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

Maranda McBride, PhD, Director, Center for Advanced Transportation Mobility

Email: mcbride@ncat.edu; Phone: (336) 285-3359; Fax: (336) 334-7093

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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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Reporting Period End Date: March 31, 2023

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 March 31, 2022.

Table 1: Progress of period 9 activities

Research	**Status**	**% Complete**
Complete Year 1 projects	Complete	100%
Complete Year 3 projects	Complete	100%
Complete Year 4 projects	Behind schedule	50%
Complete Year 5 projects	On schedule	43%
Complete Year 6 projects	On schedule	10%
Conduct annual visit to member institutions – Year 6	Behind schedule	50%
Education, Outreach, and Workforce Development Activities		
Distribute 2022-23 CATM Transportation Scholarship applications	Complete	100%
Select 2022-23 CATM Transportation Scholars	Complete	100%
Conduct Spring 2023 student-to-student K-12 initiative workshops	On schedule	50%
Recruit/select 2023 STI participants	On schedule	80%
Prepare for and hold 2023 STI	On schedule	50%
Select 2023-24 CATM Transportation Scholarship recipients	On schedule	50%
Hold the Dwight David Eisenhower Transportation Fellowship Local Competition	On schedule	50%
Student participation in the 2024 TRB conference	Forthcoming	0%
Technology Transfer Activities		
Conduct 2022 research webinars	Complete	100%
Create and distribute Fall/Winter 2022 newsletter	Complete	100%
Plan and hold the 5th Annual CATM Symposium	Behind Schedule	20%
Create and distribute Spring 2023 newsletter	On schedule	80%
Conduct 2023 research webinars	Forthcoming	0%

US DOT Reporting Activities		
Update records in RiP database	Complete	100%
Complete and submit PPPR#11	Complete	100%
Complete and submit SF425 for Q21 and Q22	Complete	100%
Complete and submit 2022 recipient share report	Complete	100%
Complete and submit 2022 performance indicator report	Complete	100%
Complete and submit PPPR#12	On schedule	75%
Review year 3 final reports for completed research projects	Complete	100%
Upload year 3 final reports to TRID database	Complete	100%
Review year 4 final reports for completed research projects	On schedule	50%
Upload year 4 final reports to TRID database	On schedule	50%
Review year 5 final reports for completed research projects	On schedule	43%
Upload year 5 final reports to TRID database	On schedule	43%
Complete and submit 2023 recipient share report	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 is 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
Development, Design, and Calibration of the Vulnerable Road User Mobility Assistance Platform	Completed/Y1	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/vrumap.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
Vulnerable Road Users demand-responsive Transit Optimization with healthcare Privatization (VRUTOP)	Continuing/Y4	IM	https://www.ncat.edu/cobe/transportation-institute/catm/vrutop.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
Detecting Early-Stage Dementia Using Naturalistic Driving	Continuing/Y4	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/detecting-dementia.php
Equitable Dynamic Pricing for Express Lanes	Completed/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	Completed/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
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
Real-time Deep Reinforcement Learning for Evacuation under Emergencies	Continuing/Y6	IM	https://www.ncat.edu/cobe/transportation-institute/catm/realtime-deep-reinforcement-learning-for-evacuation-under-emergencies.php
Rural Older Adult Driver Tailored Research-Integrated Plan	Continuing /Y6	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/rural-older-adult-driver-tailored-research.php
Improving Air Mobility in Emergency Situations	Continuing /Y6	IM, RC	https://www.ncat.edu/cobe/transportation-institute/catm/improving-air-mobility-in-emergency-situations.php
High-speed rail in the US – The intention to use and mode choice behavior	Continuing /Y6	IM, RC, PS, PE	https://www.ncat.edu/cobe/transportation-institute/catm/high-speed-rail-in-the-us1.php

IM = Improving mobility of people and goods; RC = Reducing congestion; PS = Promoting safety; PE = Preserving the environment

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

The VRU-MAP team completed their research project and submitted the final report during this reporting period. Real-world testing of the VRU-MAP app prototype (see Figure 1) demonstrated substantial promise for its functionality, while at the same time illustrating areas for future improvement and refinement including expanding capabilities, improving interface design, and improving routing component integration. The final report can be accessed using this link.

