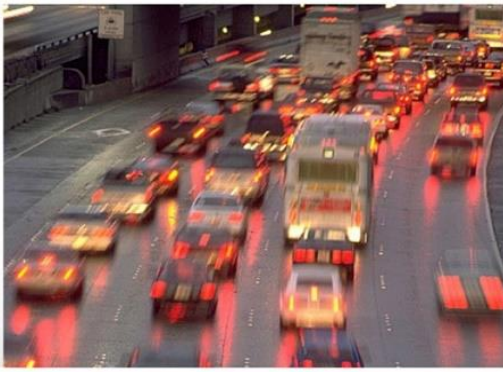
Center for Advanced Multimodal Mobility Solutions and Education

CAMMSE



UNC CHARLOTTE

Annual Performance Indicators Report for University Transportation Centers

UTC 1987 2020

October 1, 2020 to September 30, 2021

Submitted by

Center for Advanced Multimodal Mobility Solutions and Education

Prepared for

Office of the Assistant Secretary for Research and Technology (OST-R)
U.S. DEPARTMENT OF TRANSPORTATION

University of North Carolina at Charlotte (Lead)	Charlotte, NC 28223
University of Texas at Austin	Austin, TX 78712
University of Connecticut	Storrs, CT 06269
Washington State University – Pullman	Pullman, WA 99164
Texas Southern University	Houston, TX 77004



TABLE OF CONTENTS



1. PROGRAM INFORMATION

USDOT Tier 1 University Transportation Center

Annual Performance Indicators Report

Submitted to:	U.S. Department of Transportation Office of the Assistant Secretary for Research and Technology (OST-R)
Grant Number:	69A3551747133
Project Title:	Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE)
Center Director:	Wei (David) Fan, Ph.D., P.E. Professor Department of Civil and Environmental Engineering University of North Carolina at Charlotte 9201 University City Blvd., Charlotte, NC 28223 wfan7@uncc.edu | 704-687-1222
Submission Date:	October 26, 2021
DUNS:	06-630-0096
EIN:	56-0791228
Recipient Organization:	University of North Carolina at Charlotte
Project/Grant Period:	November 30, 2016 - September 30, 2022
Reporting Period Start Date:	October 1, 2020
Reporting Period End Date:	September 30, 2021
Report Term or Frequency:	Annual Performance Indicators
Signature of Submitting Official:	



2. PROGRAM-WIDE INDICATORS

University Transportation Centers Program Performance Indicators

UTC Name:	Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE)
University:	Lead University: • University of North Carolina at Charlotte (UNCC) Consortium Member Universities: • University of Texas at Austin (UT Austin) • University of Connecticut (UConn) • Washington State University – Pullman (WSU) • Texas Southern University (TSU)
Grant #:	69A3551747133
Reporting Period:	October 1, 2020 to September 30, 2021

Performance Indicators	Total	UNCC	UT Austin	UConn	WSU	TSU
1. Number of transportation-related courses offered during the reporting period that were taught by faculty and/or teaching assistants who are associated with the UTC						
Undergraduate courses	28	4	5	11	1	7
Graduate courses	22	3	3	5	1	10
2. Number of students participating in transportation research projects during the reporting period funded by this grant						
Undergraduate students in research	4	0	2	1	1	0
Graduate students in research	36	11	7	7	3	8
3. Number of transportation-related advanced degree programs that utilize grant funds during the reporting period to support graduate students						
Masters level programs	3	1	1	0	0	1
Doctoral level programs	5	1	1	2	1	0
4. Number of students supported by this grant during the reporting period						
Undergraduate students	4	0	2	1	1	0

Masters students	11	0	3	1	0	7
Doctoral students	23	9	4	6	3	1
5. Number of degrees awarded during the reporting period to students supported by this grant						
Undergraduate degrees	2	0	1	1	0	0
Masters degrees	4	0	0	1	0	3
Doctoral degrees	4	3	0	0	1	0
6. Number and total dollar value of research projects selected for funding during the reporting period using UTC grant funds (Federal and/or Recipient Share) that you consider to be applied research and advanced research						
Number of applied research projects	8	0	2	3	0	3
Dollar value of applied research projects	$601,354.00	-	$220,580.00	$190,387.00	-	$190,387.00
Number of advanced research projects	2	0	1	0	1	0
Dollar value of advanced research projects	$128,462.00	-	$65,000.00	-	$63,462.00	-

3. UTC-SPECIFIC INDICATORS

3.1. University of North Carolina at Charlotte

Part II – UTC-Specific Performance Indicators		
UTC Name	**Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE)**	
University	**University of North Carolina at Charlotte**	
Grant #	**69A3551747133**	
Reporting Period	**October 1, 2020- September 30, 2021**	
Category	**Description of indicator**	**Metric**
1. Research Capability	• Research results published in: *Analytic Methods in Accident Research, ASCE Journal of Transportation Engineering, Part A: Systems, International Journal of Transportation Science and Technology, Journal of Safety Research, Sustainability, Journal of Transportation Safety & Security, Smart and Resilient Transportation, Traffic Injury Prevention, Transportation Planning and Technology, Promet-Traffic&Transportation.* • Transportation Research results presented at: 2020 NCDOT Virtual Research & Innovation Summit, CEGR 6090/CEGR 8090/INES 8202 Course, COTA Research Lightning Talks Zoom Webinars, NC Transportation Center of Excellence on Connected and Autonomous Vehicle Technology (NC-CAV) Seminar Series, NC	• Number of refereed journal publications (20) 1. Li, Y. and Fan, W., Optimizing Transit Equity and Accessibility of the City of Charlotte by Integrating Transit Gap Index, A General Transit Feed Specification (GTFS) Data Relevant Performance Metric, *ASCE Journal of Transportation Engineering, Part A: Systems*, Volume 147 (4), 04021005. January 2021. 2. Li, Y., Song, L. and Fan, W., Day-of-the-Week Variations and Temporal Instability of Factors Influencing Pedestrian Injury Severity in Pedestrian-Vehicle Crashes: A Random Parameters Logit Approach with Heterogeneity in Means and Variances, *Analytic Methods in Accident Research*, Volume 29, 100152, March 2021. 3. Li, Y. and Fan, W., Bi-Level Optimization of Long-Term Highway Work Zone

