



## Center for Advanced Multimodal Mobility Solutions and Education

### USDOT Tier 1 University Transportation Center Semi-Annual Progress Report #5

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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 2020 Year 4 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 30, 2019. The submission deadline for all project proposals were Friday, July 12, 2019 at 4:00 pm. Research proposals 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 16 of them for funding. The decision letters were sent to all PIs by Friday, August 16, 2019. The appendix contains the list of the funded projects (in Year 4) 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 are also in the processing of being posted on the CAMMSE website as well as on RiP as required by OST-R. All funded projects in the fourth year (i.e., in the year of 2019-2020) 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 *ASCE Journal of Transportation Engineering, Part A: Systems*, *International Journal of Pavement Engineering*, *Journal of Transportation Safety & Security*, *Accident Analysis and Prevention*, *Journal of Modern Transportation*, *IEEE Transactions on Services Computing*, *IEEE Transactions on Vehicular Technology*, *Transportation Research Record: Journal of Transportation Research Board* and *Journal of the Air and Waste Management Association*.

During this reporting period, CAMMSE research results were also presented at many conferences on different occasions, which include the 19<sup>th</sup> COTA International Conference of Transportation Professionals, the 1<sup>st</sup> International Transport Frontier Seminar of Hebei Province, 2019 World Transport Convention, the 2<sup>nd</sup> Annual National Mobility Summit of US DOT University Transportation Centers, 2019 ASCE International Conference on Transportation and Development, ITE Northeastern District Annual Meeting and the Quality and Productivity Research Conference.

In addition, CAMMSE has completed all 17 research projects of year 2 during this reporting period. All final project reports of year 2 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 reviewer for two USDOT UTC proposals including one for "USDOT Tier 1 University Transportation Center - Freight Mobility Research Institute (FMRI) at the Florida Atlantic University in April 2019, and the other for "USDOT Region 4 - Southeastern Transportation Research" at the University of Florida in August 2019. Dr. Wei Fan also served as a panel member for three NCHRP projects, including: 1). NCHRP Synthesis 20-05/Topic 50-10 Availability of Pedestrian Infrastructure Data for Routing and Network Analysis, 2). NCHRP 08-116 Framework for Managing Data from Emerging Transportation Technologies to Support Decision-Making, and 3). NCHRP 03-131 Guidance for Planning and Implementing Multimodal, Integrated Corridor Management. During this reporting period, Dr. Wei Fan also served as the Co-Chair of the Connected Autonomous Vehicles Section for the World Transport Convention. In addition, Dr. Wei Fan was selected for receiving the Best Area Editor award in the 19<sup>th</sup> COTA International Conference of Transportation Professionals in July 2019.

During this reporting period, CAMMSE Center Director and Associate Directors have been actively serving on many editorial boards (e.g., 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 board of the *International Journal of Transportation*, *International Journal of Transportation Science and Technology*, *Asian Transport Studies*, *Institute of Transportation Engineers*, *Journal of Infrastructure Preservation and Resilience*, *Journal of Transportation Research Part D*, *Transportation Letters*, and *Transportmetrica A: Transport Science*), and many professional committees (e.g., member of the World Transport Convention Shared Logistics and Transportation Systems Committee, PENC state board, ASCE Advanced Technologies Committee, ASCE Connected & Autonomous Vehicles Impacts Committee, ASCE Public Transport Committee, ASCE Rail Transportation Committees, NCSITE Scholarship Committee, TRB Standing Committees (AHB60, AHD60, AP025, ADB10, ABR10, ABJ70, AFN30, ADC20, ADC60, AFP40, AT050, AW010 and AW020), session chair of the INFORMS, Co-General Chair of the 6<sup>th</sup> International Workshop on Crowd Assisted Sensing, Pervasive Systems and Communications (CASPer 2019), Co-General Chair of the IEEE 38<sup>th</sup> International Performance Computing and Communications Conference (IPCCC 2019), Co-Chair of Connected Autonomous Vehicles Section for the 3<sup>rd</sup> World Transport Convention, Session Chair and Co-Chair of Subcommittee for the 3<sup>rd</sup> World Transport Convention, 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), the dissertation award committee of the Hong Kong Society of Transportation Studies, the dissertation award committee of the Hong Kong Society of Transportation Studies, and also the organizing committee of the 2019 International Conference on Transportation Infrastructure and Materials.

### **Education and Workforce Development**

CAMMSE has been working with 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.