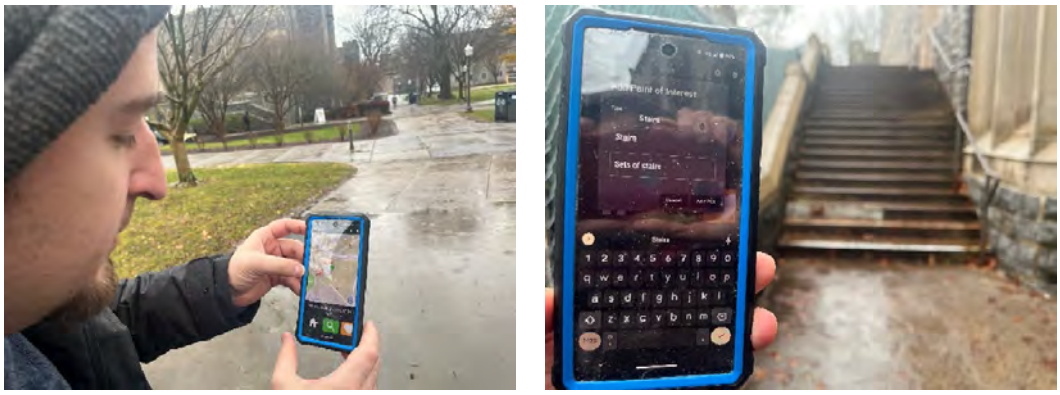

Figure 1: (left) Real-world demonstration of VRU-MAP application in use to log a water hazard. (right) Using VRU-MAP to log an impassable staircase.

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

The Situation Awareness team completed all data collection associated with this project. Major activities during this reporting period include the preparation and submission of a manuscript for publication in a transportation journal. The revision of this manuscript is currently under review.

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

The VRUTOP team achieved three conference paper publications during this reporting period based on real-world data.

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

During this performance period, the Driving Feedback research team worked with their collaborators and recruitment team to recruit, screen, and complete intake for 25 research participants. Additionally, they developed an application that will be used for months 2-5 of data collection. This application will be used by participants to view their driving performance for recent trips (see Figure 2).

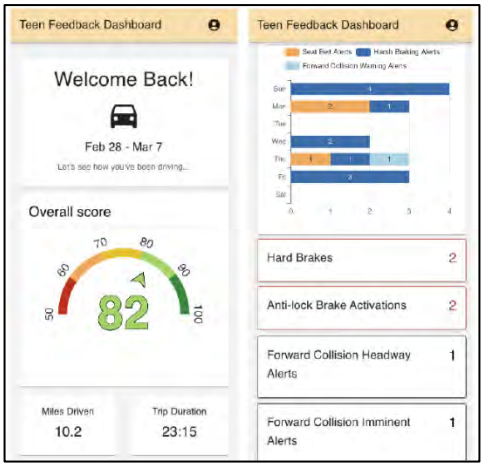

Figure 2: Example of feedback app screen capture

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

The Detecting Dementia research team acquired comparison data from the Second Strategic Highway Research Program Naturalistic Driving Study (SHRP 2 NDS) for analysis. Additionally, they continued data analysis and began drafting their final report.

Equitable Dynamic Pricing for Express Lanes (Dynamic Pricing)

The Dynamic Pricing research team completed their study and submitted their final report. Their research findings suggest designing discounts proportional to the value of time (VOT), which can be correlated with income groups, and balancing the tradeoffs by carefully identifying the agency's priorities. The final report can be accessed using this link.

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

The COVID AirTran team applied the models they have developed to parametrically analyze the spread of infection and the effect of mask usage in generic transportation systems. They analyzed five empirical events of SARS-COV-2 transmission. They also examined the effect of mask usage and mask quality and performed a sensitivity analysis of the related factors. The transmission events examined in this study provide a basis for generating high, intermediate, and low-dose model parameterizations.

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

During the reporting period, the Machine Learning team fine-tuned and verified their algorithm in simulated environments and finalized the report. They found that their dynamic airspace

reconfiguration algorithm could automatically merge non-busy airspace and allocate non-busy airports' ATC resources to assist busy airports.

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

The Mask-Wearing team completed their project and submitted their final report during the reporting period. Results showed that attitude, descriptive norms, risk avoidance, and information seeking significantly influenced the travelers' intention to wear a mask during flight during the COVID-19 pandemic. They also found that demographic and travel characteristics including age, education, income, and travel frequency can be used to predict if an airline passenger was willing to pay a large amount to switch to airlines that adopted different mask-wearing policies during the pandemic. The final report can be accessed using this link.

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

The COVID Outbreaks team has completed their study and worked on the final report.

Connected Electric Vehicles: Vehicle-Pedestrian Communications to Enhance Vision Impaired Pedestrian Safety (CEV Vision)

The CEV Vision team obtained human subjects testing approval and commenced data collection during the reporting period. While there are no significant results to report at this point, it was determined that an alternative method for survey administration (i.e., verbal) is necessary due to screen reader limitations when using survey tools.

Real-time Deep Reinforcement Learning for Evacuation under Emergencies (Reinforcement)

During this reporting period, the Reinforcement team collected data, tried out reinforcement learning algorithms, developed a baseline model, and started the development of an Asynchronous Advantage Actor Critic (A3C) agent model. The baseline models proved to be robust and stable when finding the evacuation routes. Modeling of the scenario on a conventional heuristic optimization algorithm is almost complete.

