UTC Semi-Annual Performance Report

Federal Agency and Organization Element to Which Report is Submitted:

United States Department of Transportation (USDOT)

Office of the Assistant Secretary of Transportation for Research and Technology (OST-R)

Federal Grant or Other Identifying Number Assigned by Agency: 69A3551747125

Project Title: Center for Advanced Transportation Mobility

Center Director Name, Title, and Contact Information

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Recipient Organization:

North Carolina Agricultural and Technical State University

1601 E. Market Street, Greensboro, NC 27411

Recipient Identifying Number or Account Number: 270128

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Report Term or Frequency: Semi-annual

Signature of Submitting Official:

Dr. Maranda McBride, Director, Center for Advanced Transportation Mobility

1. ACCOMPLISHMENTS:

What are the major goals of the program?

The Center for Advanced Transportation Mobility (CATM) will employ multidisciplinary approaches and processes to design, develop, and implement innovative solutions to the transportation needs of vulnerable populations. CATM will utilize the knowledge, skills, and expertise of its affiliates and partners to identify the needs of individuals who are often underrepresented in the design process due to specific physical and/or mental conditions or their socio/economic status. These collaborations will be leveraged to develop and implement comprehensive research, education, workforce development, and technology transfer programs that improve access to transportation for vulnerable users.

CATM endeavors to enhance the transportation industry by achieving the following goals:

1) Develop innovative assistive technologies to enable safe and efficient mobility for individuals with special needs (Research).
2) Develop forward-looking optimization tools to effectively manage transportation system disruptions (Research).
3) Promote equity by increasing access to transportation education and workforce development opportunities for underserved populations (Education, Outreach, and Workforce Development).
4) Disseminate knowledge about the transportation industry to a broad range of stakeholders using multiple technology transfer methods (Technology Transfer).

The overall goal of the center is to develop and implement research, education, outreach, workforce development, and technology transfer programs to address the need for improved mobility across multiple modes of transportation – primarily highway, rail, and air. In an effort to accomplish this goal, several activities took place during this reporting period. Table 1 provides a list of these activities and their statuses as of September 30, 2021.

Table 1: Progress of period 9 activities

Research	**Status**	**% Complete**
Complete Year 1 projects	Behind schedule	95%
Complete Year 3 projects	Behind schedule	80%
Complete Year 4 projects	Behind schedule	25%
Complete Year 5 projects	On schedule	20%
Initiate Year 6 projects	On schedule	10%
Conduct annual visit to member institutions – Year 6	Forthcoming	0%
Education, Outreach, and Workforce Development Activities		
Student participation in the 2021 SE UTC Spotlight Conference	Complete	100%
Conduct Spring 2021 student-to-student K-12 initiative workshops	Complete	100%
Recruit/select 2021 STI participants	Complete	100%
Prepare for and hold 2021 STI (virtual event)	Complete	100%
Distribute 2021-22 CATM Transportation Scholarship applications	Complete	100%
Select 2021-22 CATM Transportation Scholarship recipients	Complete	100%
Hold the Dwight David Eisenhower Transportation Fellowship Local Competition	Complete	100%
Initiate the Advancing STEM Education Through Transportation Studies Digital Badge Program	Forthcoming	0%
Hold transportation case competition	Forthcoming	0%
Student participation in the 2022 SE Region UTC conference	Forthcoming	0%
Student participation in the 2022 TRB conference	Forthcoming	0%
Develop and hold 2022 Transportation Awareness Day	Forthcoming	0%

Technology Transfer Activities		
Create and distribute Spring 2021 newsletter	Complete	100%
Create and distribute Fall/Winter 2021 newsletter	On schedule	80%
Conduct 2021 research webinars	On schedule	50%
Plan and hold the 2021-22 Annual CATM Symposium	On schedule	25%
Assist with the 2022 SE Region UTC Conference planning	On schedule	25%
US DOT Reporting Activities		
Update records in RiP database	Complete	100%
Complete and submit PPPR#8	Complete	100%
Complete and submit SF425 for Q16 and Q17	Complete	100%
Complete and submit 2021 recipient share report	On schedule	80%
Complete and submit 2021 performance indicator report	Behind schedule	80%
Complete and submit PPPR#9	Behind schedule	75%
Complete and submit SF425 for Q18 and Q19	Forthcoming	0%
Complete and submit 2022 recipient share report	Forthcoming	0%
Review year 3 final reports for completed research projects	On schedule	60%
Upload year 3 final reports to TRID database	On schedule	60%
Review year 4 final reports for completed research projects	On schedule	15%
Upload year 4 final reports to TRID database	Forthcoming	0%
Review year 5 final reports for completed research projects	Forthcoming	0%
Upload year 5 final reports to TRID database	Forthcoming	0%

What was accomplished under these goals?

During the reporting period, a variety of accomplishments were made in the areas of research, education/workforce development, and technology transfer. A summary of the activities and the associated accomplishments are described below.

Research

Table 2 provides a running list of the year 1 through 5 projects that were active at the beginning of the reporting period along with their statuses, the primary research priority areas that are addressed by each project, and the link to the project abstracts. This is followed by a summary of the key accomplishments associated with each project.

Table 2: Funded projects active during reporting period

Project Title	Status/Award Year	Research Priority Area(s)	Project Link
Automated Last Mile Connectivity for Vulnerable Road Users	Completed/Y1	IM, RC, PS	https://www.ncat.edu/cobe/transportation-institute/catm/alms.php
Development, Design, and Calibration of the Vulnerable Road User Mobility Assistance Platform	Continuing/Y1	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/vrumap.php
Multi-agent Reinforcement Learning-based Pedestrian Dynamics Models for Emergency Evacuation	Continuing/Y3	IM, RC	https://www.ncat.edu/cobe/transportation-institute/catm/multi-agent-pedestrian-dynamic-models.php
DRONETIM: Dynamic Routing Of uNmanned-aerial and Emergency Team Incident Management	Continuing/Y3	IM, RC, PS	https://www.ncat.edu/cobe/transportation-institute/catm/dynamic-routing-unmanned-aerial.php
VRU-Personalized, Optimum, and Dynamic (POD) Routing	Completed/Y3	IM	https://www.ncat.edu/cobe/transportation-institute/catm/vrupod.php