	Transportation Centers of Excellence Year 1 Update and Technical Advisory Panel Meeting, The 100th Annual Meeting of the Transportation Research Board, Third Annual CAMMSE Research Symposium, UNCC Department of Civil and Environmental Engineering Graduate Research Symposium, UNCC INES 8102/8104 Infrastructure Systems.	Scheduling Considering Elastic Demand, Accepted for Publication, *Smart and Resilient Transportation*, June 2021. 4. Lin, Z. and Fan, W., Exploring Bicyclist Injury Severity in Bicycle-vehicle Crashes Using Latent Class Clustering Analysis and Partial Proportional Odds Models, *Journal of Safety Research*, Volume 76, pp.101-117. February 2021. 5. Liu, P. and Fan, W., Extreme Gradient Boosting (XGBoost) Model for Vehicle Trajectory Prediction in Connected and Autonomous Vehicle Environment, *Promet - Traffic&Transportation*, Vol. 33, No. 5, pp. 767-774, 2021. 6. Liu, P. and Fan, W., Exploring the Impact of Connected and Autonomous Vehicles on Mobility and Environment at Signalized Intersections through Vehicle-to-Infrastructure (V2I) and Infrastructure-to-Vehicle (I2V) Communications, *Transportation Planning and Technology*, October 2020. 7. Liu, S., Fan, W. and Li, Y. Injury Severity Analysis of Rollover Crashes for Passenger Cars and Light Trucks Considering Temporal Stability: A Random Parameters Logit Approach with Heterogeneity in Means and Variances, Accepted for Publication, *Journal of Safety Research*, March 2021. 8. Liu, S., Lin, Z. and Fan, W., Investigating Contributing Factors to Injury Severity Levels in Crashes Involving Pedestrians and Cyclists Using Latent Class Clustering Analysis and Mixed Logit Models, *Journal of Transportation Safety & Security*, pp.1-28, July 2021. 9. Liu, S. and Fan, W., Investigating Operational

		Performance of Connected and Autonomous Vehicles on Signalized Superstreets, *Transportation Planning and Technology*, Volume 44, Issue 6, pp. 594-607, June 2021. 10. Song, L., Fan, W., Li, Y. and Wu, P., Exploring Pedestrian Injury Severities at Pedestrian-Vehicle Crash Hotspots with An Annual Upward Trend: A Spatiotemporal Analysis with Latent Class Random Parameter Approach, *Journal of Safety Research*, Volume 76, pp.184-196, February 2020. 11. Song, L., Li, Y., Fan, W. and Wu, P., Modeling Pedestrian-Injury Severities in Pedestrian-Vehicle Crashes Considering Spatiotemporal Patterns: Insights from Different Hierarchical Bayesian Random-Effects Models, *Analytic Methods in Accident Research*, Volume 28, 100137, December 2020. 12. Song, L. and Fan, W., Exploring Truck Driver-Injury Severity at Intersections Considering Heterogeneity in Latent Classes: A Case Study of North Carolina, Accepted for Publication, *International Journal of Transportation Science and Technology*, December 2020. 13. Song, L., Fan, W. and Li, Y., Time-of-day Variations and the Temporal Instability of Multi-vehicle Crash Injury Severities under the Influence of Alcohol or Drugs after the Great Recession, *Analytic Methods in Accident Research*, Volume 32, pp. 100183: 1-17, December 2021. 14. Song, L., Li, Y., Fan, W. and Liu, P., Mixed Logit Approach to Analyzing Pedestrian Injury Severity in Pedestrian-Vehicle Crashes in North



		Carolina: Considering Time-of-day and Day-of-week, *Traffic Injury Prevention*, Volume 22, Issue 7, pp. 524-529, July 2021. 15. Song, L., Fan, W. and Liu, P., Exploring the Effects of Connected and Automated Vehicles at Fixed and Actuated Signalized Intersections with Different Market Penetration Rates, *Transportation Planning and Technology*, Volume 44, Issue 6, pp. 577-593, June 2021. 16. Zhu, W., Xiao, X., Huang, Z. and Fan, W., Evaluating the Wheelset Health Status of Rail Transit Vehicles: Synthesis of Wear Mechanism and Data-Driven Analysis, *ASCE Journal of Transportation Engineering, Part A: Systems*, Volume 146, Issue 12, October 2020. 17. Chen, Z. and Fan, W., A Freeway Travel Time Prediction Method Based on an XGBoost Model, *Sustainability*, Volume 13, Issue 15, pp. 8577: 1-15, July 2021. 18. Qiu, B. and Fan, W., Machine Learning Based Short-Term Travel Time Prediction: Numerical Results and Comparative Analyses, *Sustainability*, Volume 13, Issue 13, pp. 7454: 1-19, July 2021. 19. Qiu, B. and Fan, W., Travel Time Forecasting on a Freeway Corridor: a Dynamic Information Fusion Model based on the Random Forests Approach, Accepted for Publication, *Smart and Resilient Transportation*, June 2021. 20. Qiu, B. and Fan, W., Mixed Logit Models for Examining Pedestrian Injury Severities at Intersection and Non-Intersection Locations,