Rural Older Adult Driver Tailored Research-Integrated Plan (ROAD TRIP)

The ROAD TRIP team conducted driving consultations with three participants and three participants completed the study during the reporting period. The team identified the aspects of the study essential to its success and discussed ways to retain those facets of study in any version where its footprint is greatly expanded.

Improving Air Mobility in Emergency Situations (Air Mobility)

The Air Mobility team worked on developing algorithms and testing the algorithms in the simulated environment throughout the reporting period. They finished the development of the spectral clustering-driven dynamic airspace re-allocation algorithm and completed the airspace configuration fine-tuning algorithm for the re-allocation algorithm. The combination of the re-allocation and fine-tuning algorithm can significantly balance the workload of ATC operators according to their data.

High-speed Rail in the US – Intention to Use and Mode Choice Behavior (High-speed Rail)

The High-speed Rail team completed data analysis for the mode choice analysis and completed and submitted a peer-reviewed article during the reporting period.

Research Assistants

Eighteen students worked as research assistants on CATM products 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	1	2	3
Master's	5	1	6
Doctoral	4	5	9
Total	**10**	**8**	**18**

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

During the reporting period, graduate students working on CATM research have been applying scientific research methods as they work on their master and doctoral research projects. CATM researchers have been assisting them throughout this process and helping them prepare technical papers based on their research so they can be submitted to reputable journals and conferences.

Senior design teams in Mechanical Engineering at NC A&T were engaged in projects partially funded by CATM through which they have been learning about transportation topics, such as autonomous vehicle design, as they relate to their projects. ERAU faculty developed a new transportation model that was delivered to first year, first semester civil engineering students during this reporting period, providing an early introduction to the transportation domain.

In November 2022, a group of five NC A&T students visited VTTI and engaged in presentations and demonstrations on naturalistic driving research. Approaches used in the Detecting Dementia and ROAD TRIP studies were highlighted during the presentations. The students also had the opportunity to speak with one of the African American VT researchers working on CATM projects who imparted some wisdom and encouragement to aid them as they matriculate through their undergraduate degree program.

Also in November, two candidates were selected for the 2022-2023 Dwight David Eisenhower Transportation Fellowship Program and their research is currently underway. Seven NC A&T undergraduate students (Figure 3), including the DDETFP recipients, attended the 2023 TRB Annual Meeting in Washington D.C. where they engaged with and learned from transportation researchers and professionals.

Figure 3: NCA&T undergraduate students at 2023 TRB Annual Meeting

Students have been successfully leveraging the knowledge they have obtained through their transportation research projects in various ways. For instance, a previous VT undergraduate student on the CEV Vision project leveraged her experiences and was accepted as a VT ISE MS-thesis student as a result of the project she worked on. Other students involved in the project have used it as an artifact for graduate applications and post-graduate employment.

Workforce Development and Outreach

On March 28th, two NC A&T undergraduate students visited Dudley High School (a predominantly black high school in Greensboro, NC) and talked to students about STEM, supply chain, and transportation educational paths and careers as well as their personal experiences and aspirations. On March 27th, two NC A&T undergraduate students participated in the NC A&T STEM Early College's Curriculum Night informing students about transportation and supply chain career opportunities.

Technology Transfer

What opportunities for training and professional development were provided?

NC A&T faculty and administrative staff currently engaged in CATM funded activities attended the NCDOT Research and Innovation Summit in March 2023. During the Summit, they had the opportunity to present their research projects and learn more about the projects in which the NCDOT is involved. This was an excellent event for networking and building collaborations with transportation professionals throughout the state.

Students working on CATM projects are receiving training on and are learning how to apply methods required to conduct their respective studies. For instance, the master's student working on the Driving Feedback project obtained on-the-job training as he coordinated IRB efforts and worked with the Information Technology Department at VTTI to ensure that the data they are receiving corresponds with what was expected. He also worked with the VTTI recruitment team to confirm that their recruitment methods match with best practices established from previous recruitment efforts and coordinated procedures for participant intake. Finally, he was responsible for writing the initial draft for the final report for the project. This is just an example of the types of hands-on tasks students are doing that help them develop both technical and non-technical skills necessary to become successful transportation professionals.

Have the results been disseminated?

Two webinars were conducted by CATM researchers during the reporting period. On October 4, 2022, Dr. Houbing Song (ERAU) introduced the audience to his research laboratory, the SONG (Security and Optimization for Networked Globe) Lab, and discussed how cyber physical systems (CPS) serve as a foundation for safe and efficient highway transportation systems by connecting vehicles, infrastructure, people, and goods. His presentation went on to describe his work on drone neutralization using a counter unmanned aircraft system (C-UAS), which he characterized as "hacking for good."