Real-Time Recommendations for Traffic Control in an Intelligent Transportation System During an Emergency Evacuation	Continuing/Y3	IM, RC	https://www.ncat.edu/cobe/transportation-institute/catm/real-time-traffic-control-intelligent-system.php
Discrete Dynamics and Epidemiological Multi-Physics Models for Transportation Applications	Completed/Y4	IM, RC	https://www.ncat.edu/cobe/transportation-institute/catm/discrete-dynamics.php
Multi-scale and Collaborative Disaster Evacuation Planning Framework	Continuing/Y4	IM, RC	https://www.ncat.edu/cobe/transportation-institute/catm/multi-scale-collab-disaster-evac.php
Detecting Early-Stage Dementia Using Naturalistic Driving	Continuing/Y4	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/detecting-dementia.php
Evaluation of Web-Based Driving Feedback for Teens and their Parents	Continuing/Y4	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/web-based-driving.php
Epidemiological Models for Transportation Applications: Secondary Crashes	Continuing/Y4	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/epidemiological-models-secondary-crashes.php
Real-Time Recommendations for Traffic Control in an Intelligent Transportation System During an Emergency Evacuation – Part 2	Continuing/Y4	IM, RC	https://www.ncat.edu/cobe/transportation-institute/catm/real-time-traffic-control-part2.php
Vulnerable Road Users demand-responsive Transit Optimization with healthcare Privatization (VRUTOP)	Continuing/Y4	IM	https://www.ncat.edu/cobe/transportation-institute/catm/vrutop.php
Acoustic Situation Awareness and Its Effects on Pedestrian Safety within a Virtual Environment	Continuing/Y4	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/acoustic-situation-awareness.php
Equitable Dynamic Pricing for Express Lanes	Continuing/Y5	IM, RC	https://www.ncat.edu/cobe/transportation-institute/catm/15-equitabledynamicpricingforexpresslanes.php
Analyzing the Role of Air-Transportation in COVID-19 Pandemic Disaster	Continuing/Y5	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/24-airtransportationcovid19.php
Machine Learning for Dynamic Airspace Configuration towards Optimized Mobility in Emergency Situations	Continuing /Y5	IM, RC	https://www.ncat.edu/cobe/transportation-institute/catm/25-machinelearningabstract.php
Mask-Wearing Behaviors in Air Travel During Coronavirus Pandemic– An Extended Theory of Planned Behavior Model	Continuing/Y5	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/26-maskwearingabstract.php
Modeling Future Outbreaks of COVID-19 Using Traffic as Leading Indicator	Continuing/Y5	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/27-modelingfutureoutbreaks.php

Usability of Urban Air Mobility: Quantitative and Qualitative Assessments of Usage in Emergency Situations	Continuing/Y5	IM, PS, RC	https://www.ncat.edu/cobe/transportation-institute/catm/28-urbanairmobilityabstract.php
Connected electric vehicles: Vehicle-pedestrian communications to enhance vision impaired pedestrian safety	Continuing/Y5	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/29-cev-visionimpairedabstract.php

IM = Improving mobility of people and goods; RC = Reducing congestion; PS = Promoting safety; ID = Improving durability and extending the life of transportation infrastructure; PE = Preserving the environment; TS = Preserving the existing transportation system

Automated Last Mile Connectivity for Vulnerable Road Users (Last Mile)

This project was completed during the last reporting period and the final report draft was written.

Development, Design, and Calibration of the Vulnerable Road User Mobility Assistance Platform (VRU-MAP)

The VRU-MAP research team completed production of the prototype app. The team incorporated available sidewalk map data and other accessible data elements. Additional app components were implemented and improved, including the graphical user interface, crowdsourcing module, routing algorithm, and associated databases.

Multi-agent Reinforcement Learning-based Pedestrian Dynamics Models for Emergency Evacuation (Multi-agent)

The team developed the computational model for pedestrian evacuation at the airport through the integration of the decision-making model and simulated social force model. Integration of the optimal navigation model was ultimately able to reduce overall evacuation time of multiple scenarios. Overall maximum evacuation time savings realized was 10.6%. The extension to the multi-agent collaboration method was found to perform better than the single-agent exploration in regards to evacuation time, death counts, and reward.

DRONETIM: Dynamic Routing Of uNmanned-aerial and Emergency Team Incident Management (DRONETIM)

During the performance period, a utility patent associated with the project was filed.

VRU-Personalized, Optimum, and Dynamic Routing (VRU-POD)

The VRU-POD project was completed. The results can be found in the final report which can be accessed by clicking on the following link: VRUPOD.

Real-Time Recommendations for Traffic Control in an Intelligent Transportation System During an Emergency Evacuation – Parts 1 and 2 (Real-Time and Real-Time2)

The Real-Time team developed and tested a model-based approach and a multi-commodity network flow model for multimodal rescheduling of airline passengers to mitigate passenger disruption during a hurricane. They also initiated development of a stochastic optimization model for decision making of road protection before an approaching hurricane. A simulation model of North Carolina hurricane evacuations was developed and tested using Hurricane Florence data and a Lens model to quantify individual decision behavior in an Air Traffic Conflict Judgment Task Environment using Machine Learning algorithm models was developed.

Discrete Dynamics and Epidemiological Multi-Physics Models for Transportation Applications (Multi-Physics Models)

The Multi-Physics Models team completed the project. The final report is under review and will be posted during the next reporting period.

Multi-scale and Collaborative Disaster Evacuation Planning Framework (Multiscale Collaborate)

The Multiscale Collaborate team developed and validated a learning and planning approach to large-scale flight dispatch for disaster evacuation. The objective was to add additional flights for hurricane evacuation while minimizing the airspace's complexity and air traffic controllers' workload. Experiments using the real-world dataset for Hurricane Irma demonstrated the efficacy and efficiency of the proposed schema. Members of the team won the Air Force Research Laboratory Information Directorate (AFRL/RI)'s Innovare Aspire Challenge for 2 problems: Transfer Learning of Control Policies and Artificial Intelligence for Theater Multi-Domain Operations. They were invited to attend the Innovare Aspire Summit in August 2021.

Detecting Early-Stage Dementia Using Naturalistic Driving (Detecting Dementia)

After receiving IRB approval last reporting period, the Detecting Dementia research team initiated data collection with the first on-road participants.

Evaluation of Web-Based Driving Feedback for Teens and their Parents (Driving Feedback)

The Driving Feedback research team revised the research design to accommodate improvements to the project that came about through additional collaborations. In addition, the research team began working on the data pipeline which includes secure transfer of OnStar data and participant interfaces. A pilot data set that will be used to refine the data processing procedures and verify the transfer process is being collected.