		Journal of Transportation Safety & Security, pp.1-25, June 2021. • Number of conference papers presented, and other presentations made (18) • Number of technical research reports published (6) 1. Hajibabai, L., Hajbabaie, A., Tajalli, M., Mirheli, A., and Fan, W. *Utilization Measurement and Management of Fleet Equipment* (No. NCHRP Project 13-05). National Cooperation Highway Research Program, Washington, D.C. February 2021. 2. Fan, W. and Qiu, B., *Travel Time Forecasting on a Freeway Corridor: a Dynamic Information Fusion Model Based on the Random Forests Approach*, Technical Report for CAMMSE Research 2020 Project 01, U.S. Department of Transportation, September 2021. 3. Fan, W. and Li, Y., *Optimization of Long-Term Highway Work Zone Scheduling*, Technical Report for CAMMSE Research 2020 Project 02, U.S. Department of Transportation, September 2021. 4. Fan, W. and Liu, S., *Impact of Connected and Autonomous Vehicles on Nontraditional Intersection Design: Superstreets*, Technical Report for CAMMSE Research 2020 Project 03, U.S. Department of Transportation, September 2021. 5. Fan, W. and Liu, P., *Machine Learning-based Trajectory Optimization of Connected and Autonomous Vehicles*,

		Technical Report for CAMMSE Research 2020 Project 04, U.S. Department of Transportation, September 2021. 6. Fan, W., Lin, Z., Liu, S., Searcy, S. and Carter, B., *Bicycle Volume: Counting Machine Validation & Correction, Estimating & Forecasting, and Analysis of Injury Risk*, Technical Report for Research Project 2020-43, North Carolina Department of Transportation (NCDOT), FHWA/NC/2020-43, September 2021.
2. Leadership	• Handling Editor, *TRR Inaugural Editorial Board of Transportation Research Record* • Guest Editor-in-Chief, *Journal of Advanced Transportation* • Guest Lead Editor, *Journal of Traffic and Transportation Engineering, Special Issue on How to Break through the Barriers Hindering Connected and Automated Vehicles (CAVs) Hitting the Ground Running* • Guest Editor, *World Electric Vehicle Journal (Special Issue Title: Emerging Technologies in Electrification of Urban Mobility)* • Associate Editor, *IEEE Transactions on Intelligent Transportation Systems*, *ASCE Journal of Transportation Engineering, Part A: Systems, International Journal of Transportation Science and Technology* • Editorial Board, *Journal of World Review of Intermodal Transportation Research* • Chair, 2020 CAMMSE Research Symposium • Co-Chair, Connected and Autonomous Vehicles Section, World Transport Convention	• Handling Editor (1) • Guest Editor-in-Chief (1) • Guest Lead Editor (1) • Guest Editor (1) • Editorship (4) • Organizing committee chair, secretary, session chair or area editor of conference (4) • Number of professional committees or board member (13) • Technical Reviewer (4)

	• Secretary, TRB Committee on Light Rail Transit Systems (AP075) • Conference Organizer and Moderator, the Sixth COTA Webinar Panel • Member, Board of Director, Chinese Overseas Transportation Association (COTA) • Advisory Board Member, ASCE National Artificial Intelligence (AI) Committee • Member, ASCE National Connected & Autonomous Vehicles Impacts Committee, TRB Standing Committees (A0020C, ACP60, AP075, AHB60), WTC Shared Logistics and Transportation Systems Committee, NCDOT Fully Autonomous Vehicle (FAV) Research Working Group Committee, ASCE National Public Transport Committee, ASCE National Rail Transportation Committee, NCSITE Scholarship Committee, PENC State Board • Technical Reviewer, Luxembourg National Research Fund (NSF) Technical Report Review, Independent Research Fund Denmark, USDOT Tier 1 UTC - Freight Mobility Research Institute, National Science Foundation Review Panel	
3. Education and Workforce Development	• Four existing undergraduate courses and three existing graduate courses • Eleven graduate students in CAMMSE projects • Two degree programs in the Department of Civil and Environmental Engineering, College of Engineering, UNC	• Transportation related courses offered by faculty (7) • Number of students participating in CAMMSE funded projects (11) • Number of transportation related degree programs with students funded by