On December 2, 2022, Dr. Jon Antin and Mr. Brian Wotring (VTTI) held a webinar during which they discussed the development of their program designed to provide individualized transportation solutions to older adults residing in rural areas. Such solutions will enable them to maintain their mobility well after it is no longer safe or feasible for them to drive so they can more easily access the services and personal relationships required to maintain happy, healthy lifestyles. Recordings of all CATM webinars can be viewed by clicking on this link.

The VRU-MAP, Dynamic Pricing, and Mask Wearing project final reports were all posted on the CATM website and can be accessed by clicking on this link. In addition, the High-Speed Rail and Detecting Dementia projects along with the 2022 Summer High School Transportation Institute activities were all featured in the Winter 2022 CATM Newsletter. The 2022 CATM Summer Transportation Research Interns were also introduced in this issue of the newsletter. Copies of the CATM newsletters can be obtained by clicking on this link.

The CEV Vision project was disseminated at Virginia Tech through an Undergraduate Research Seminar (ENGR 1014) in the Center for Enhancement of Engineering Diversity (CEED). The presentation was facilitated by one of the female doctoral students working on the project and the audience consisted of approximately 400 freshman engineering students.

The Machine Learning project was used to describe how clustering algorithms can be applied in the real world in three different upper level/graduate courses at ERAU.

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.

- Close out currently active research projects
- Further disseminate research findings for completed projects
- Distribute the Spring 2023 newsletter
- Host the NC A&T's 31st Summer High School Transportation Institute
- Recruit applicants for the 2023-24 DDETFP
- Plan the 4th Annual CATM Symposium

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.; & 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 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 Mathematics	Daytona Beach, FL	Collaborative Research	Yougxin Li, 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
Computer Science	Pensacola, FL	In-Kind Support	Dr. Ashok Srinivasan	University of West Florida
National Surface Transportation Safety Center for Excellence	Blacksburg, VA	Financial Support	Dr. Jon Hankey	Virginia Tech
General Motors	Detroit, MI	In-Kind Support	Dan Glaser	

Other collaborators or contacts involved

During the reporting period, members of the CAV Vision team collaborated with the Virginia Tech ADA Compliance Department for survey tool review and vetting. In addition, Drs. Joseph Huscroft, Kimberly McNeil, and Venktesh Pandey are mentoring the two 2022-23 NC A&T Dwight D. Eisenhower Transportation Fellows - Keshawn Johnson and Anusha Neupane. Keshawn's paper titled "Marketing Towards a Sustainable Future" describes how marketing can influence consumers to make more environmentally conscious vehicle purchases, such as

electronic vehicles, to help slow down global warming. Anusha's research involves the development of a prototype adaptive trip planning algorithm that can be integrated into a cell phone application and uses datasets available for the state of North Carolina.

3. OUTPUTS:

The subsections below outline some of the outputs that have resulted from completed and currently active Center research projects as well as the education, workforce development, and technology transfer activities.

Publications, conference papers, and presentations

Journals

- Dam, A., Oberoi, P., Pierson, J., Jeon, M., Patrick, R., (n.d.). Technological and Social Distractions at Unsignalized Campus Crosswalks: A Mult-Stage Naturalistic Observation Study, Transportation Research Part F: Traffic Psychology and Behaviour, Under review; Acknowledged Federal Support: yes.
- Dekkata, S. C., Yi, S., Muktadir, M. A., and Garfo, S. (2023). LiDAR-Based Obstacle Detection and Avoidance for Navigation and Control of an Unmanned Ground Robot Using Model Predictive Control. Journal of Mechatronics and Robotics, 7(1), 27-41; Published; Acknowledged Federal Support: yes.
- Wu, Y. and Namilae, S. Parametric Analysis of SARS-CoV-2 Dose-Response Models in Transportation Scenarios; Under review; Acknowledged Federal Support: yes.

Books and Non-Periodical, One-Time Publications

- Kwakye, K., Seong, Y., and Yi, S. (2022). Travel Time, Distance and Costs Optimization for Paratransit Operations using Graph Convolutional Neural Network; Publisher: arXiv preprint arXiv:2205.10507; Acknowledged Federal Support: yes.
- Owens, J.M., and Miller, A., (2023). Vulnerable Road User Mobility Assistance Platform: CATM Final Report; Report; published; Acknowledged Federal Support: yes.