CAMMSE Center Staff (Drs. Wei Fan, Miguel Pando, David Weggel, Martin Kane, and Yu Wang) has been meeting on a regular basis. Topics discussed among these important regular meetings include, but are not limited to, the second annual research symposium, annual summer camp at UNCC, research, education and outreach as well as technology transfer activities. In particular, on April 28, 2019, CAMMSE graduate students conducted outreach activities in the NC Science Expo Festival on the campus of UNCC. On May 7, 2019, CAMMSE Director Dr. Wei Fan and six graduate students participated in the 1<sup>st</sup> NCDOT Research Summit hosted by the North Carolina Agricultural and Technical State University (NCAT) at Greensboro, NC. Also, the 3<sup>rd</sup> CAMMSE Transportation Summer Camp was held from June 10 to 14 at UNC Charlotte. Drs. Miguel Pando, David Weggel and Martin Kane helped coordinate this event. This edition of the camp had 23 participants from grade 9 to 11 with 31% of the campers being females. On August 16, 2019, Dr. Martin Kane conducted educational outreach activities to the "Youth in Planning Day" organized by the Charlotte Planning, Design & Development at the City of Charlotte by touring the UNCC Engineering Department (ages 12 and older) and discussed about transportation at first hand. On September 27, 2019, Dr. Martin Kane served for the Networking/Alumni part of the Engineering Picnic and Job Fair. 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 to understand way. Students also had to use creativity to think of an interesting way to capture young children's attention and keep them engaged. 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 "Traffic Control and Operation" course in the Spring 2019 semester and "Transportation System Analysis" course in the Fall 2019 semester to several graduate students. Dr. Yu Wang gave one invited talk at Beijing University of Posts and Telecommunications in July 2019, and advised an REU student during Summer 2019 on smart sensing. Dr. Martin Kane served as a committee chair for Victor Saha's master work and also a committee member for Ravina Jain's master presentation. In September 18, 2019, CAMMSE INES Ph.D. research assistant Mr. Pengfei Liu was a Second Place Award Winner out of 16 posters at the UNCC's Civil and Environmental Engineering Graduate Research Symposium. From March to July 2019, Mr. Yu Pan, a visiting scholar from Wuhan University of Science and Technology (China) joined and worked with CAMMSE research group at UNCC. Another visiting scholar, Ms. Yizhe Yang from Heibei University of Technology (China) joined CAMMSE in September 2019 and is currently conducting collaborative research with CAMMSE research group at UNCC.

At Washington State University (WSU), the Ph.D. students Sen Du and Yan Zhang were awarded the Richard Perteet Graduate Fellowship in Civil Engineering and the Howard & Martha Copp Scholarship, respectively, chosen by the Department of Civil and Environmental Engineering. Michelle Akin led a WSU team to conduct a wide variety of K-12 outreach activities, as part of the research project. Some tools that were used for outreach included wind-up cars, balloon cars, alternate fuels display and a steam-powered boat. Dr. Michelle Akin designed a Multimodal Transportation Engineering Curriculum for Middle and High School Students funded by the CAMMSE through UNCC from April to September 2019. Some students won the scholarships, including: Mehrzad Mehrabipour (the 2019 President Leadership Award of WSU), Rasool Mohebifard (the 2019 WSU Outstanding Research Assistant Excellence Award), Rasool Mohebifard (the 2019 Civil and Environmental Engineering Department Outstanding Teaching Assistant



Award of WSU), Mehrzad Mehrabipour (the 2019 Helene M. Overly Memorial Scholarship, Women's Transportation Seminar Scholarships, Puget Sound Chapter), Rasool Mohebifard and Mehrdad Tajalli (the 2019 Pertee Engineering Graduate Fellowship in Civil Engineering of WSU), and Rasool Mohebifard (the 2019 Ph.D. Student Workshop on Transportation and Logistics Challenges and Opportunities travel scholarship, National Science Foundation).

At Texas Southern University (TSU), there were five undergraduate and six graduate transportation related courses offered by faculty who are associated with CAMMSE. One master thesis was directly supported by CAMMSE, which was "Signal Design and Timing for Continuous Flow Intersection". The TSU Summer Maritime Academy (SMA) was held from June 10-14, 2019, on the campus of TSU. The day camp was designed to introduce rising high school sophomores through seniors to the maritime and transportation industry and to the Maritime Transportation Management and Security degree offered at TSU. In addition, during the reporting period, two Transportation Seminars were held at TSU.

At University of Connecticut (UConn), the Transportation Undergraduate Research Fellowship (TURF) has supported over two dozen students. Student-led research projects were conducted under the supervision of CAMMSE faculty. TURF fellows presented the results of their research at a seminar in the fall.

At the University of Texas at Austin (UT Austin), there were a total of 10 students involved in CAMMSE projects, including both graduate and undergraduate students. The University of Texas student team again won the Annual ITE International Traffic Bowl Competition in June 2019.

### **Technology Transfer**

CAMMSE faculty, staff, researchers and students have been making presentations at different meetings including the 2<sup>nd</sup> Annual National Mobility Summit of USDOT University Transportation Centers in April 11, 2019, Washington, D.C.; the 1<sup>st</sup> NCDOT Research & Innovation Summit in May 7, 2019; the ACWA Stormwater Summit in May 8, 2019; the ITE Northeastern District Annual Meeting in May 10, 2019; the Quality and Productivity Research Conference in June 2019, Washington D.C., the ASCE International Conference on Transportation and Development in June 11, 2019; the 2019 World Transport Convention in June 16, 2019 in Beijing, China; the 1<sup>st</sup> International Transport Frontier Seminar of Hebei Province in June 18, 2019, Shijiazhuang Tiedao University, China; 2019 Council of University Transportation Centers (CUTC) Summer Meeting from June 24-26, 2019 in Norman, OK; the 19<sup>th</sup> COTA International Conference of Transportation Professionals in July 7, 2019, Nanjing, China; and the webinar co-sponsored by CESTiCC, CAMMSE, and TRB AHD65 (Winter Maintenance) Committee on both May 20 and August 12, 2019.