Epidemiological Models for Transportation Applications: Secondary Crashes (Secondary Crashes)

The Secondary Crashes team developed a new point process model to estimate secondary crashes for scenarios in which the crash location and times are given.

Vulnerable Road Users demand-responsive Transit Optimization with healthcare Privatization (VRUTOP)

The VRUTOP team developed a clustering model considering the interactions between key contributing trip characteristics influencing time window uncertainty. The NCDOT Integrated Mobility team expressed interest in applying VRUTOP to the NC public transit system.

Acoustic Situation Awareness and Its Effects on Pedestrian Safety within a Virtual Environment (Situation Awareness)

The Situation Awareness team completed data collection for the Observation Study and initiated data analysis. IRB approval for the Non-Vehicle 2 Pedestrian Altered Virtual Reality Street Crossings task was received.

Equitable Dynamic Pricing for Express Lanes (Dynamic Pricing)

The Dynamic Pricing research team fine-tuned their model to incorporate different transportation choice settings associated with express lane pricing and incorporated departure time choice, schedule delays, and mode shift into a modeling framework. Alternate tolling options were identified to address equity gaps posed by dynamic pricing on express lanes and the impacts of

different alternate tolling methods on equity differentials was investigated. Findings indicate travelers with a lower value of time suffer additional burdens of "jam and harvest" and that differential is mitigated by offering a fixed discount addressing the cost burden of tolls directly.

Analyzing the Role of Air-Transportation in COVID-19 Pandemic Disaster (COVID AirTran)

The COVID AirTran team completed development of a point process model for air travel during the COVID pandemic and agent-based models to estimate infection spread in airports.

Machine Learning for Dynamic Airspace Configuration towards Optimized Mobility in Emergency Situations (Machine Learning)

The Machine Learning team explored the concept of time-variant stability of airspace configuration transition in response to assumed flight fluctuations. Simulation results show the existing graph partitioning method is not adapted to imbalanced traffic patterns, which does not show the potential of the reconfiguration algorithm's robustness in response to air traffic fluctuation.

Mask-Wearing Behaviors in Air Travel During Coronavirus Pandemic– An Extended Theory of Planned Behavior Model (Mask-Wearing)

The Mask-Wearing research team completed data cleaning and data analysis.

Modeling Future Outbreaks of COVID-19 Using Traffic as Leading Indicator (COVID Outbreaks)

The COVID Outbreaks team found that the percent change in traffic appears to be inversely proportional to COVID case rates among the population. In the US, this correlation appears strongest after approximately 5 days.

Usability of Urban Air Mobility: Quantitative and Qualitative Assessments of Usage in Emergency Situations (Urban Air)

Results obtained from the Urban Air research project indicate participants' strong support for the use of urban air mobility in response to natural disasters. These findings provide evidence that first responders and municipalities may be well suited to be main deployment partners of these new technologies. Participant data also enabled the research team to identify preferred locations for vertiports, both on a temporary and permanent basis.

Connected electric vehicles: Vehicle-pedestrian communications to enhance vision impaired pedestrian safety (CEV Vision)

The CEV Vision team ordered the equipment necessary to run the study. They are refining their research method while awaiting the delivery of the equipment.

Research Assistants

A total of 42 students worked as research assistants on projects within CATM during the reporting period. Table 3 provides a breakdown of these students by classification and gender.

Table 3: Demographics of student research assistants

Classification	Male	Female	Total
Undergraduate	7	4	11
Master's	7	4	11
Doctoral	16	4	20
Total	**30**	**12**	**42**

Table 4 lists additional transportation research grants directly connected to the center that were active during the reporting period and the primary agencies funding them.

Table 4: Transportation research grants awarded

Project Title	Lead Institution	Funding Agency
Advancing STEM Education Through Transportation Studies	N.C. A&T State University	National Science Foundation
NC Transportation Center of Excellence in Advanced Technology Safety and Policy	University of North Carolina – Chapel Hill	NC Department of Transportation
University Transportation Center of Excellence – Mobility and Congestion	North Carolina State University	NC Department of Transportation

Education

Student research assistants gain valuable educational experience working on the various CATM research projects. Several students' master's theses or doctoral dissertations are based on their CATM research. Some students submitted or drafted their results as journal papers and presented their results at professional conferences. A couple of undergraduate research assistants graduated and elected to continue their research in a master's degree program.

The findings from the Dynamic Pricing project were integrated within Civil Engineering courses taught by the PI during the reporting period. Students were made aware of the equity issues associated with infrastructure management and ways to discuss and address these issues.

Four NC A&T undergraduate students, including three CATM scholars, completed their Dwight D. Eisenhower Transportation Fellowship Program (DDETFP) papers, with the assistance of their research mentors, during the reporting period. The 2021-22 DDETFP Local Competition was held in May and four students were recommended for scholarship.

Twelve CATM scholars were selected for the 2021-22 academic year. The initial activity held in September 2021 consisted of a Meet-and-Greet, during which the students received an orientation. Additional activities will be offered throughout the academic year.

Development of a new digital badge program was initiated during the reporting period. The Advancing STEM Education Through Transportation Studies (ASETTS) Program is a digital badge program encouraging and enabling undergraduate students to increase their knowledge in STEM and core subject skills by establishing mentorship programs, embedding engaging experiential learning activities in courses, providing research opportunities and scholarships, and increasing students' exposure to transportation career opportunities

Figure 1: ASETTS Program Digital Badges

through an array of experiential activities. Digital badges are validated indicators of a student's accomplishment and skill in a specific area that they can include on their resume to assure potential employers of basic knowledge and competency. Five badges will be offered through the program (Figure 1). The ASETTS Program has been endorsed by the NCDOT and the Institute of Transportation Engineers (ITE). The program is primarily being funded through a National Science Foundation Targeted Infusion Program HBCU-UP Catalyst Award.

Workforce Development and Outreach

In April 2021, seven CATM scholars presented virtually to Guilford County, NC high school students during a Student-To-Student session. The scholars presented on the following topics: What is Supply Chain Management, Why Study Supply Chain at NC A&T, Intelligent Transportation Systems: Decreasing Food Deserts in North Carolina, A Better World through Supply Chain Management, and projects presented during the 2020 TRB annual meeting.