Other Publications, Conferences, and Presentations

- Antin, J. and Wotring, B. (2022). Rural Older Adult Driver Tailored Research Integrated Plan (ROAD TRIP); Center for Advanced Transportation Mobility; Webinar; December 1; Presented; URL: https://youtu.be/gco25jmZrW0; Acknowledged Federal Support: yes.
- Kwakye, K., Seong, Y., and Yi, S. SigSegment: A Signal-Based Segmentation Algorithm for Identifying Anomalous Driving Behaviours in Naturalistic Driving Videos; Submitted to IEEE Computer Vision and Pattern Recognition Conference; Under review, Acknowledged Federal Support: no.
- Kwakye, K., Seong, Y., and Yi, S. Classification of Human Driver Distraction Using 3D Convolutional Neural Networks; Submitted to Human Factors & Ergonomics Society Annual Meeting 2023. Under review. Acknowledged Federal Support: no.
- Park, H. (2023). Advancing Temporal Multimodal Multivariate Learning, State of the Art in Deep Learning and Its Applications in Transportation (Workshop 5004). 102th Annual Meeting of Transportation Research Board (TRB 2023), # P23-21032, Washington, DC; January, 8-12; Presented and Published; Acknowledged Federal Support: yes.
- Park, H., Darko, J., Yoon, G., and Sundaram, I. (2023). Trip Planner MODE (Multimodal Optimal Dynamic pErsonalized). INFORMS Transportation and Logistics Society Second Triennial Conference, Paper #5243, July 23-26, Chicago, Illinois; Accepted; Acknowledged Federal Support: yes.
- Wu, Y. (2023). Poster: Analyzing the Role of Air-Transportation in COVID-19 Pandemic Disaster. 102th Annual Meeting of Transportation Research Board (TRB 2023), Washington, DC; January, 8-12; Presented; Acknowledged Federal Support: yes.

- Yoon, G., Park, H., and Monast, K. Paratransit Routing Considering Dwell Time Uncertainty and Contexts of Requests. INFORMS Transportation and Logistics Society Second Triennial Conference, #9152, July 23-26, Chicago, Illinois; Accepted; Acknowledged Federal Support: yes
- Zhou, Y., Yang, Y., Liu, D., Namilae, S., and Song H., A Survey of Machine Learning Algorithms and Techniques for Evacuation Under Emergency. IISE Annual Conferences and Expo; Accepted; Acknowledged Federal Support: yes.

Websites or other internet material

- CATM Website: https://www.ncat.edu/cobe/transportation-institute/catm/index.php
- CATM Fall 2022 Newsletter: https://www.ncat.edu/cobe/transportation-institute/_files/pdfs/winter2022finalada.pdf
- CATM Facebook Page: https://www.facebook.com/NCATCATM/
- Teen Feedback Website: https://www.vtti.vt.edu/teenfeedback/
- Webinar titled “Secure and Trustworthy Transportation Cyber-physical Systems”: https://youtu.be/Zh7ngOsUmd4
- Webinar titled “ROAD TRIP: An Early Program Readout”: https://youtu.be/gco25jmZrW0

Technologies or techniques

- Situation Awareness project: 1:1 physical and virtual crosswalk testbed using an Oculus Quest 2 and the ICAT Perform Studio facilities at VT.
- Machine Learning project: Dynamic spectral clustering for airspace reconfiguration. The team plans to share the technical details with sample data on a dedicated Github page and IEEE Dataport.
- ROAD TRIP project: In this project, an algorithm was developed that distills assessment data and the results of driving data analysis into a graphic representation with actionable recommendations for altering driving behaviors and patterns to extend mobility and enhance safety. The graphics and recommendations are shared with study participants during driving consultation meetings.

Inventions, patent applications, and/or licenses

- Nothing to report

Other products

- Nothing to report

4. OUTCOMES:

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

- VRU-MAP project: The final report provides a publicly available report of the current understanding and awareness of the challenges faced by pedestrians with disabilities and a potential technological countermeasure in support of future research and development.
- Situation Awareness project: This work has increased the understanding and awareness of university culture-based pedestrian behavior, driver non-verbal communication methods, and self-imposed reductions in acoustic situation awareness due to the use of personal listening devices during street crossings through survey distributions, demos at on-campus student symposiums, and oral presentations at international conferences.
- VRUTOP project: This research focuses on improving transit services for vulnerable road users while addressing recent trends in Medicaid transformation, particularly service performance changes before and after the COVID-19 pandemic.