At UConn, a law event entitled "Putting Humans in the AV Drivers' Seat: People, Policy & Law" was held on April 1, 2019. This research included: What does the public want from Autonomous Vehicles? and How Do Policy-Makers Respond to that input? In this pilot project, UConn staff conducted a forum to engage the general public about what their "hopes and fears" surrounding Autonomous Vehicles. The findings will be presented to the Connecticut Task Force on Autonomous Vehicles to understand how policy-makers view and incorporate public perspectives into the policy-making process.

At UT Austin, there are a total of four active projects sponsoring two master's students, six PhD students, one undergraduate student, three principal investigators, and one researcher. One of the best technology transfer tools are 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. UT students are invited to spend time in



the City Traffic Control Center representing a valuable learning environment, but the learning is really two-way as the City engineers and students learn from each other.

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 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 working with other UTCs, such as attending the second annual national mobility summit of USDOT UTCs. Dr. Fan also collaborated with several other universities across the country and abroad (e.g., NCAT, NC State University, and Tongji University) in co-writing proposals and/or papers. Dr. Yu Wang collaborated with Dr. Fan Li's group in Beijing Institute of Technology on vehicular networks and smart sensing.

At WSU, during this time period, Dr. Xianming Shi (WSU) served as a visiting professor at Wuhan Polytechnic University, China. Dr. Shi also hosted two visiting scholars from Harbin Institute of Technology and another one from Wuhan University of Science and Technology, China. Dr. Shi also collaborated with Oregon State University and University of Washington for a Connected Vehicle research project. Michelle Akin was an active member of the Palouse STEAM Coalition, coordinating quarterly forums with keynote speakers and professional development hours for in-service teachers.

During the reporting period, TSU collaborated with other universities on developing new proposals (e.g., with University of Houston and Case Western Reserve University on two national NSF proposals; and with University of Texas at El Paso and University of Houston on two TxDOT proposals).

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, seven international graduate students (Mr. Zhen Chen, 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 advised by Dr. Wei Fan to conduct his thesis research. Dr. Wei Fan also served as the advisor of two Chinese visiting scholars (Ms. Yizhe Yang and Mr. Yu Pan). At WSU, one female research engineer (Michelle Akin, P.E.) has been actively involved in all the CAMMSE projects. One female minority undergraduate (civil engineering) student (Nicole Kim, WSU), and another female undergraduate student (Olivia Willis) were involved in CAMMSE 2019 Project 15. Three international graduate students (Mr. Chuang Chen, Mr. Sen Du, and Mr. Yan Zhang, all from P.R. China) worked on CAMMSE research projects. Starting August 2019, a female international Ph.D. student (Aya Shatanawi, from Jordan) joined the Transportation Engineering PhD. Program and she will be contributing to the CAMMSE research projects. At TSU, two undergraduate students and nine graduate students have been working as research assistants and supported by CAMMSE. They all come from different background, including five female students and nine international students. In addition, TSU is one of the nation's largest historically black universities, and the majority of students enrolled are minority students. At UT Austin, students sponsored by CAMMSE come from all sorts of diverse backgrounds. Specifically, UT Austin supported two females (Ms. Zenia and Ms. Carolina)

and seven males (Mr. Hao, Mr. Abdullah, Mr. Kun, Mr. Suyash, Mr. Jonathan, Mr. Cesar, and Mr. Tengkuo) through CAMMSE.

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

The bi-weekly seminars at UNCC are open to the general public, particularly to the local and state transportation agencies, as well as the industry practitioners. At WSU, Dr. Xianming Shi gave two presentations including “Multiple Dimensions to the Sustainability of Winter Road Maintenance Operations” on May 20, 2019, and “The Search for ‘Greener’ Materials for Winter Road Maintenance Operations” on August 12, 2019 in the webinar co-sponsored by CESTiCC, CAMMSE, and TRB AHD65 (Winter Maintenance) Committee. At TSU, CAMMSE organized Transportation Seminar Series, which is open to faculty, students and general public. During the reporting period, two seminars were held: “University District Automated Vehicle Shuttle at TSU” by Kimberly Williams, the Esquire Chief Innovation Officer of Houston METRO, and “The key word for Transportation in the 21<sup>st</sup> Century is choice” by Dr. Alena Mikhaylova from Rinker Materials Concrete Pipe. Also, CAMMSE funding provides research assistantships to students who want to develop their careers in transportation area.

### **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. UT Austin has presented the results through conference proceedings, technical reports, technical presentations and website in: <http://sboyles.github.io/>, <https://sites.utexas.edu/machemehl/> and <http://www.mass-lab-ut.com/>.

### **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 2 (2017-2019) 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) For all research projects that were selected for funding in 2020 year 4, the CAMMSE project information forms will be posted and updated on the CAMMSE website as well as on RiP once the subcontracts are officially signed.
- (3) CAMMSE Center Director Dr. Wei Fan plans to attend and present at the Third Annual National Mobility Summit of US DOT University Transportation Centers, April 2, 2020, Washington, D.C.
- (4) Attend North Carolina Section Institute of Transportation Engineers (NCSITE) Annual Meeting in November 2019 to present papers based on research, and attend the 2020 TRB 99<sup>th</sup> Annual Meeting that will be held January 12-16, 2020 at the Walter E. Washington Convention Center in Washington, D.C.