A 3-week Summer High School Transportation Institute was held virtually via Zoom (Figure 2) in July 2021. Sixteen high school juniors and seniors completed the program. Because it was virtual, the program was able to expand its geographical reach outside the local area. Students came from across the state of North Carolina with one logging in from the Chicago, IL area. The keynote speaker at the opening ceremony was Robert Hampshire, PhD., Deputy Assistant Secretary for Research and Technology at the US Department of Transportation. Dr. Hampshire shared the education and varied career path he took and emphasized the vital role transportation plays as part of the infrastructure of society. He also answered questions and interacted with students and guests after his talk.

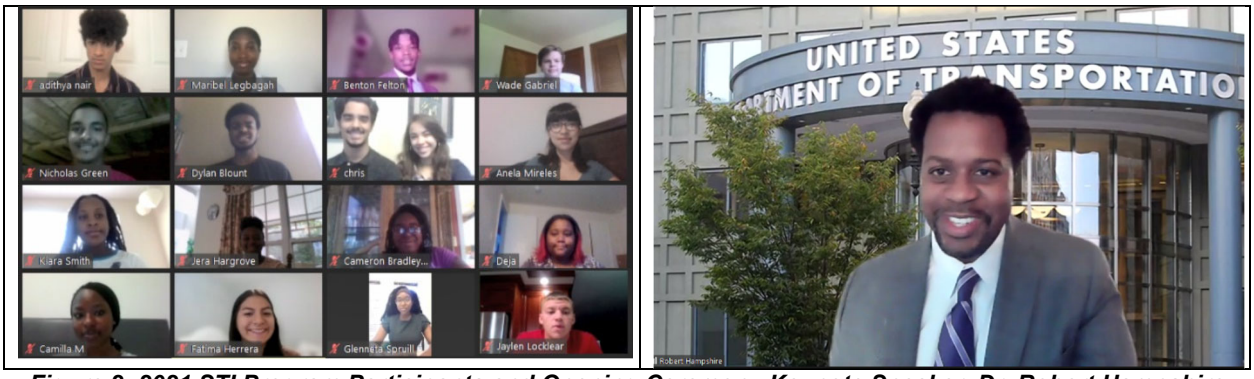

Figure 2: 2021 STI Program Participants and Opening Ceremony Keynote Speaker, Dr. Robert Hampshire

This year's program activities included the following: virtual talent show, "Shark Tank" team company idea competition, virtual tour of the Turner-Fairbanks Research, bridge building kit assembly and video competition, introduction to supply chain and engineering education paths by various industry professionals and college educators, SAT math and English preparation and practice, and public speaking coaching by Toastmasters.

Technology Transfer

A patent was filed based on the DRONETIM project. In addition, various presentations were given and several journal and conference papers were submitted and/or published during the reporting period. They are listed in the Outputs section of this report.

What opportunities for training and professional development were provided?

In addition to the specialized training received by student researchers associated with the various projects, the DRONETIM project trained researchers about data-driven data mining and decision making of traffic incident management systems and potential training and professional development sessions in traffic incident management are under consideration. The team is currently communicating with NCDOT traffic incident management staff about the new data adaptation to North Carolina and how the training should be modified. The Real-Time team had frequent online meetings with students and other professionals to connect them. Students attended multiple transportation-related technical webinars.

Have the results been disseminated?

Various project results have been disseminated at conferences and symposia during the reporting period. These presentations and papers are listed in the Outputs section of this report. Additionally, elements of the DRONETIM, Situation Awareness, COVID AirTran, and COVID Outbreaks projects as well as CATM Scholar activities were highlighted in the Spring 2021 CATM Newsletter.

What do you plan to do during the next reporting period to accomplish these goals?

Below is a list of the primary tasks for the next reporting period.

- Continue research project specific activities
- Initiate Year 6 projects
- Hold at least two research webinars
- Distribute the Winter 2021 newsletter
- Recruit for NC A&T's 30th Summer High School Transportation Institute
- Recruit applicants for the 2022-23 DDETFP and 2022-23 CATM Scholars
- Hold the Second Annual Transportation Awareness Day
- Hold the 4th Annual CATM Symposium
- Help plan and participate in the 2022 UTC Conference for the Southeastern Region

2. PARTICIPANTS & COLLABORATING ORGANIZATIONS:

Organizations that have been involved as partners

Table 5 provides a list of the individuals who were involved in center activities as partners during the reporting period and their associated organizations. This list does not include the center staff at NC A&T nor the various students involved in CATM activities.

Table 5: List of partners

Organization Name	Organization Location	Partner's Contribution to the Project	Name (First and Last)	Partner University
Dept. of Industrial and Systems Engineering	Greensboro, NC	Collaborative Research	Xiuli Qu, Ph.D.; Lauren Davis, Ph.D.; & Younho Seong, Ph.D.	NC A&T
Dept. of Computational Science and Engineering	Greensboro, NC	Collaborative Research	Hyoshin (John) Park, Ph.D.	NC A&T
Dept. of Electrical and Computer Engineering	Greensboro, NC	Collaborative Research	Ali Karimoddini, Ph.D.	NC A&T
Dept. of Mechanical Engineering	Greensboro, NC	Collaborative Research	Sun Yi, Ph.D.	NC A&T
Dept. of Civil, Architectural, and Environmental Engineering	Greensboro, NC	Collaborative Research	Venktesh Pandey, Ph.D.	NC A&T
Dept. of Industrial and Systems Engineering	Blacksburg, VA	Collaborative Research	Rafael Patrick, Ph.D.; Charlie Klauer, Ph.D.; Myounghoon Jeon, Ph.D.	Virginia Tech
Virginia Tech Transportation Institute	Blacksburg, VA	Collaborative Research	Jon Antin, Ph.D.; Andrew Alden, Ph.D.; Justin Owens; & Andrew Miller	Virginia Tech
Dept. of Graduate Studies, College of Aviation	Daytona Beach, FL	Collaborative Research	Dahai Liu, Ph.D.; Jennifer Thropp, Ph.D.; & Scott Winter, Ph.D.; Jing Yu Pan, Ph.D.	ERAU
Dept. of Electrical Engineering and Computer Science	Daytona Beach, FL	Collaborative Research	Houbing Song, Ph.D.	ERAU
Dept. of Civil Engineering	Daytona Beach, FL	Collaborative Research	Scott Parr, Ph.D.	ERAU
Aerospace Engineering	Daytona Beach, FL	Collaborative Research	Namilae Sirish, Ph.D.	ERAU