- COVID-AirTran project: This study found that the dose level had a significant impact on the number of secondary infections in transportation scenarios. In general, mask usage reduced infections at all dose levels. High-quality N-95 masks are effective for all dose levels, while lower-quality masks exhibit limited mitigation efficiency, especially for high-dose conditions. Sensitivity analysis indicated that the reduction in infection distance threshold is a critical factor in mask usage.
- Machine Learning project: Data visualization technology was used to help aviation business management students understand the degree of imbalance in air traffic demands.
- CAV Vision project: This project has exposed undergraduate ISE, graduate ISE, and general engineering students at Virginia Tech to the role and importance of Human Factors Psychology and Engineering within the transportation domain, more specifically pedestrian safety. Through weekly course meetings, undergraduate students have been guided by a graduate research assistant to systematically gather and critically evaluate relevant scholarly literature and produce technical documentation describing their findings. This skill is essential for young researchers. In addition, now that data collection has begun, students will gain invaluable experience with human-subject interaction and data collection.
- Reinforcement project: This project addresses emergency response transportation systems, which are characterized by high time pressure and uncertainty. The characteristics of these situations are being investigated with the consideration of more realistic factors, such as moving threats in the environment. The emergency evacuation flight planning and capacity maximization case scenario from this project was used to demonstrate the complexity of the transportation planning problem as well as the potential loss and gain in the following ERAU courses: DS615 - Data Modeling and MA540 - Database and Information Retrieval.
- ROAD TRIP project: Introducing research-based driving intervention plans to study participants equips older adults with essential tools for extending their mobility and enhancing their safety and that of those sharing the roadways with them.
- Air Mobility project: The spectral clustering approach for dynamic airspace reconfiguration and the corresponding fine-tunning algorithm are major contributions of this project.
- High-speed Rail project: The findings of this study can enhance the understanding of the acceptance of HSR as a viable option for domestic travel as well as the intention to use HSR in the US, which can aid policy makers as they develop suitable strategies for HSR development in the US.

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:

- VRUTOP project: Compared to the existing fixed transit system, this project will provide guidelines for new scheduling and routing policies for service vehicles considering the Medicaid transformation toward private control.
- Reinforcement project: The project results can be used as a decision aid for policy makers to determine the best strategies and routes for humans to evacuate under specific types of emergency situations.

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

- VRU-MAP project: The final report for this project will provide a publicly available source describing the various challenges faced by pedestrians with disabilities and a potential technological countermeasure in support of future research and development.
- Situation Awareness project: The development of the 1:1 crosswalk testbed was disseminated to an international community of auditory display researchers and designers and is expected to lead to further research and development of pedestrian safety simulation displays.

- VRUTOP project: Analyzing the impact of the Managed Care Organization model in a larger community in order to illustrate the trade-off between Medicaid recipients and non-recipients requires a significant data collection effort. Due to this limitation, existing transit service tools have had difficulties capturing essential parameters and adjusting to the new environments. This project includes data mining and data-driven optimization of the paratransit service that helps overcome some of these limitations.
- Reinforcement project: This project investigates the possibility of using AI and heuristic optimization to address transportation planning issues, which provides a great case study for transportation operators. Additionally, the application of A3C agents in evacuation scenarios is very limited and this project demonstrated the benefits of applying Advantage Actor Critic (A2C) for evacuation route optimization. In particular, for multi-agent collaboration, this model provides an adaptive learning alternative for an uncertain environment.
- ROAD TRIP: This research has highlighted the connection between increased mobility and the positive health outcomes related to reduced social isolation and greater accessibility of essential goods and services.
- High-speed Rail project: HSR has been a research interest for many years, but the research has been mainly conducted in successful HSR countries, particularly in Europe and Asia. There is a substantial gap in the research regarding HSR in the US. While some studies focused on challenges and opportunities in HSR development in the US, there has been very limited study examining HSR development from travelers' perspectives. The findings of this study can fill this important research gap.

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

- Situation Awareness project: This project brings awareness to the dangers and additional pedestrian vigilance requirements necessary to traverse a crosswalk safely while engaging in acoustically distracting tasks both within a group or alone and at signalize or unsignalized intersections.
- VRUTOP project: Without knowing exactly how specific Medicaid privatization trends will affect changes to the where, when, and how user patterns of the transit system, it is difficult to improve the efficiency of the service. This project improves the process by providing a dynamic method of optimizing the operation of paratransit service.
- Machine Learning project: Data visualization technology was used to enable aviation business management students to better understand the degree of imbalance in air traffic demands and teach them a programmatic way of reconfiguring the airspace dynamically. The results of reconfiguring by human efforts and by the algorithm were compared to confirm improvement.
- Reinforcement project: The application of machine learning in transportation is fast growing. Pedestrian navigation to safety after an incident is critical to saving lives and preventing injury in a multitude of emergency situations. The project outcomes will lead to guidelines for the safe egress of pedestrians in complex environments.
- ROAD TRIP project: The methodology developed in the context of this research integrates data collected across domains to inform personalized recommendations to the research subject. It is the first known instance of combining assessments of driving knowledge, history, physical activity, and measures of social isolation with analysis of naturalistic driving data to provide targeted solutions to specific mobility challenges faced by older adults.
- Air Mobility project: Two course projects for students were developed in the data science program at ERAU. This is the first time that ERAU students performed optimization tasks with transportation systems using real datasets, regulation constraints, and actual known limitations. ERAU Ph.D. candidates from the Computer Science department worked on this project and shared the code internally. This expands and furthers their understanding of transportation systems as well.