## 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**

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

### 2.2. What organizations have been involved as partners?

**Table 2.** A List of Organizations Creating Partnerships with CAMMSE

Organization Name	Type / Location	Partners Contribution to Project				
		Financial Support	In-kind Support	Facilities	Collaborative Research	Personal Exchanges
Capital Metro – Austin Public Transit	Government /TX		X	X		
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		
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					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	
Northeast Forestry University	University /China				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	
Qilu University of Technology	University /China				X	X
Texas Department of Transportation	Government /TX		X	X		
Texas Southern University	University /TX	X	X	X		
Tongji University	University /China				X	
University of Arizona	University				X	

	/AZ					
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 Texas at Austin	University /TX	X	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		
Wuhan University of Science and Technology	University /China				X	

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

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

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

Dr. Wei Fan, CAMMSE Director, has been making presentations, working, 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. Dr. Fan was also invited to give presentations at several other universities in China (e.g., Shijiazhuang Tiedao University, Wuhan University of Science and Technology, Qilu University of Technology at Jinan, and South China University of Technology) and is currently building a collaborative relationship with these universities.

The PacTrans, Region 10 UTC has been involved by sharing the interests in exploring CV technologies for better winter road maintenance operations and in reaching out to K-12 groups. TSU established a collaboration with Houston Bike Share, a 501(c)(3) non-profit organization the bike share program (Houston BCycle) in Houston. Houston Bike Share shared the ridership data including trip start time and date, trip end time and date, trip duration, start station, end station, number of docks per station, bicycle id, etc. to be used in CAMMSE's research project. 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.

## 3. OUTPUTS

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

#### Journal publications

- [1] Gu, J.J., Jiang, Z., Fan, W., Wu, J. and Chen, J., Real-Time Passenger Flow Anomaly Detection Considering Typical Time Series Clustered Characteristics at Metro Stations, Accepted for Publication, *ASCE Journal of Transportation Engineering, Part A: Systems*, September 2019.
- [2] Xu, Y.L., Fan, W., Cheng, P.F. and Shan, L.Y., Mechanical Characterisation of Interface Shear Strain of Multi-Layer Composite Pavement, *International Journal of Pavement Engineering*, <https://doi.org/10.1080/10298436.2019.1662905>, September 2019.
- [3] Liu, P. and Fan, W., Analysis of Head-On Crash Severity Using A Partial Proportional Odds Model, Accepted for Publication, *Journal of Transportation Safety & Security*, <https://doi.org/10.1080/19439962.2019.1667933>, September 2019.
- [4] Li, Y. and Fan, W., Modelling Severity of Pedestrian-Injury in Pedestrian-Vehicle Crashes with Latent Class Clustering and Partial Proportional Odds Model: A Case Study of North Carolina, *Accident Analysis and Prevention*, Volume 131, pp. 284-296, July 2019.
- [5] Chen, Z. and Fan, W., Data Analytics Approach for Travel Time Reliability Pattern Analysis and Prediction, *Journal of Modern Transportation*, pp. 1-16, September 2019.
- [6] Teng, J., Chen, T. and Fan, W., An Integrated Approach to Vehicle Scheduling and Bus Timetabling for an Electric Bus Line, Accepted for Publication, *ASCE Journal of Transportation Engineering, Part A: Systems*, July 2019.
- [7] Lin, Z. and Fan, W., Cyclist Injury Severity Analysis with Mixed Logit Models at Intersections and Non-intersection Locations, *Journal of Transportation Safety & Security*, <https://doi.org/10.1080/19439962.2019.1628140>, May 2019.
- [8] Zhu, W., Wei, J. and Fan, W., Data Fusion Approach for Evaluating Route Choice Models in Large-Scale Complex Urban Rail Transit Networks, Accepted for Publication, *ASCE Journal of Transportation Engineering, Part A: Systems*, April 2019.
- [9] Li, Y., Li, F., Yang, S., Wu, Y., Chen, H., Sharif, K. and Wang, Y., MP-Cooperation: Competitive and Cooperative Mechanism for Multiple Platforms in Mobile Crowd Sensing, Accepted for Publication, *IEEE Transactions on Services Computing (TSC)*, May 2019.
- [10] Laha, A., Yin, B., Cheng, Y., Cai, X. L. and Wang, Y., Game Theory Based Charging Solution for Networked Electric Vehicles: A Location-Aware Approach, *IEEE Transactions on Vehicular Technology (TVT)*, Volume 68, Issue 7, pp. 6352-6364, July 2019.
- [11] Liu, Y., Hao, L., Liu, Z., Sharif, K., Wang, Y. and Das, S., Mitigating Interference via Power Control for Two-Tier Femtocell Networks: A Hierarchical Game Approach, *IEEE Transactions on Vehicular Technology (TVT)*, Volume. 68, Issue 7, pp. 7194-7198, July 2019.
- [12] Akin, M., Fay, L. and Shi, X., Friction and Snow-Pavement Bond after Salting and Plowing Permeable Friction Surfaces. *Transportation Research Record – Journal of Transportation Research Board*, 2019.
- [13] Sun, X., Chen, X., Qi, Y., Mao, B., Yu, L. and Tang, P., Effects of Advanced Traffic Signal Status Warning Systems on Vehicle Emission Reductions at Signalized Intersections, *Journal of the Air and Waste Management Association*, <https://doi.org/10.1080/10962247.2018.1506834>, Volume 69, Issue 4, pp. 391-401, April 2019.
- [14] Wang, Q. and Lownes, N.E., All Links Based E-Hailing Service Surcharge Mechanism and Performance Estimation, *Transportation Research Record – Journal of Transportation Research Board*, <https://doi.org/10.1177/0361198119850799>. pp. 1-16, June 2019.