	Charlotte • Three doctoral students graduated • Eight UNC Charlotte ITE student chapter seminars and thirty-two UNC Charlotte transportation graduate student weekly seminars • Conducted CLT Airport Webinar and CAMMSE's Transportation Engineering Summer Camp	CAMMSE (2) • Number of graduated students (3) • Number of education and outreach, and workforce development activities (2) • Number of research symposium (1) • Number of transportation seminars (40) • Student scholarships or awards (4) 1. Shaojie Liu, Third Place Award, 2021 Graduate Research Symposium, Department of Civil and Environmental Engineering, UNC Charlotte, April 9, 2021. 2. Zhen Chen and Wei Fan, Most Cited Article for the Year 2020 Award, International Journal of Transportation Science and Technology, January 2021. 3. Yang Li, Don Blackburn Memorial Scholarship, North Carolina Section of the Institute of Transportation Engineers, McKimmon Center, North Carolina State University, Raleigh, NC, November 2020. 4. Pengfei Liu, Cyrus Painter Memorial Scholarship, North Carolina Section of the Institute of Transportation Engineers, McKimmon Center, North Carolina State University, Raleigh, NC, November 2020.
4. Technology Transfer	• Three presentations were made at the Department of Civil and Environmental Engineering Graduate Research Symposium at UNC Charlotte • Four presentations at the Third Annual CAMMSE Research Symposium at UNC Charlotte • One presentation at the NC Transportation Centers of Excellence Year 1 Update and	• Presentations given at professional and academic meeting (18) • Number of professionals in the audience (est. 600)

	Technical Advisory Panel Meeting • Four poster presentations and one presentation at the 2020 NCDOT Virtual Research & Innovation Summit, University of North Carolina at Chapel Hill • One presentation at the COTA Research Lightning Talks Zoom Webinars • Two presentations at the UNCC INES Invited Guest Lecture Series • One presentation at the NC Transportation Center of Excellence on Connected and Autonomous Vehicle Technology (NC-CAV) Seminar Series at North Carolina A&T University • One presentation at the 100th Annual Meeting of the Transportation Research Board at Washington D.C.	
5. Collaboration	• North Carolina DOT, North Carolina A&T State University, and North Carolina State University in collaborative research and UNC Charlotte in providing cash, in-kind support, facilities, etc. • Research Collaboration with Tongji University • Center personnel: Dr. Wei Fan, Dr. Martin Kane, Dr. David Weggel, and Kim Wilson	• Number of collaborative partners (4) • Number of national and international collaboration (1) • Number of Center personnel involved (4)

3.2. University of Texas at Austin

Part II – UTC-Specific Performance Indicators		
UTC Name	**Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE)**	
University	**University of Texas at Austin**	
Grant #	**69A3551747133**	
Reporting Period	**October 1, 2020 - September 30, 2021**	
Category	**Description of indicator**	**Metric**
1. Research Capability	• Research results published in: *IEEE Transactions on Intelligent Transportation Systems* • Research results presented at the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR)	• Number of refereed publications (3) 1. Vishnoi S. C. and Claudel, C. G. Variable Speed Limit and Ramp Metering Control of Highway Networks using Lax-Hopf Method: A Mixed Integer Linear Programming Approach, *IEEE Transactions on Intelligent Transportation Systems*, March 2021. 2. Liu, H., Claudel, C., and Machemehl, R., Robust Traffic Control Using a First Order Macroscopic Traffic Flow Model, *IEEE Transactions on Intelligent Transportation Systems*, pp. 1-15, May 2021. 3. Liu, H., Claudel, C., Machemehl, R., and Perrine, K. A., A Robust Traffic Control Model Considering Uncertainties in Turning Ratios, *IEEE Transactions on Intelligent Transportation Systems*, pp. 1-17, February 2021. • Number of refereed conference proceedings (2) 1. Abduallah, M., Qian, K., Elhoseiny, M. and Claudel, C. *Social-STGCNN: A Social*

		Spatio-temporal Graph Convolutional Neural Network for Human Trajectory Prediction. In Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition, pp. 14424-14432. 2020. 2. Mohamed, A., Chen, H., Wang, Z., and Claudel, C. *Skeleton-Graph: Long-Term 3D Motion Prediction From 2D Observations Using Deep Spatio-Temporal Graph CNNs Code instructions, The ROAD Challenge: Event Detection for Situation Awareness in Autonomous Driving*. In Proceedings of the IEEE International Conference on Computer Vision Workshops, 2021.
2. Leadership	• Associate Editor, *ITE Journal - Institute of Transportation Engineers, IEEE Transactions on Intelligent Transportation Systems* • Editorial Board, *Transportation Research Part B*, *Transportation Research Part C*, *Journal of Infrastructure Systems* • Chair, TRB, Transit, Freight, and Logistics Subcommittee • Member, TRB Transportation Network Modeling Committee	• Editorship (5) • Committee membership (2)
3. Education and Workforce Development	• Five undergraduate courses and three graduate courses • Three undergraduate students and seven graduate students in CAMMSE projects • Two degree programs in the Cockrell School of Engineering in the Civil, Architectural and Environmental Engineering Department	• Transportation related course offered by faculty (8) • Number of students participating in CAMMSE funded projects (10) • Number of transportation related degree programs with students funded by CAMMSE (2)
4. Technology Transfer	• One undergraduate student graduated with CAMMSE support • Four Ph.D. student, three MS students, and two undergraduates	• Number of graduated students (1) • Number of students supported by CAMMSE (9)