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

- Research projects: Undergraduate and graduate students working on CATM research projects receive training and hone their skills in both discipline-specific and interdisciplinary methods. These skills can be used to solve complex transportation issues upon entry into the workforce.
- VRU-MAP project: Over the course of the project, the VRU-MAP team supported several undergraduate students, providing them with coding, research and presentation experience.
- VRUTOP project: This project provides training in the operation of paratransit, transportation data management, traffic demand modeling, and transportation mesoscopic simulations.
- Machine Learning project: The utilization of data visualization technology provides a more engaging way to help ERAU business aviation management students better understand the task of balancing air traffic demands. These students were taught a programmatic way of reconfiguring the airspace dynamically and were able to see the differences between the results obtained from reconfiguring using human effort and by using the algorithm.
- Reinforcement project: As a result of this project, possible solutions using AI and heuristic optimization in addressing the transportation planning issue were obtained for comparison. This information provides a great demonstrative case for transportation operators. The material has also been used in graduate level core courses at ERAU.
- ROAD TRIP project: This research, which combines driving research and community outreach, has the potential to broaden the future contributions of both immediate research team members and transportation professionals exposed to the research through webinars and presentations beyond traditional research-driven policy and technology outcomes, including the ability to realize practical, discrete results in the lives of older adults. The research team is reaching out to students across disciplines (e.g., public health, gerontology, pre-med) to join the program. The hands-on experience these students will gain by interacting with study participants will inform their professional practice far beyond their involvement in this particular effort.
- ASETTS program: NC A&T undergraduate students majoring in civil engineering and supply chain management were exposed to education and career opportunities in transportation through the ITE Student Leadership Summit, TRB Annual Meeting, and various transportation educational activities.
- Student-to-Student program: High school students were introduced to education and career opportunities in transportation and supply chain management during presentations delivered by current supply chain management undergraduate students at NC A&T.

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

- Situation Awareness project: Participants and presentation attendees were educated on the potential dangers of reduced auditory situation awareness while engaging in street crossings and were informed of the value of maintaining high levels of visual vigilance and open-ear features associated with some personal listening devices.
- VRUTOP project: Compared to traditional deterministic paratransit service, the data-driven optimization technique used in this project is considered to effectively address uncertainty within the paratransit transportation system.
- Reinforcement project: The A3C algorithm used in this project combined with multi-agent reinforcement learning models are innovative in transportation evacuation studies.
- Air Mobility project: Two course projects were developed for and will be used by students in the data science program at ERAU. These projects will provide ERAU students with the opportunity to optimize transportation systems using real datasets and constraints, such as regulations and actual system limitations.

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	3
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	2
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	1
Outcome #4	Dissemination of research results through presentations, publications, conference papers, and technical reports	Number of presentations and workshops given	6	8
		Number of peer-reviewed journal papers published	2	0
		Number of newsletter articles, conference papers, and technical reports published	10	11

5. IMPACTS:

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

- VRUTOP project: The VRUTOP project aims to improve access to health care in underserved areas using public transportation and mobility as a service (MaaS), while considering Medicaid shifts towards privatization and modeling the interactions between the key contributing trip characteristics influencing arrival time window uncertainty. As a result, a new service tool that will benefit both paratransit workers and users will be developed.
- Reinforcement project: The results of this project can result in a significant reduction in workload for emergency services dispatchers.

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?

- VRU-MAP project: This project and final report will support additional development and potential commercialization of the VRU-MAP platform to support increased mobility of pedestrians with disabilities.
- Situation Awareness project: The project is likely to make an indirect impact on commercial technologies, such as virtual reality, in terms of providing additional examples of how the technology can be used for scientific research, especially when investigating potentially harmful behaviors. In addition, study results may inform developers and users about the need for and importance of high levels of auditory perception and passthrough features while engaging in street crossings.
- VRUTOP project: For use with training transpiration service operators, this project adapts to possible changes in the system delay due to wait or load time of previous pick up.