#### Conference papers

- [1] Xie, Y., Li, F., Wu, Y., Yang, S., and Wang, Y., D3-Guard: Acoustic-based Drowsy Driving Detection Using Smartphones, IEEE 38<sup>th</sup> Conference on Computer Communications (INFOCOM 2019), April 2019, Paris, France.



- [2] Wang, Q., Miao, F., Wu, J., Niu, Y., Wang, C. and Lownes N.E. Dynamic Pricing for Autonomous Vehicle E-hailing Services Reliability and Performance Improvement, Proceedings of the 2019 IEEE 15<sup>th</sup> International Conference on Automation Science and Engineering, Paper No. 547. July 2019, Vancouver, BC, Canada.

## Presentations

- [1] Liu, P. and Fan, W., Impact of Connected and Autonomous Vehicles on Freeway Capacity Using Microscopic Traffic Simulation, Department of Civil and Environmental Engineering Graduate Research Symposium, UNC Charlotte, September 13, 2019.
- [2] Fan, W., Optimal Variable Speed Limit Control in Connected Autonomous Vehicle Environment for Mitigating Freeway Congestion, South China University of Technology, Guangzhou, China, July 17, 2019.
- [3] Fan, W., Optimal Variable Speed Limit Control in Connected Autonomous Vehicle Environment for Mitigating Freeway Congestion, Wuhan University of Science and Technology, Wuhan, China, July 15, 2019.
- [4] Fan, W., Optimal Variable Speed Limit Control in Connected Autonomous Vehicle Environment for Mitigating Freeway Congestion, Invited Presentation, Tongji University, Shanghai, China, July 11, 2019.
- [5] Fan, W., Exploring the Impact of Connected and Autonomous Vehicles on Freeway Capacity Using Microscopic Traffic Simulation, Poster Presentation, 19th COTA International Conference of Transportation Professionals, Nanjing, China, July 7, 2019.
- [6] Fan, W., Integrated Connected Autonomous Vehicles Platooning and Optimal Variable Speed Limit Control on Freeways, Poster Presentation, 19th COTA International Conference of Transportation Professionals, Nanjing, China, July 7, 2019.
- [7] Fan, W., Using General Transit Feed Specification (GTFS) Data as a Basis for Evaluating and Improving Public Transit Equity, Poster Presentation, 19th COTA International Conference of Transportation Professionals, Nanjing, China, July 7, 2019.
- [8] Fan, W., Optimal Variable Speed Limit Control at a Lane Drop Bottleneck: Tabu Search Approach, Plenary Presentation, 19th COTA International Conference of Transportation Professionals, Nanjing, China, July 6, 2019.
- [9] Fan, W., Optimal Variable Speed Limit Control in Connected Autonomous Vehicle Environment for Relieving Freeway Congestion, Keynote Speech, 1st International Transport Frontier Seminar of Hebei Province, Shijiazhuang Tiedao University, Shijiazhuang, Hebei, China, June 18, 2019.
- [10] Fan, W., Optimal Variable Speed Limit Control in Connected Autonomous Vehicle Environment for Relieving Freeway Congestion, 2019 World Transport Convention, Room 402B, China National Convention Center, Beijing, China, June 16, 2019.
- [11] Fan, W., Calibration of Microscopic Traffic Simulation Models Using Metaheuristic Algorithms, 2019 World Transport Convention, Room 215, China National Convention Center, Beijing, China, June 15, 2019.
- [12] Fan, W., Developing a Systematic Data Analytics Approach to Identifying and Ranking Freeway Bottlenecks, Keynote Presentation, Crossing-cutting Group Forum, 2019 World Transport Convention, China National Convention Center, Beijing, China, June 14, 2019.
- [13] Fan, W., Tabu Search Strategies for Variable Speed Limit Control at a Lane Drop Bottleneck, Hebei University of Technology, Tianjing, China, June 11, 2019.
- [14] Fan, W., Variable Speed Limit Control at a Lane Drop Bottleneck: Tabu Search Based Metaheuristics Approach, Qilu University of Technology, Jinan, Shandong Province, China, June 10, 2019.
- [15] Fan, W., Optimal Variable Speed Limit Control in Connected Autonomous Vehicle Environment for Mitigating Freeway Congestion, North Carolina Agricultural and Technical State University, May 7, 2019.
- [16] Fan, W., Year 2 Updates and Recent Activities at Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE), University Research Panel, the Second Annual National Mobility Summit of US DOT University Transportation Centers, April 11, 2019, Washington, D.C.
- [17] Shi, X. The Search for "Greener" Materials for Winter Road Maintenance Operations. A webinar co-sponsored by CESTiCC, CAMMSE, and TRB AHD65 (Winter Maintenance) Committee. August 12, 2019.