	have been supported by CAMMSE this past year. The CAMMSE-supported students that have graduated during this reporting period will carry the new technology that they have developed with them for the rest of their careers • The professors at UT Austin have also used their classes to teach the new techniques developed through the CAMMSE UTC, therefore planting the new technology in students that are not directly supported by the UTC	• Number of students in courses taught by CAMMSE-related faculty members (249) • Number of presentations (8) 1 Machemehl, R., Understanding E-Scooter Paths in Urban Infrastructure, presented at the Third Annual CAMMSE Research Symposium, UNC Charlotte, November 5, 2020. 2 Machemehl, R., Connected and Autonomous Vehicle and Machine Learning Applications, presented at the Third Annual CAMMSE Research Symposium, UNC Charlotte, November 5, 2020. 3 Boyles, S., Assessment of Parcel Delivery Systems using Unmanned Aerial Vehicles, presented at the Third Annual CAMMSE Research Symposium, UNC Charlotte, November 5, 2020. 4 Claudel, C., Social-STGCNN: A Spatial-Temporal Graph Convolutional Neural Network for Human Trajectory Prediction, presented at the Third Annual CAMMSE Research Symposium, UNC Charlotte, November 5, 2020. 5 Machemehl, R., Are E-Scooters a Transit Last-Mile Solution? presented at the Third Annual CAMMSE Research Symposium, UNC Charlotte, November 6, 2020. 6 Hall, J., Forecasting Bicycle Facility Demand, presented at the Third Annual CAMMSE Research Symposium, UNC Charlotte, November 5, 2020. 7 Qian, K., Real-time Mobile Sensor Management Framework for City-Scale Environmental Monitoring,

		presented at the Third Annual CAMMSE Research Symposium, UNC Charlotte, November 5, 2020. 8 Vishnoi, S., Variable Speed Limit and Ramp Metering Control of Highway Networks using Lax-Hof Method: A Mixed Integer Linear Programing Approach, presented at the Third Annual CAMMSE Research Symposium, UNC Charlotte, November 5, 2020.
5. Collaboration	• City of Austin in collaborative research and UT's Center for Transportation Research providing in-kind support, facilities, etc. • National Science Foundation (NSF) on Project 2020 Project 08 • Prof. Wang at the ECE department, UT Austin • Prof. Thomaz Edison's group in ECE at UT Austin • Prof. Linda Boyle's group in Civil Engineering at University of Washington • Center personnel: Dr. Randy Machemehl, Dr. Stephen Boyles, Dr. Christian Claudel, Carolina Baumanis	• Number of collaborative partners (5) • Number of Center personnel involved (4)



3.3. University of Connecticut

Part II – UTC-Specific Performance Indicators		
UTC Name	**Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE)**	
University	**University of Connecticut**	
Grant #	**69A3551747133**	
Reporting Period	**October 1, 2020 to September 30, 2021**	
Category	**Description of indicator**	**Metric**
1. Research Capability	• Research results published in: *ISPRS International Journal of Geo-Information* • Research results presented in: Third Annual CAMMSE Virtual Research Symposium, Bridging Transportation Researchers #3 Conference	• Number of refereed journal publications (1) 1. Zhang, B., Li, W., Lownes, N. and Zhang, C., Estimating the Impacts of Proximity to Public Transportation on Residential Property Values: An Empirical Analysis for Hartford and Stamford Areas, Connecticut. *ISPRS International Journal of Geo-Information*. Volume 10 (2), 44., January 2021. • Number of conference papers presented, and other presentations made (8) 1. Ivan, J.N. and Burnicki, A., Estimation of Pedestrian Volume Using Geospatial and Traffic Conflict Data, Third Annual CAMMSE Virtual Research Symposium, November 5, 2020. 2. Maher, A., Atkinson-Palombo, C. and Garrick, N., Evidence of Ridesourcing Increasingly Being Used for Commuting in New York City's Low-Income Communities, Third Annual CAMMSE Virtual Research Symposium,

		November 5, 2020. 3. Lownes, N., Prioritizing People - Mixed Equilibrium Assignment for AV Based on Occupancy, Third Annual CAMMSE Virtual Research Symposium, November 5, 2020. 4. Cohen, J. and Lownes, N., Highways and Wealth Distribution: A Geospatial Analysis, Third Annual CAMMSE Virtual Research Symposium, November 5, 2020. 5. Zhu, J. and Ren, Z., Entropy-based Diversity Quantification of Multimodal Transportation Systems: Physical Infrastructure Perspective versus Travel Behavior Perspective, Third Annual CAMMSE Virtual Research Symposium, November 5, 2020. 6. Mantri, S., People - Mixed Equilibrium Assignment for AV Based on Occupancy, Third Annual CAMMSE Virtual Research Symposium, November 5, 2020. 7. Tanvir, A., Using Computational Biology to Mitigate Path Overlap in Transit Assignment, Third Annual CAMMSE Virtual Research Symposium, November 5, 2020. 8. Joshi, P., Ivan, J., and Burnicki, A. Effects of Traffic Conflicts on Pedestrian Crossing Volume Considering Geospatial & Other Location Data, An online presentation at Bridging Transportation Researchers #3, Aug 2021. • Number of technical research reports published (3) 1. Zhu, J., Ren, Z., and Chowdhury, S., Disaster Resilience through Diverse