Other collaborators or contacts involved

During the reporting period, Dr. Hyoshin Park continued working with researchers at UNC-Chapel Hill, Appalachian State University, UNC-Charlotte, NC State University, Duke University, and Fayetteville State University on two separate NCDOT Transportation Centers of Excellence grants. Dr. Sirish Namilae worked with the Florida Highway Patrol to obtain crash data for the Secondary Crashes project. The University of West Florida also provided his team with high performance computing assistance for the COVID Air-Tran project. Dr. Venktesh Pandey collaborated with Dr. Md Sami Hasnine at Howard University in the area of developing models for travel behavior in response to real-time information with an application in express lanes. He also worked in collaboration with the research team at the Indian Institute of Science, Bangalore on research problems related to the optimization of ridesharing supplies. Dr. Charlie Klauer received feedback from General Motors on the app that will be used to collect data for the Driving Feedback study. Dr. Steven Parr collaborated with researchers at Louisiana State

University and Clemson University on journal articles. He also worked with Dr. Zhao Zhang at BUAA University in Beijing on a larger paper related to the COVID Outbreaks topic. Dr. McBride continued collaborating on a transportation safety research paper with researchers from the University of North Texas and the University of Alabama. She also initiated collaborations with faculty at the University of New South Wales in Sydney, Australia on a teen distracted driving paper.

Drs. Tameka Coly, Joseph Huscroft, and Ahren Johnston continued mentoring the 2020 NC A&T Dwight D. Eisenhower Transportation Fellows as they completed their research papers during the reporting period. In addition, three faculty members volunteered as mentors to the four 2021 NC A&T Dwight D. Eisenhower Fellowship Program applicants.

3. OUTPUTS:

The subsections below outline some of the outputs that have resulted from the research projects listed in Table 2 as well as the education, workforce development, and technology transfer activities.

Publications, conference papers, and presentations

Journals

- Derjany, P., Namilae, S., & Srinivasan, A. (2021). Parameter Space Exploration in Pedestrian Queue Design to Mitigate Infectious Disease Spread. Journal of the Indian Institute of Science: 1-11 (published). Acknowledgement of federal support: yes.
- Folsom, L., Ono, M., Otsu, K., & Park, H. (2021). Scalable Information-Theoretic Path Planning for a Rover-Helicopter Team in Uncertain Environments. International Journal of Advanced Robotic Systems 18(2), 1-18 (published). Acknowledgement of federal support: yes.
- Jiang, Y., Niu, S., Zhang, K., Chen, B., Xu, C., Liu, D. & Song, H. Spatial-Temporal Graph Data Mining for IoT-enabled Air Mobility Prediction,.IEEE Internet of Things Journal, doi: 10.1109/JIOT.2021.3090265 (published). Acknowledgement of federal support: no.
- Koliou, K., Parr, S., Kaisar, E., Murray-Tutie, P., & Wolshon, B. COVID-19's Effects on Truck Traffic and Freight Movement. Transportation Research Record, Journal of the Transportation Research Board (under review). Acknowledgement of federal support: yes.
- Meda, H., Vogiatzis, C., & Davis, L.B. A Graph Theoretical Approach Integrating Geospatial Information to Analyze Airport Network. INFORMS Journal on Data Science (under review). Acknowledgement of federal support: yes.
- Meda, H., Vogiatzis, C., & Davis, L.B. Multimodal Rescheduling of Airline Passengers. Transportation Science (under review). Acknowledgement of federal support: yes.
- Pugh, N., Park, H., Namilae, S., & Liu., D. Safe and Efficient Airport Evacuation Considering Pedestrian Dynamics. IEEE Transactions of ITS (under review). Acknowledgement of federal support: yes.
- Parr, S., Kristiansson, F., Wolshon, B., Zhang, Z., & Murray-Tuite, P. Traffic Impacts of the COVID-19 Pandemic: International Analysis of Social Separation and Activity Restriction. ASCE Transportation Engineering Part 1: Policy (under review). Acknowledgement of federal support: yes.
- Pugh, N., Park, H., Derjany, P., Namalie, S., & Liu, D. (2021) Deep Adaptive Learning for Safe and Efficient Navigation of Pedestrian Dynamics. IET Intelligent Transport Systems, 15 (4), 538-548 (published). Acknowledgement of federal support: yes.
- Yang, Y., Yu, J., Liu, D., Lee, S, Namilae, S., Islam, S., Gou, H., Park, H., & Song, H. Multi-Agent Collaboration for Emergency Evacuation Using Reinforcement Learning for Transportation

Systems, IEEE Journal on Miniaturization for Air and Space Systems (JMASS) (under review). Acknowledgement of federal support: yes.

Books and Non-Periodical, One-Time Publications

- Meda, H. (2021). A Theoretical Approach and Optimization Model Integrating Network Theory to Analyze and Mitigate Airport Network Disruption. Dissertation, North Carolina A&T State University, Greensboro, NC.
- Mhatre, S. (2021). Optimization Models for Road Network Protection and Restoration during a Natural Disaster. Dissertation, North Carolina A&T State University, Greensboro, NC.

Other Publications, Conferences, and Presentations

- Dam, A., Patrick, R, & Jeon, M. (2021). Acoustic Situation Awareness and Its Effects on Pedestrian Safety within a Virtual Environment, N.C. A&T Virtual Summer Transportation Institute (presented). Acknowledgement of federal support: yes.
- Darko, J., Folsom, L., Deshpande, N., & Park. H. (2021). Distributed Constraint Optimization Problem for Coordinated Response of Unmanned Aerial Vehicles and Ground Vehicles. 55th Annual Conference on Information Sciences and Systems (CISS 2021) (published). Acknowledgement of federal support: yes.
- Darko, J., Folsom, L., Deshpande, N., & Park, H. (2022). Unmanned Aerial and Ground Emergency Vehicles in Traffic Incident Management: An Anticipatory Assignment Model. The 101st Annual Meeting of TRB, Paper #22-03332, January 9-13, Washington, D.C. (accepted). Acknowledgement of federal support: yes.
- Darko, J., Folsom, L., Deshpande, N., Park, H. (2021). A New Distributed Agent Framework for Traffic Incident Management. ASCE International Conference on Transportation & Development (ISTD 2021), May 31- June 3, Seattle, Washington (published). Acknowledgement of federal support: yes.
- Darko, J., Folsom, L., Deshpande, N., & Park, H. (2022). Integrating Pedestrian Accessibility with Public Transit Routing in a Multimodal Trip Planning Framework. 101st Annual Meeting of TRB, Paper #22-03342, January 9-13, Washington, D.C. (accepted). Acknowledgement of federal support: yes.
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Websites or other internet material