- [18] Shi, X. Multiple Dimensions of Sustainable Winter Road Operations. Presentation invited by the School of Transportation Engineering, Changsha University of Technology, Changsha, Hunan, China, June 28, 2019.
- [19] Shi, X. Multiple Dimensions of Sustainable Winter Road Operations. Presentation invited by the Yunan Institute of Building Sciences, Kunming, Yunan, China, June 25, 2019.
- [20] Shi, X. Multiple Dimensions of Sustainable Winter Road Operations. Presentation invited by the School of Transportation Science & Engineering, Beihang University, Beijing, China. June 12, 2019.
- [21] Shi, X. Multiple Dimensions of Sustainable Winter Road Operations. Presentation invited by the National Center for Materials Service Safety, Beijing University of Science and Technology, Beijing, China. June 10, 2019.
- [22] Shi, X. Multiple Dimensions to the Sustainability of Winter Road Maintenance Operations. A webinar co-sponsored by CESTiCC, CAMMSE, and TRB AHD65 (Winter Maintenance) Committee. May 20, 2019.
- [23] Shi, X. Environmental Risks of Snow/Ice Control Materials: A Hidden Cost of Winter Mobility. Presentation invited by the ACWA Stormwater Summit, Eugene, OR, May 8, 2019.
- [24] Lownes, N.E. Big Data and Analytics for Rail and Public Transit, ASCE International Conference on Transportation and Development, June 11, 2019.
- [25] Smith, R. and Lownes, N.E. A Method for Assessing Transit Access of Specific Populations to Basic Services Utilizing the Transit Opportunity Index, ASCE International Conference on Transportation and Development, June 10, 2019.
- [26] Zhang, B. and Lownes, N.E. Impacts of accessibility to public transportation on residential property values in Connecticut, ASCE International Conference on Transportation and Development, June 10, 2019.
- [27] Smith, R., Bertolaccini, K and Lownes N.E. Scoring Public Housing Locations: Using Developer Data to Measure Transit Access to Basic Services, ITE Northeastern District Annual Meeting, May 10, 2019.
- [28] Toman, Patrick T. 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, June 2019.

### 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

UConn proposed a new technique of using dynamic compositional modeling as well as global and local Moran's I statistics for the ridesourcing data framework based on the project of "Are Transportation Network Companies Synergistic with Other Shared Ride Mode Offerings? An Exploratory Analysis of Demand Data from NYC Utilizing High Resolution Spatiotemporal Models". Detailed information is provided as follows:

- (1) Dynamic Compositional time series analysis, using the following R packages: xts, compositions, vars, KFAS
- (2) Spatio-temporal analysis using the following R packages: forecast, tseries, fGarch, plyr, sf, tmap, raster, spdep, mapview, gridExtra, tidyverse, broom, reshape2

UT Austin also developed two novel methods, including:

- (1) Mohamed, A., Hua, X., Zhou, X., Claudel, C. (2019) IEA: Inner Ensemble Average within a convolutional neural network. Center for Transportation Research. <https://arxiv.org/abs/1808.10350>.
- (2) Mohamed, A., Claudel, C. (2019) MCRM: Mother Compact Recurrent Memory. Center for Transportation Research. <https://arxiv.org/abs/1808.02016>

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

Nothing to report.

### 3.5. Other outputs

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

- [1] "Optimizing Transit Equity and Accessibility by Integrating Relevant GTFS Data Performance Metrics (TGI)", Presented by Mr. Yang Li (CAMMSE INES Ph.D. research assistant), 9-10am, September 25, 2019, EPIC CEE Conference Room 3344.
- [2] "Temporal Instability and Latent Transition Analysis", Presented by Mr. Pengfei Liu (CAMMSE INES Ph.D. research assistant), 9-10am, September 18, 2019, EPIC CEE Conference Room 3344.
- [3] "Bicycle Volume: Counting Machine Validation & Correction, Estimating & Forecasting, and Analysis of Injury Risk: An Upcoming NCDOT Research Project", Presented by Ms. Zijing Lin (CAMMSE INES Ph.D. research assistant), 9-10am, September 11, 2019, EPIC CEE Conference Room 3344.
- [4] "Travel Time Prediction Using XGBoost Model", Presented by Mr. Zhen Chen (CAMMSE INES Ph.D. research assistant), 9-10am, September 4, 2019, EPIC CEE Conference Room 3344.
- [5] "Topics about the Statistic Inferences and Applied Regression Analysis", Presented by Mr. Bo Qiu (CAMMSE INES Ph.D. research assistant), 9-10am, August 28, 2019, EPIC CEE Conference Room 3344.
- [6] "Latent Tree Analysis (LTA): A Brief Introduction", Presented by Mr. Yang Li (CAMMSE INES Ph.D. research assistant), 9-10am, August 21, 2019, EPIC CEE Conference Room 3344.
- [7] "The Role of Intersection and Street Design on Severity of Bicycle-motor Vehicle Crashes", Presented by Ms. Zijing Lin (CAMMSE INES Ph.D. research assistant), 9-10am, May 8, 2019, EPIC CEE Conference Room 3344.
- [8] "Cluster Analysis", Presented by Mr. Pengfei Liu (CAMMSE INES Ph.D. research assistant), 9-10am, April 24, 2019, EPIC CEE Conference Room 3344.
- [9] "Tuning Parameters in XGBoost Model", Presented by Mr. Zhen Chen (CAMMSE INES Ph.D. research assistant), 9-10am, April 17, 2019, EPIC CEE Conference Room 3344.
- [10] "Resample Methods in Machine Learning", Presented by Mr. Bo Qiu (CAMMSE INES Ph.D. research assistant), 9-10am, April 10, 2019, EPIC CEE Conference Room 3344.
- [11] "Latent Class Analysis Using SAS and R - A Brief Introduction", Presented by Mr. Yang Li (CAMMSE INES Ph.D. research assistant), 9-10am April 3, 2019, EPIC CEE Conference Room 3344.