		Evacuation and Emergency Transportation Systems, Technical Report for CAMMSE Research 2020 Project 11, September 2021. 2. Ivan, J., Burnicki, A., Joshi, P., Estimation of Pedestrian Volume Using Geospatial and Traffic Conflict Data, Technical Report for CAMMSE Research 2020 Project 12, May 2021. 3. Mantri, S., Lownes, N., and Bergman, D., Prioritizing People – Mixed Equilibrium Assignment for AV Based on Occupancy, Technical Report for CAMMSE Research 2020 Project 09, August 2021.
2. Leadership	• Associate Editor, *Accident Intervention and Prevention*	• Editorship (1)
3. Education and Workforce Development	• Eleven undergrad course offerings and five graduate course offerings • Seven graduate students in CAMMSE projects, one undergraduate student • Two degree programs in civil engineering, geography and statistics	• Transportation related courses offered by faculty (16) • Number of students participating in CAMMSE funded projects (8) • Number of transportation related degree programs with students funded by CAMMSE (2)
4. Technology Transfer	• Two presentations at professional and academic meetings	• Presentations given at professional and academic meeting (2) • Number of professionals in the audience (est. 100)
5. Collaboration	• Connecticut DOT, CT Transit, University of Queensland. • Dissertation Reviewer, UNSW; Research Collaboration with University of Queensland • Center personnel: Drs. Nicholas Lownes, John Ivan, Jin Zhu, Amy Burnicki, Norman Garrick and Carol Atkinson-Palumbo	• Number of collaborative partners (3) • Number of international collaboration (1) • Number of Center personnel involved (6)



3.4. Washington State University – Pullman

Part II – UTC-Specific Performance Indicators		
UTC Name	**Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE)**	
University	**Washington State University**	
Grant #	**69A3551747133**	
Reporting Period	**October 1, 2020 - September 30, 2021**	
Category	**Description of indicator**	**Metric**
1. Research Capability	• Research results published in: *Canadian Journal of Civil Engineering, IEEE Transactions on Intelligent Transportation Systems, Transportation Research Part C, ASCE Journal of Cold Regions Engineering* • Research results presented at: The 100th Transportation Research Board Annual Meeting, 2021 Salt Symposium, TRB Resource Conservation and Recovery Committee (AMS20) Summer Workshop, Region 10 University Transportation Center PacTrans Annual Conference, WSU CEE Graduate Seminar, etc.	• Number of refereed journal publications (4) 1. Du, S., Akin, M., Bergner, D., Xu, G., and Shi, X., Material Application Methodologies for Winter Road Maintenance Operations: A Renewed Perspective, *Canadian Journal of Civil Engineering*, February 2021 2. Tajalli, M., and Hajbabaie, A. Traffic Signal Timing and Trajectory Optimization in a Mixed Autonomy Traffic Stream, *IEEE Transactions on Intelligent Transportation Systems*, February 2021. 3. Al Islam, S. B., Hajbabaie, A., and Aziz, H. A. A real-time network-level traffic signal control methodology with partial connected vehicle information, *Transportation Research Part C: Emerging Technologies*, Volume 121, 102830, October 2020. 4. He, Y., Akin, M., Yang, Q., and Shi, X., Conceptualizing How Agencies Could Leverage Weather-related Connected Vehicle Application to Enhance Winter Road Services, *ASCE Journal of Cold Regions Engineering*, Volume 35 Issue 3, pp. 04021011: 1-13,

		September 2021. • Number of presentations (6) • Number of technical research reports published (4) 1. Petrie, J., Qi, Y., Cornwell, M., Sarker, Md A.A., Biswas, P., Du, S., and Shi. X. *Design of Living Barriers to Reduce the Impacts of Snow Drifts on Illinois Freeways*. Final report for the Illinois Center for Transportation, Springfield, IL. Research Report No. FHWA-ICT-20-012. November 2020. 2. Hajibabai, L., Hajbabaie, A., Tajalli, M., Mirheli, A., & Fan, W. *Utilization Measurement and Management of Fleet Equipment* (No. NCHRP Project 13-05). National Cooperation Highway Research Program, Washington, D.C. February 2021. 3. Dey, K., Ashraf, Md T., Shi, X. *Multimodal Connected Vehicle Pilot for Winter Travel*. Final report for the Center for Advanced Multimodal Mobility Solutions & Education. Charlotte, North Carolina. August 2021. 4. Shi, X., Bergner, D., Du, S., Keep, D., Reed, C. *Review and Summary of Pre-wet Methods and Procedures*. Final report for the Clear Roads Pooled Fund and Minnesota Department of Transportation, June 2021.
2. Leadership	• Editor-in-Chief of *Journal of Infrastructure Preservation and Resilience*; Editorial Board of *Transportmetrica*; Editorial Board of *International Journal of Transportation Science and Technology* • Advisory Committee, Salt Symposium 2021, August 3-4, 2021, online	• Editorship (3) • Organizing committee member or subcommittee chair of conference or workshop (3) • Number of professional committees or affiliated centers (3)



	• Scientific Committee, 2021 Transportation Consortium of the South-Central States (TranSET) Conference, June 3-4, 2021, online • Transportation & Infrastructure (T&I) Committee, Cold Regions Engineering Division of ASCE, Member since June 2021 • Full Member, Sigma Xi, The Scientific Research Honor Society, Sept. 2020 – August 2021 • Affiliated Faculty, WSU Center for Environmental Research, Education, and Outreach, 2014-Present	
3. Education and Workforce Development	• Teaching the following undergraduate level course related to transportation: CE 405 Decision-making for sustainable and resilient civil infrastructure, 30 students; Teaching one graduate level courses related to transportation: CE531, Probability and Stat. Models, 18 students • Supporting three PhD students, and one undergraduate student in CAMMSE funded projects • One female PI (Dr. Ji Yun Lee), one PhD student (Jie Zhao), one female staff (Cheryl A. Reed), and one female undergraduate student (Olivia R. Willis) contributed to CAMMSE funded projects. One international Ph.D. student, Yan Zhang, assisted in the statistical analysis of the collected data	• Transportation related courses offered by faculty (2) • Student scholarships or awards (5) 1. Olivia Rose Willis: Emeritus Society Award for Excellence in Undergraduate Research 2. Olivia Rose Willis: 1) Scholarship for the Social, Economic and Behavioral Sciences, Washington State University, 2021; 2) 2020-2021 Auvil Scholars Fellowship, WSU Office of Undergraduate Research 3. Chuang Chen: Alfred Suksdorf Fellowship, Voiland College of Engineering and Architecture, Washington State University, 2020 4. Yan Zhang: University Transportation Center (UTC) Student of the Year, awarded by the U.S. Department of Transportation, 2020 • Number of students participating in CAMMSE funded projects (4) • Number of transportation related degree programs with students funded by CAMMSE (1)
4. Technology	• Two poster presentations at the	• Presentations given at

