduation. At UConn, two undergraduate students and five graduate students received training and experience in transportation analysis. Skills gained include GIS, python scripting, technical writing, technical presenting, and the transportation planning process. No new graduates joined during this six-month period at UT Austin. A doctoral student Hao Li completed his dissertation developing advanced signal timing techniques. Two students (Suyash Vishnoi and Abduallah Mohamed) have obtained their MS degree with support from this project.

## 4.6. Incorporation of new techniques, practices, technologies

Nothing to report.

# 5. IMPACTS

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

TSU's research projects "Development of Guidelines for Implementation of Contraflow Left-Turn Lanes (CLL) at Signalized Intersections" and "Signal Timing Strategy for Displaced Left-Turn Intersections" focused on two innovative intersection designs. The proposed new signal design strategies could greatly improve the intersection performances, therefore, significantly improve the effectiveness of the whole transportation system.

UT Austin developed statistical models in 2019 Project 05 "Forecasting Bicycle Facility Demand to Estimate Societal Impacts (Phase II)" to 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. Meanwhile, it is noted that electric vehicles and drones have the potential to improve the efficiency of freight delivery, and to reduce emissions associated with the transportation system. The research results from 2019 Project 07 suggest how these technologies can be integrated into logistics operations.

## 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.

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

At TSU, all three research projects conducted by TSU CAMMSE team were new and innovative research. By conducting such research, they increased the understanding of transportation issues, and proposed new methods and practices.

For 2019 Project 07, 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 they have developed tailored heuristics that exploit problem structure, producing reasonable solutions in an acceptable amount of time. 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, 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 and TSU 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.

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.

# 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. 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. Also at WSU, the COVID-19 pandemic and associated lockdowns starting March 2020 have caused some delays in the CAMMSE project activities. Regional wildfire in August 2020 also caused some delays in the CAMMSE project activities at WSU. Our plan to resolve the aforementioned problems will be to catch up on 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

Nothing to report

## 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<br>Yi Qi | Applied Research | Use of Vessel Automatic Information System Data to Improve Multi-modal Transportation in and around the Ports |
| | Yi Qi | Applied Research | Use of Innovative Intersection Designs for Improving Mobility and Reducing Roadway Traffic Congestion |

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

| University | Principle Investigator(s) | Category | Title of the Funded Project |
|---|---|---|---|
| **University of North Carolina at Charlotte** | Wei Fan | Advanced Research | Use of Multisensor Data in Modeling Freeway Travel Time Reliability |
| | Wei Fan<br>Martin Kane | Applied Research | Using General Transit Feed Specification (GTFS) Data as a Basis for Evaluating and Improving Public Transit Equity |
| | Wei Fan<br>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<br>Charles Patton<br>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<br>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<br>Mehdi Azimi<br>Qun Zhao | Applied Research | Determination of Freeway Acceleration Lane Length for Smooth ad Safe Truck Merging |
| | Yi Qi<br>Mehdi Azimi<br>Qun Zhao | Applied Research | Innovative Countermeasures for Reducing the Truck Waiting Time at Marine Terminals |

| | | | |
|---|---|---|---|
| | Mehdi Azimi<br>Yi Qi<br>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<br>Martin Kane | Applied Research | Optimizing Transit Equity and Accessibility by Integrating Relevant GTFS Data Performance Metrics |
| | Wei Fan<br>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<br>Nicholas Lownes | Applied Research | Highways and Wealth Distribution: A Geospatial Analysis |
| | Karthik Konduri<br>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<br>Carol Atkinson-Palombo | Applied Research | Understanding the Surprising and Oversized Use of Ridesourcing Services in Poorer Neighborhoods in NYC |
| **Washington State University** | Michelle Akin<br>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<br>Mehdi Azimi<br>Qun Zhao | Applied Research | Development of Guidelines for Implementation of Contraflow Left-Turn Lanes at Signalized Intersections |
| | Yi Qi<br>Qun Zhao<br>Mehdi Azimi | Applied Research | Signal Timing Strategy for Displaced Left Turn Intersections |
| | Mehdi Azimi<br>Yi Qi | Applied Research | Impacts of Bicycling Corridor Improvements on Users' Behaviors in Large Cities |

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

| 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<br>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<br>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<br>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<br>Mehdi Azimi<br>Qun Zhao | Applied Research | A New Method for Estimating Truck Queue Length at Marine Terminal Gates |
| | Mehdi Azimi<br>Yi Qi | Applied Research | Analysis of Intermodal Vessel-to-Rail Connectivity |
| | Mehdi Azimi<br>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** | Nicholas Lownes<br>Timothy Becker | Advanced Research | Pedestrian Behavior and Interaction with Autonomous Vehicles |
| | John Ivan<br>Amy Burnicki | Applied Research | Estimation of Pedestrian Compliance at Signalized Intersections Considering Demographic and Geographic Factors |
| | Carol Atkinson Palombo<br>Norman Garrick | Applied Research | An Evaluation of the Transportation Equity Impacts of Uber and Lyft Usage in Chicago |
| **Washington State University** | Ji Yun Lee | Advanced Research | Effect of Connected and Autonomous Vehicles on Supply Chain Performance |
| **Texas Southern University** | Yi Qi<br>Mehdi Azimi<br>Qun Zhao | Applied Research | Short Term Intersection Traffic Flow Forecasting |
| | Yi Qi<br>Mehdi Azimi<br>Qun Zhao | Applied Research | The Impacts of COVID-19 on Public Transit |
| | Mehdi Azimi<br>Yi Qi | Applied Research | Studying the Impact of Pandemic Outbreaks on Maritime Transportation and Port Operation |


# Center for Advanced Multimodal Mobility Solutions and Education