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

- [1] "A Resume and Career Development Workshop", lectured By Dr. Patrick Madsen, the Director of The University Career Center at UNC Charlotte. EPIC 3222, September 23, 2019.
- [2] "The key word for Transportation in the 21st Century is 'choice'", lectured by Dr. Alena Mikhaylova, from Rinker Materials Concrete Pipe. TSU, 2019.

#### **Transportation Undergraduate Research Fellowship (TURF) Program @ UConn, Sponsored by CAMMSE**

In Summer 2019, CAMMSE funds were used to support three TURF Fellows with \$2,000 fellowships to conduct independent transportation research under the supervision of a UConn transportation faculty member. The students conducted their research over approximately 10 weeks during the summer, and then presented the results of their work at the UConn Graduate Transportation Seminar on September 30, 2019. The three students were:

- [1] Bridget Burke: "Electric Vehicle Distribution in New York" (advisor: Carol Atkinson-Palombo)

- [2] Bartosz McCormick: “Utilizing Machine Learning to Develop a Robust Method for Calculating Gross Vehicle Weight in Strain Time History Based Bridge Weigh-in-Motion Applications.” (advisor: Shinae Jang)
- [3] Akira Dunham: “Mobility Options to basic services in rural Connecticut” (advisor: Nicholas Lownes)

### Technical Reports

- [1] Fan, W. and Chen, Z., *Use of Multisensor Data in Modeling Freeway Travel Time Reliability*, Technical Report for CAMMSE Research 2018 Project 01, September 2019.
- [2] Fan, W. and Li, Y., *Using General Transit Feed Specification (GTFS) Data as a Basis for Evaluating and Improving Public Transit Equity*, Technical Report for CAMMSE Research 2018 Project 02, September 2019.
- [3] Fan, W. and Lin, Z., *Evaluating the Potential Use of Crowdsourced Bicycle Data in North Carolina*, Technical Report for CAMMSE Research 2018 Project 03, September 2019.
- [4] Fan, W. and Liu, P., *Impact of Connected and Automated Vehicles (CAVs) on Freeway Capacity*, Technical Report for CAMMSE Research 2018 Project 04, September 2019.
- [5] Fan, W. and Yu, M., *Optimal Variable Speed Limit Control for the Mixed Traffic Flows in a Connected and Autonomous Vehicle Environment*, Technical Report for CAMMSE Research 2018 Project 05, September 2019.
- [6] Fu, M. and Machemehl, R. *Characterization of Bicycle Rider Behavior among Various Street Environments*, Technical Report for CAMMSE Research Project 2018 Project 06, September 2019.
- [7] Ahmed A. and Machemehl, R. *Evolution of Advanced Signal Priority with Gap-Based Signal Recovery Strategy*, Technical Report for CAMMSE Research Project 2018 Project 07, September 2019.
- [8] Stephen B. and Yahia, C. *Assessment of Parcel Delivery Systems Using Unmanned Aerial Vehicles*, Technical Report for CAMMSE Research Project 2018 Project 08, September 2019.
- [9] Christian C. and Adel, A. *User Trajectory Estimation from Visual Features: Development of Inner-Ensemble Averaging (IEA) for Deep Learning*, Technical Report for CAMMSE Research Project 2018 Project 09, September 2019.
- [10] Lownes, N., Bertolaccini, K. and Smith, R., *Investigating the Linkage Between Transit Access to Services and Affordable Housing Availability*, Technical Report for CAMMSE Research Project 2018 Project 10, September 2019.
- [11] Konduri, K., *Development of Continuous Time, Temporally Constrained and Behaviorally Consistent Tour Pattern Generation System for Modeling the Impacts of Autonomous Vehicle Future*, Technical Report for CAMMSE Research Project 2018 Project 11, September 2019.
- [12] Garrick, N. and Atkinson-Palombo, C., *What Do We Want from Autonomous Vehicles (AVs)? Using Participatory Planning and Scenario Analysis of Alternative Features to Identify Stakeholders' Desired Outcomes from the Strategic Deployment of Emerging Transportation Technology*, Technical Report for CAMMSE Research Project 2018 Project 12, September 2019.
- [13] Qi, Y., Zhao, Q., Liu, S. and Li, J. *Determination of Freeway Acceleration Lane Length for Vehicle Safe Merging*, Technical Report for CAMMSE Research Project 2018 Project 13, September 2019.
- [14] Qi, Y., Zhao, Q., Azimi, M. and Jinna, H. *Innovative Countermeasures for Reducing the Truck Waiting Time at Marine Terminal*, Technical Report for CAMMSE Research Project 2018 Project 14, September 2019.
- [15] Azimi, M., Lan, L. and Qi, Y. *Investigating the Impact of Different Attributes on Bicycling Mode Share as A Multimodal Connectivity Strategy in Large Cities: A Case Study in Houston*, Technical Report for CAMMSE Research Project 2018 Project 15, September 2019.
- [16] Akin, M., Zhang, Y. and Shi, X., *Developing Friction Data to Support the Optimal Use of Pre-Wet Deicing Salt for Enhanced Winter Mobility*, Technical Report for CAMMSE Research 2018 Project 16, U.S. Department of Transportation, October 2018
- [17] Chen, C. and Shi, X. *Modeling the Macroscopic Effects of Winter Maintenance Operations on Traffic Mobility on Washington Highways*. Technical Report for CAMMSE Research 2018 Project 17, August 2019.