Transfer	100th Transportation Research Board Annual Meeting; 2021 Salt Symposium; WSU CEE Graduate Students; TRB Resource Conservation and Recovery Committee (AMS20) Summer Workshop; Region 10 University Transportation Center PacTrans Annual Conference	professional and academic meeting (5) • Number of professionals in the audience (102)
5. Collaboration	• West Virginia University: CAMMSE 2020 Project 16 • Washington State Potato Commission: development of a hypothetical potato supply chain system • Center personnel: Dr. Ji Yun Lee, Dr. Xianming Shi.	• Number of collaborative partners (2) • Number of Center personnel involved (2)

3.5. Texas Southern University

Part II – UTC-Specific Performance Indicators		
UTC Name	**Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE)**	
University	**Texas Southern University**	
Grant #	**69A3551747133**	
Reporting Period	**October 1, 2020 to September 30, 2021**	
Category	**Description of indicator**	**Metric**
1. Research Capability	• Research results published in: *ASCE Journal of Transportation Engineering, Part A: Systems, Entropy, Future Transportation, Gases, IEEE Access, International Journal of Engineering Science Invention (IJESI), International Journal of Environmental Research and Public Health, Journal of Advanced Transportation, Journal of Safety Research, Sustainability, Transportation Research Part D* • Research Results presented at: 100th Transportation Research Board Annual Meeting, Sixth Biennial Marine Transportation System Innovative Science and Technology Conference	• Number of refereed journal publications (12) 1. Jiang, Y., Song, G., Zhang, Z., Zhai, Z. and Yu, L. Estimation of Hourly Traffic Flows from Floating Car Data for Vehicle Emission Estimation, *Journal of Advanced Transportation*, Volume 2021, 6628335, March 2021. 2. Qiu, H., Li, X., Zhang, J., Yu, D., Yu, L., Wang, H. and Zhu, S. Single Variable-Constrained NDT Matching in Traffic Data Collection Using a Laser-based Detector, *IEEE Access*. March 2021. 3. Huang, J., Song, G., Zhang, J., Li, Z., Wu, Y. and Yu, L. The Impact of Pedestrians and Nonmotorized Vehicle Violations on Vehicle Emissions at Signalized Intersections in the Real World: A Case Study in Beijing, *Journal of Advanced Transportation*, Volume 2021, 8849234, February 2021. 4. Wang, X., Song, G., Zhai, Z., Wu, Y., Yin, H., and Yu, L., Effects of Vehicle Load on Emissions of Heavy-Duty Diesel Trucks: A Study Based on Real-World Data, *International Journal of*

		Environmental Research and Public Health, Volume 18, Issue 8, pp. 3877: 1-17, April 2021 5. Du, J., Qiao, F., Yu, L., and Lv, Y., Impact of Managed Lane Pricing Strategies on Vehicle-Sourced NOx and HC Emissions, *Gases*, Volume 1, Issue 2, pp. 117-132, June 2021. 6. Du, J., Qiao, F., Wang, H., Zhang, Y., and Yu, L., Frequent Pattern Analysis of the Roadside Safety Devices Related On-road Crashes, *International Journal of Engineering Science Invention (IJESI)*, Volume 10, Issue 5, Series I, pp. 35-46, May 2021. 7. Meng, D., Song, G., Wu, Y., Zhai, Z., Yu, L., & Zhang, J., Modification of Newell's car-following model incorporating multidimensional stochastic parameters for emission estimation, *Transportation Research Part D*, Volume 91, pp. 102692: 1-20, April 2021. 8. Qu, W., Liu, S., Zhao, Q., and Qi, Y. Methods for Identifying Truck Crash Hotspots. *Journal of Advanced Transportation*, October 2020. 9. Qu, W., Liu, S., Zhao, Q., and Qi, Y., Development of a Progression-Based, Signal-Timing Strategy for Continuous Flow Intersections, *ASCE Journal of Transportation Engineering, Part A: Systems*, Volume 147, Issue 3. pp. 04021002: 1-11, April 2021. 10. Qu, W., Li, J., Yang, L., Li, D., Liu, S., Zhao, Q., and Qi, Y. Short-Term Intersection Traffic Flow Forecasting. *Sustainability*, Volume 12(19), 8158, October 2020. 11. Li, J., Liu, J., Liu, P., and Qi, Y. Analysis of Factors Contributing to the Severity of Large Truck Crashes.