- CATM Website: https://www.ncat.edu/cobe/transportation-institute/catm/index.php
- CATM Spring 2021 Newsletter: https://www.ncat.edu/cobe/transportation-institute/_files/pdfs/spring2021finalada1.pdf
- CATM Facebook Page: https://www.facebook.com/NCATCATM/
- STI Facebook Page: https://www.facebook.com/groups/627756624232070/
- Webpages where STI program information is provided: https://www.ncat.edu/cobe/transportation-institute/summer-high-school-transportation-institute.php
- Lecture titled "Real-Time Machine Learning for Quickest Detection" delivered by Dr. Houbing Song through the ACM Distinguished Speaker Program: https://speakers.acm.org/lectures/13940.

Technologies or techniques

- Real-Time project: The multi-commodity network flow model for multimodal rescheduling of airline passengers has been submitted as a journal paper. The evacuation traffic simulation model using MATSim was presented at the 2021 NCDOT Research & Innovation Summit and will be submitted as a conference paper.
- Secondary Crashed project: A new point process model for estimating secondary crashes has been developed. It will be disseminated through journal and conference publications.

- Situation Awareness project: An immersive environment that utilizes virtual reality in combination with physical spatial audio is under development. A packaged portable version is being consideration.

Inventions, patent applications, and/or licenses

- DRONETIM project patent filed: System and Methods for Efficient Robotics Navigation Through Global Mapping, No. 63/074,889, Provisional Application Utilities (Claims) Filed 2021. August Acknowledgement of federal support: yes.

Other products

Publications

- Dynamic Pricing project: Education materials associated with the project topic were developed and will be made available on PI's website at the end of the project.

Data

- Nothing to report

4. OUTCOMES:

The results of the activities during this reporting period are increasing understanding and awareness of transportation issues in the following ways:

- Last Mile project: This project has influenced subsequent implementations of low-speed autonomous vehicles (LSAV) in the Commonwealth of Virginia in particular. This project was the first public implementation of an LSAV and the resulting shared experience guided others in Virginia, including municipalities and the state DOT on other implementations.
- VRU-MAP project: The VRU-MAP app is developed to assist individuals with disabilities while they move throughout the built environment, typically as pedestrians or when using personal mobility devices. Often underrepresented in the design and deployment of products, these individuals may often have specialized or intensive needs. While the development of the app is underway, efforts are ongoing to highlight the needs all individuals have when maneuvering through the world, allowing for their needs to be incorporated into the app design as well.
- Multi-agent project: To safely reduce the congestion effect among other agents and ultimately produce shorter evacuation time, an adaptive routing strategy per individual passenger is required. In this study, a dynamic routing model is developed to identify faster evacuation options.
- DRONETIM project: The project results have helped incident management operators identify which incident has priority and what incident response resource should be allocated during different times of the day.
- Real-Time project: This research facilitates better understanding of a future with autonomous technologies involved - especially the role of humans and technologies together in this society.
- Multiscale Collaborate project: Extreme weather conditions cause large scale human movement and evacuation, without proper planning and scheduling, it could cause chaos, especially when evacuating people from disaster areas using aircrafts. Due to complex factors involved, studies on these issues were very limited. Models developed for this project provide a new way to look at these issues and lead to an effective real-time scheduling policy when emergency happens.
- Secondary Crashes project: Estimates of queue time and distances for secondary crashes will help transportation planning and the safety of first responders.
- VRUTOP project: This research focuses on improving the transit service of vulnerable road users while addressing recent trends in Medicaid transformation, particularly service performance changes before and after the COVID-19 pandemic.
- Situation Awareness project: Focus groups discussed unearthed non-verbal communication habits between pedestrians and drivers. This information is being decoded and will be used for further analysis to be shared with others in various forms.

- Dynamic Pricing project: This work has created discussions around associating equity issues with different elements of transportation systems.
- COVID-AirTran project: The research addresses the question - As air-travel resumes, what are the transportation and pedestrian crowd management related measures that can help mitigate further spread of COVID-19?
- Machine Learning project: The purpose of this study is to enable dynamic airspace configuration (DAC) to optimize air mobility during emergency evacuation. The anticipated outcome is a prototype demonstrating the Machine Learning (ML)-augmented capability supporting DAC.
- Mask Wearing project: The findings of this study so far have identified key factors that influenced the intention to wear a mask when flying during the COVID-19 pandemic, thus increasing the understanding and awareness of mask use in the air transport context.
- COVID Outbreaks project: This works has shown that the movement of people is inherently connected to the spread of viral diseases. Understanding the relationship between social/economic activity and the spread of COVID-19 could prove invaluable.
- Urban Air project: The data from this study demonstrate a strong willingness to support the use of urban air mobility in response to natural disasters.

The activities that took place during the reporting period are expected to affect the passage of new policies, regulation, rulemaking, or legislation in the following ways:

- Multi-agent project: Project results show that in an airport evacuation scenario, it is important for police officers and security guards to be placed along the evacuation path to guide pedestrians and ensure they follow the specified optimal guided path.
- DRONETIM project: In response to new FAA regulations, the developed proactive data-driven model estimates the importance of the information and decides where the emergency response vehicles and unmanned aerial vehicles should be located. Various incident management policies will be generated through simulation for the operator to easily make decisions during emergency.
- VRUTOP project: Compared to the existing fixed transit system, this project will provide guidelines for new policies for scheduling and routing of service vehicles considering the Medicaid transformation toward private control.

The research activities during the reporting period have led (or will lead) to increases in the body of knowledge in the following ways:

- Last Mile project: This project has informed others on the benefits and potential pitfalls of using LSAVs for last mile connectivity, especially with respect to older riders.
- Multi-agent project: The findings of this project will lead to a multidisciplinary computational framework for understanding and modelling the human decision-making process and resulting actions in emergency evacuations.
- DRONETIM project: This project developed a distributed constraint optimization problem (DCOP) framework to allocate resources to highway incidents under static environments, simplifying dynamic behavior in distinct unconnected decisions. This is a new data-driven optimization that proactively adapts to environmental changes in the transportation system.
- Real-Time project: With the statistics collected throughout multiple sites, a better understanding of the state-wide status of potential factors affecting real time evacuation under emergency was developed.
- Multiscale Collaborate project: The model aims to formulate flight dispatch under emergency as a weighted graph matching problem. Spatial temporal quantization and combinatorial optimization approaches were applied to train the machine learning model for prediction of efficiency of the different policies for the flight dispatch.
- Real-Time2 project: The project extended the single system design Lens model to a double system design using data simulation techniques.