## 4. OUTCOMES

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

TSU's research project "Innovative Countermeasures for Reducing the Truck Waiting Time at Marine Terminals" increased understanding and awareness of terminal congestion issue through literature review and survey relevant personnel at the Port and Trucking companies.

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

The role of cycling in city transportation systems has gained increasing attention in the recent years with increasing cycle usage, improving the first mile/last mile connection to other modes of transportation, and lessening the environmental impacts of transportation activities. 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" examines the users' activities and investigates the impacts of different attributes on the bike share usage. The findings of this research will help planners predict hourly ridership, choose future station locations, and improve and rebalance the bicycle efficiency.

Ensemble learning is a method of combining multiple trained models to improve model accuracy. Research team from UT Austin proposed the usage of such methods, specifically ensemble average, inside Convolutional Neural Network (CNN) architectures by replacing the single convolutional layers with Inner Average Ensembles (IEA) of multiple convolutional layers. Empirical results on different benchmarking datasets show that CNN models using IEA outperform those with regular convolutional layers. A visual and a similarity score analysis of the features generated from IEA explains why it boosts the model performance.

LSTMs and GRUs are the most common recurrent neural network architectures used to solve temporal sequence problems. The two architectures have differing data flows dealing with a common component called the cell state (also referred to as the memory). UT Austin attempts to enhance the memory by presenting a modification that they call the Mother Compact Recurrent Memory (MCRM). MCRMs are a type of a nested LSTM-GRU architecture where the cell state is the GRU hidden state. The concatenation of the forget gate and input gate interactions from the LSTM are considered an input to the GRU cell. Because MCRMs has this type of nesting, MCRMs have a compact memory pattern consisting of neurons that acts explicitly in both long-term and short-term fashions. For some specific tasks, empirical results show that MCRMs outperform previously used architectures.

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

TSU's research project "*Determination of Freeway Acceleration Lane Length for Vehicle Safe Merging*" considered the acceleration characteristics of heavy trucks and developed an analytical model for estimating the required freeway acceleration lane lengths for both heavy trucks and passenger cars. In addition, this research provides a chart and a lookup table for estimating required acceleration lane lengths for both heavy trucks and passenger cars under different traffic volume conditions for different

combinations of the freeway and entrance ramp design speeds, which is an improvement of current ASSHTO Greenbook's recommendation.

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**

One CAMMSE sponsored master student graduated at TSU. The education he received at TSU and CAMMSE makes him a trained transportation professional.

From UT Austin, two students involved in CAMMSE graduated with their MS degrees.

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

Nothing to report.



## 5. IMPACTS

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

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

Nothing to report.

### **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?**

Nothing to report.

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

Nothing to report.

### **5.4. What is the impact on transportation workforce development?**

Nothing to report.

## 6. CHANGES AND PROBLEMS

### 6.1. Changes in approach and reasons for change

Nothing to report.

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

Nothing to report.

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

Mrs. Michelle Akin, P.E. has served as the PI for the CAMMSE Project titled “Multimodal Transportation Engineering Curriculum for Middle and High School Students” (April 2019 - Sept. 2020). She has resigned from WSU in June 2019 but promised to deliver the draft project final report by Dec. 2019. Dr. Xianming Shi is working with Michelle Akin and the student Olivia Willis to wrap up this project, but a request for PI change may be necessary.

Dr. Ali Hajibabaie has left WSU for the North Carolina State University, but he remains to be affiliated with WSU and plans to complete the CAMMSE Project under the WSU contract with UNCC.

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

Nothing to report.

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

Nothing to report.

### 6.6. Additional information regarding products and impacts

With respect to Project 2019 Project 08. Deep-Learning Based Trajectory Forecast for Safety of Intersections with Multimodal Traffic (Continuation): since the beginning of the project UT Austin has worked on modeling the interactions between pedestrians and rest of vehicles and used deep learning methods for this. Since the deep learning methods are not very robust, UT Austin has investigated modifications of the standard architecture (second reference in the above list: MCRM) and have worked on improving robustness through ensemble averaging (IEA: first reference on the list). UT Austin now has preliminary results on the actual problem but would like not to share these results in reports as UT Austin is about to submit them to the CVPR conference (deadline on November 15). After the deadline UT Austin will publish these.

## 7. SPECIAL REPORTING REQUIREMENTS

- (1) **External Advisory Board:** Available on the program website:  
<https://cammse.uncc.edu/directory/external-advisory-board>
- (2) **Financial and Annual Recipient Share Reports:** The SF 425 requirements will be met by separate reports.

# APPENDIX

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

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

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

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

	Mehdi Azimi Yi Qi Qun Zhao	Applied Research	Investigating the Impact of Different Attributes on Bicycling Mode Share as A Multimodal Connectivity Strategy in Large Cities: A Case Study in Houston
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CAMMSE @ UNC Charlotte Funded Projects, 2018-2020 (Year 3), Ongoing

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

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

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



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