		Entropy, Volume 22 (11), 1191. October 2020. 12. Azimi, M., Oyelade, I., Aremu, A. M., Balal, E., Cheu, R. L., and Qi, Y., Selection and Implementation of Intelligent Transportation Systems for Work Zone Construction Projects, *Future Transportation*, Volume 1, Issue 2, pp. 169-187, July 2021. • Number of technical research reports published (3) 1. Qi, Y., Azimi, M., and Zhao, Q., A New Method for Estimating Truck Queue Length at Marine Terminal Gates, Technical Report for CAMMSE Research 2020 Project 13, September 2021. 2. Azimi, M., and Qi, Y., Analysis of Intermodal Vessel-To-Rail Connectivity, Technical Report for CAMMSE Research 2020 Project 14, September 2021. 3. Azimi, M., and Qi, Y., Exploring the Impact of Infrastructure on Bike Sharing System Performance in Houston City, Technical Report for CAMMSE Research 2020 Project 15, September 2021. • Number of conference papers (5) 1. Chen, X, Ye, Q., Fan, A., Zhang, Y. and Yu, L. *Developing a Bus Eco-driving Strategy with Consideration of Holding Control*. 100th Transportation Research Board Annual Meeting Paper 21-02338, Session 1393, Transportation Research Board of the National Academies, Washington D.C., January 2021. 2. Ge, M, Song, G., Zang, J., Wu, Y. and Yu, L. *Link-based Traffic Volume Forecasting for Dynamic Emission Estimation Based on Pattern*

		Clustering and Recognition. 100th Transportation Research Board Annual Meeting Paper 21-04182, Session 1253, Transportation Research Board of the National Academies, Washington D.C., January 2021. 3. Ma, J, Chen, X., Han, X. and Yu, L. *Integrated Scheduling Optimization Model with Multi-Type Bus Transit Service Patterns Considering Emissions*. 100th Transportation Research Board Annual Meeting Paper 21-02339, Session 1375, Transportation Research Board of the National Academies, Washington D.C., January 2021. 4. Wang, X, Song, G., Zhai, Z., Wu, Y. and Yu, L. *Effects of Vehicle Load on Emissions of Heavy-duty Diesel Trucks: A Study based on Real-world Data*. 100th Transportation Research Board Annual Meeting Paper 21-04178, Session 1107, Transportation Research Board of the National Academies, Washington D.C., January 2021. 5. Zhu, S, Li, X., Li, Y., Yu, D., Yu, L. and Lan, Q. *Ultra-Wideband (UWB)-Based System for Positioning at Tunneling Construction Site*. 100th Transportation Research Board Annual Meeting Paper 21-02804, Session 1205, Transportation Research Board of the National Academies, Washington D.C., January 2021. • Number of presentations (1) 1. Enamul Karim Fayek and Mehdi Azimi. *Application of Artificial Intelligence in Maritime Automation*. Sixth Biennial Marine

		Transportation System Innovative Science and Technology Conference organized by the Transportation Research Board (TRB) and the U.S. Committee on the Marine Transportation System (CMTS), March 15, 2021.
2. Leadership	• Editorial Advisory Board member of *Asian Transport Studies*, Member of Editorial Board, *Journal of Transportation Research Part D*; Associate Editor, *Current Trends in Civil & Structural Engineering* • Member, TRB Standing Committees (AT050, AW010, AW020, AW010(2), AW010(3)); Committee Research Coordinator, TRB Standing Committees (AW010); Committee Communications Coordinator TRB Standing Committees (AW020) • Member, Maritime Education, Training, and Outreach subcommittee of the Lone Star Harbor Safety Committee (LSHSC)	• Editorship (3) • Number of professional committees or affiliated centers (6) • Number and type of notable national and regional awards (1)
3. Education and Workforce Development	• Seven undergrad courses and ten graduate courses • Eight graduate students supported by CAMMSE projects • One undergraduate degree program and one M.S. degree program in the College of Science, Technology and Engineering at TSU • Three master theses directly supported by CAMMSE: “Severity analysis Analysis of the severity of large truck crashes -Comparison between the regression modeling methods with machine learning methods”, “Vessel-to-Rail Intermodal Connectivity Analysis for the Port of Houston”, and “Impact of Bicycle Corridor Improvement on User’s Behavior”. • Organized one Transportation	• Transportation related courses offered by faculty (17) • Number of faculty in transportation areas (4) • Number of students participating in CAMMSE funded projects (8) • Number of transportation related degree programs with students funded by CAMMSE (2) • Number of Master’s theses (3) • Number of seminars (7) • Student scholarships or awards (1)

	Seminars: *"Countermeasures for Post-COVID Public Transit Service Recovering".* • Organized one Education Webinar on Career Development • Organized "Lunch and Learn Series" • CAMMSE funded students received: ITS Texas Scholarship	
4. Technology Transfer	• One presentation at the Sixth Biennial Marine Transportation System Innovative Science and Technology Conference	• Presentations given at professional and academic meeting (1) • Number of technical research reports published by the consortium (3)
5. Collaboration	• Collaborate with TxDOT, Houston BCycle • Collaborate with the University of Houston and Texas A&M Transportation Institute to develop several new proposals • Collaborate with the International Association of Maritime and Port Executives (IAMPE) for a certificate program • Center personnel: Dr. Yi Qi, Dr. Lei Yu and Dr. Mehdi Azimi	• Number of collaborative partners (5) • Number of Center personnel involved (3)

Center for Advanced Multimodal Mobility Solutions and Education