- VRUTOP project: This project includes data mining and data-driven optimization of paratransit service to overcome difficulties in capturing essential parameters in adjusting to the new environments.
- Situation Awareness project: A better understanding of pedestrian-driver non-verbal communication behaviors provides researchers with a better understanding of intervention opportunities.
- Dynamic Pricing project: The project's work has contributed towards optimization-based methods for addressing equity concerns associated with the project and towards model development for the identification of equity issues.
- Mask-Wearing project: By identifying the key determinants of the intention to wear a mask during flight, this study contributes to the knowledge of mask use in global pandemics.
- COVID Outbreaks project: This project works to establish viral spread as not just a medical issue, but as a transportation issue as well.
- Urban Air project: As far as the researchers are aware, no prior study has investigated the use of UAM in response to emergencies or natural disasters. This study demonstrates strong support across participants for the use of UAM within this domain.

The following projects are expected to result in improved processes, technologies, techniques and skills in addressing transportation issues:

- Last Mile project: The implementation of the LSAV as part of this project provided key information to vehicle technology providers on operational challenges.
- VRU-MAP project: This team is applying novel mapping techniques to the advancement of accessible navigation for people with disabilities.
- Multi-agent project: When applied to a simulated airport emergency evacuation, the integrated modelling technique will reduce the total overall evacuation time of pedestrians in an emergency airport situation.
- DRONETIM project: This project improved the way unmanned aerial vehicles are utilized in incident management to provide critical information to emergency vehicle routing and predicting short-term traffic state during non-recurring and recurring congestion.
- Real-Time project: Theoretical and simulation models were developed to better understand and support real time evacuation for constituents.
- Multiscale Collaborate project: Innovative machine learning models were created that combine off-line learning and on-line planning to address flight dispatch issues under emergent situations.
- Real-Time2 project: The model-based approach and a multi-commodity network flow model for multimodal rescheduling of airline passengers can help airline companies mitigate passenger disruption during a hurricane. The evacuation traffic simulation model for eastern NC can support government agencies in decision making of traffic control during a hurricane evacuation.
- VRUTOP project: The privatization of Medicaid will change the patterns of users of transit systems making it difficult to improve the efficiency of the service. This project improves the process of optimizing the operation of paratransit service.
- Machine Learning project: The significance of machine learning (ML) for Dynamic Airspace Configuration (DAC) lies in its potential to continually adjust the airspace structure and controller resources to meet user needs using ML methods, thus optimizing mobility in emergency situations. In the long run, this will re-envision air traffic management.

The following activities are expected to result in the enlargement of the pool of trained transportation professionals:

- Multi-agent project: This work will provide training for transportation professionals at the airport or other organizations considering simulation-based operations to find the best route for pedestrians during evacuation. Security-related officials and others (such as those interested in machine learning technology) will also be considered as potential training recipients.

- VRUTOP project: This project provides training in the operation of paratransit, transportation data management, traffic demand modeling, and transportation mesoscopic simulations.
- Research projects: Several student research assistants graduated this reporting period and are now in the workforce prepared to make significant contributions to the transportation domain. A diverse population of other students started or continued receiving specialized training in various aspects of transportation as part of their research experiences. Many are considering careers in transportation for the first time due to these experiences.
- Education and Workforce Development activities: Over 30 students were introduced to various careers in transportation through CATM program activities. Feedback from a few of these students can be found in the Winter 2021 CATM newsletter.

The following research projects have led or will lead to the adoption of new technologies, techniques or practices:

- Multi-agent project: In line with the advancement of building surveillance systems and machine learning for determining pedestrian trajectory, this project can make use of those surveillance systems for practical applications. Since new surveillance technology is more advanced, the fidelity of the project outcome will be improved.
- DRONETIM project: As unmanned aerial vehicle autonomy improves, the proposed project concept will adapt to changes in human control in response to various incident severity levels.
- VRUTOP project: Compared to traditional deterministic paratransit service, the data-driven optimization technique is considered to address uncertainty of the transportation systems.
- Situation Awareness project: Once developed, the tool can be used for demos and training associated with safe street-crossings with and without the use of personal listening devices.
- Urban Air project: Based on the data from this study, it appears that if deployed within the context of first responders, emergencies, and natural disaster response, it is likely that there will be strong support from constituents in regards to the use of UAM.

Table 6 contains the center-specific performance measures for outcomes, the target per year, and the status of each goal.

Table 6: CATM Outcome Performance Measures

Outcome #	Goals	Research Performance Measures	Target per year	Current Status
Outcome #1 (technology focused)	Adoption of new technologies to help vulnerable road users identify suitable transportation services	Number of technology transfer activities that offer implementation or deployment guidance	2	4
Outcome #2 (technology focused)	Enhanced decision-making techniques that improve the efficiency and effectiveness of emergency evacuation processes	Number of decision-making technology training courses or webinars developed and delivered	2	5
Outcome #3	Automated vehicle design guidelines based on an increased understanding and awareness of human perceptions of and interactions with automated vehicles	Number of human factors guideline documents published	2	0

Outcome #4	Dissemination of research results through presentations, publications, conference papers, and technical reports	Number of presentations and workshops given	6	30
		Number of peer-reviewed journal papers published	2	7
		Number of newsletter articles, conference papers, and technical reports published	10	24

5. IMPACTS:

What is the impact on the effectiveness of the transportation system?

- Last Mile project: This work helped demonstrate how LSAVs may effectively be integrated into the larger transportation system and revealed important operational constraints such as the impacts of traffic speed differential.
- Multi-agent project: The overall maximum evacuation time savings presented by this model was 10.6%. The multi-agent collaboration method was found to outperform the single-agent exploration concerning evacuation time, death counts, and reward.
- DRONETIM project: The proactive distributed constraint optimization model reports a 5.26% improvement in response time compared to the nearest neighbor strategy.
- Real-Time project: The model is expected to have an impact on future NC resident evacuation strategies and policies.
- VRUTOP project: This project aims to improve access to health care in underserved areas using public transportation and Mobility as a Service by providing a new service tool for paratransit. Time window uncertainty will be uniquely formulated by taking advantage of real-world data collected before and after the Medicaid transformation. This will result in this research becoming a pioneer in demand response transportation systems.
- COVID AirTran project: Results suggest queue layouts in airport security areas and boarding deplaning strategies at airport gates to minimize COVID spread.

What is the impact on the adoption of new practices, or instances where research outcomes have led to the initiation of a start-up company?

- Last Mile project: This work has influenced those developing and implementing LSAVs in many areas across the US.
- VRU-MAP project: Wide-scale adoption of the app may assist individuals with disabilities greatly as they travel. If the VRU-MAP is not deployed as a standalone app, the outcomes from the research as well as the fundamental basis of the application may be integrated into an existing, readily available app.
- Multi-agent project: For training of airport security managers, the team plans to apply this integrated modelling technique to a simulated airport emergency evacuation. With the advancement of airport surveillance technology, video data will confirm pedestrian traffic density in real time and provide a new model to guide pedestrians.
- DRONETIM project: The research is expected to result in a data-driven decision aid tool for traffic operators dealing with traffic incident management.
- Real-Time2 project: The multi-commodity network flow model for multimodal rescheduling of airline passengers can help airline companies mitigate passenger disruption during a hurricane. The evacuation traffic simulation model for eastern North Carolina can support government agencies making traffic control decision during a hurricane evacuation.
- VRUTOP project: For training of transportation service operators, this project adapts to possible changes in system delay due to wait or load time of a previous pick up.
- Dynamic Pricing project: The algorithms developed for discount optimization are expected to be useful for organizations and companies responsible for express lane pricing operations.

- Mask-Wearing project: The findings will provide policy makers and airlines information needed to formulate public health strategies to ensure inflight safety, hence helping the airline industry recover more quickly from pandemics.
- Urban Air project: First responders and municipalities can use UAM vehicles associated with this project to serve the community. Manufacturers might want to consider developing these aircraft for use in response to emergencies or natural disasters.

What is the impact on the body of scientific knowledge?

- Last Mile project: This work revealed many considerations of which those planning to implement LSAVs for public transport would otherwise not be aware. Focus was on how older riders might make us of LSAVs. Findings related to how their preconceptions and riding experience might influence the ultimate usability of LSAVs was groundbreaking.
- VRU-MAP project: Though extant literature exists on improving the mobility of pedestrians, cyclists, and those utilizing similar modes of transportation, the body of knowledge surrounding the mobility of individuals with explicit accessibility needs has been limited to research conducted by certain special interest groups/organizations. The work from this project is expected to extend this body of knowledge to incorporate critical components for the mobility of underrepresented populations that may yet have been identified and addressed on a grander scale.
- Multi-agent project: The integration of the deep reinforcement model and social force model in pedestrian evacuation in transportation system has not done before and this project will open up new related research paths.
- DRONETIM project: The data driven optimization method is further extended to proactively anticipate future events and allocate incident response resources (e.g., unmanned aerial vehicles and ground response vehicles) in a distributed way.
- Multiscale Collaborate project: The resulting model will be beneficial for real-time evacuation planning and decision-making for a wide range of situations that involve air travel.
- Real-Time2 project: The models developed for this project will support the government's efforts to organize an effective emergency evacuation and can reduce the impact of hurricane disruptions on airline transportation.
- VRUTOP project: The integration of the data-mining model and optimal pick-up and drop off model can handle unexpected delays in the system and reduce operating costs.
- Dynamic Pricing project: The project's work has contributed towards optimization-based methods for addressing equity concerns associated with highway projects by appropriate design of toll discounts that address equity differentials. Furthermore, research tools developed in this project will assist transportation agencies in providing affordable and reliable transportation options for travelers across all population groups, leading to improved well-being of individuals in society.
- Machine Learning project: Air traffic control workers' workload could be reduced to prevent the rate of aviation accidents.
- Mask-Wearing project: The findings of this study can expand the knowledge base of air travelers' behavioral intention, especially as it pertains to public safety during a pandemic.

What is the impact on transportation workforce development?

- Research projects: The various projects not only provided students with hands-on experience with an array of transportation-related methods and tools, it also gave them experience presenting and discussing their work in academic settings including at symposia and through journal articles. This supports their career growth within and outside of the transportation domain.
- Last Mile project: This project demonstrated a need for an attendant on LSAVs even when driving tasks were not part of their responsibility.
- Multi-agent project: This multidisciplinary work will provide machine learning and artificial intelligence training for the transportation workforce.
- Situation Awareness project: The tool and methods developed can be used to further study human factors aspects of pedestrian street-crossings. Using a high fidelity, full-motion simulation allows for training in a realistic environment, which should translate better to real-world situations.

- Urban Air project: In the future, municipalities will need to train their first responders in the usage and integration of UAM vehicles within their first responder fleet of equipment and technology.
- Education and Workforce Development activities: The STI program helped make high school students aware of career options within the transportation industry. All of the participants agreed that the program activities helped them understand transportation better. Several of the students indicated their intent to consider degrees and/or careers in transportation in the near future.

Table 7 contains the center-specific performance measures for impacts, the target per year, and the status of each goal.

Table 7: CATM Impact Performance Measures

Impact #	Goals	Research Performance Measures	Target per year	Current Status
Impact #1 (technology focused)	Increase in the number of vulnerable road users able to acquire transportation services that fit their special needs	Number of instances of vulnerable road user technology adoption or commercialization	2	2 created/ 0 adopted
Impact #2 (technology focused)	More effective and efficient emergency transportation management processes	Number of instances optimization models or technologies are utilized or commercialized	3	6 created/ 0 adopted
Impact #3	Increase the body of knowledge for human factors in automated vehicles	Number of instances of research changing behavior, practices, decision making, policies (including regulatory policies), or social actions	2	1

6. CHANGES/PROBLEMS:

The project completion dates for several projects have been extended due to delays caused by the pandemic primarily in 2020. The scope of the Detecting Dementia and Driving Feedback projects changed in order to accommodate the addition of more data from and collaboration with other supporting companies/organizations. Due to change in PI for the CEV Vision project, user-centered human factors engineering will be implemented to accomplish the project objectives.

7. SPECIAL REPORTING REQUIREMENTS

Nothing to report for this period.