- COVID AirTran project: In this study, dose level was found to have a significant impact on the number of secondary infections and mask usage reduced infections at all dose levels. High-quality N-95 masks are effective for all dose levels, while lower-quality masks exhibit a limited mitigation efficiency, especially for high-dose conditions. Sensitivity analysis indicated that the reduction in infection distance threshold is a critical factor in mask usage. These results can be used to encourage mask-wearing in future infectious disease transportation cases.
- CEV Vision project: The research outcomes are likely to make an impact on commercial technology in terms of their potential to facilitate safe crosswalk activities through vehicle-to-pedestrian communication systems while survey results will provide insights in terms of visually impaired user preferences and dislikes regarding certain technology and street crossing aids.
- Reinforcement project: The technology and simulation case will be made available directly to students in the ERAU College of Aviation and integrated into their course material. Also, the project team plans to make all of their products open-source and publicly available.
- High-speed Rail project: This project will inform transportation planners and developers about the likely acceptance of HSR by potential passengers in the US and their intention to use HSR once it becomes a viable option for domestic travel. The findings can inform both industry professionals and government officials as they develop guidelines and strategies to prepare for the implementation of HSR systems nationwide.

What is the impact on the body of scientific knowledge?

- VRU-MAP project: The research described in this project's final report supports the extension of the practice and theory surrounding improved mobility for pedestrians with disabilities.
- Situation Awareness project: This project is likely to make an impact because it utilizes a novel multi-stage (e.g., observation, survey, focus group) research methodology to investigate pedestrian, more specifically crosswalk, behavior in a naturalistic yet informative manner. When published, other researchers will have a methodological reference-point for future holistic explorations of pedestrian behavior.
- VRUTOP project: The integration of the data mining model and optimal pick-up and drop-off model developed for this project can handle unexpected delays in the system and reduce operating costs.
- Detecting Dementia project: The premise of this work is that degraded driving performance can serve as an early indicator of pre-mild cognitive impairment (pre-MCI). The data analysis reveals that safety performance in drivers complaining of cognitive difficulties is indistinguishable from healthy controls, suggesting that pre-MCI does not negatively affect driving performance. However, poor driving performance (e.g., increased instances of forward collision warning alerts) in one subject with subjective complaint of cognitive difficulties who scored well on a cognitive assessment administered at intake suggests that pre-MCI may show up in driving performance in some fashion before it is detectable on an assessment.
- COVID AirTran project: Transportation systems involve high-density crowds of geographically diverse people with variations in susceptibility and intervention use; therefore, they play a large role in the spread of infectious diseases like SARS-COV-2. The project team analyzed five empirical events of SARS-COV-2 transmission where the spatiotemporal details of the infected persons are known. They found that the dose level had a significant impact on the number of secondary infections and mask usage reduced infections at all dose levels. High-quality N-95 masks are effective for all dose levels, while lower-quality masks exhibit a limited mitigation efficiency, especially for high-dose conditions. Sensitivity analysis indicated that the reduction in infection distance threshold is a critical factor in mask usage.
- CEV Vision project: The research is likely to make an impact on the base of knowledge in terms of low vision and visually impaired technology interface and intervention preferences, auditory signal perception latency based on explored intervention devices, and provide additional evidence in terms of the value of immersive virtual environments for safe crosswalk research and training.

- Reinforcement project: The A3C algorithm is one of the most powerful algorithms in deep reinforcement learning, this project will demonstrate its potential to optimize evacuation processes in an airport environment during emergencies. In this project, a multi-agent collaborative evacuation modeling framework for a complex and changing airport environment with moving targets based on the A3C algorithm, which is innovative in the application of A3C agents, was proposed. Pedestrian navigation to safety, especially in public transportation hubs is critical to saving lives and preventing injury in a multitude of emergency situations.
- ROAD TRIP project: The methodology being developed in the context of this research has the potential to revolutionize our nation's approach to extending mobility and thus improving health outcomes for older adults using personalized interventions based on the analysis of individual functional assessment and naturalistic driving data.
- High-speed Rail project: There is little literature on the intention to use HSR in the US. This study aims to fill this important gap by investigating (1) passengers' choice among car, air, and HSR for domestic travel in the US and (2) key determinants of American passengers' intention to use HSR. A new theoretical framework will be proposed based on the theory of planned behavior. By providing empirical evidence from the lens of passenger intention and behavior, this study can expand the knowledge base of mode use intention of American travelers, especially following the pandemic.

What is the impact on transportation workforce development?

- VRU-MAP project: The VRU-MAP project supported the development of a number of undergraduate students, enabling them to participate in hands-on research supporting mobility for people with disabilities, as well as presenting their work at academic symposia and conferences.
- VRUTOP project: This work will train transportation professionals working with health care providers and paratransit service departments on effective methods of matching the right service deliveries using the proposed machine learning and artificial intelligence methods.
- COVID AirTran project: Graduate students working on this project were trained in interdisciplinary research methods and data analysis tools.
- Machine Learning project: Students were exposed to data visualization technology for analyzing air traffic demands and were taught programmatic means of reconfiguring the airspace dynamically. These tools can be added to their toolkit and used as needed in their professional lives.
- Reinforcement project: This project will provide a valuable case study for application of deep reinforcement learning that can used as a demonstration in graduate level courses. Publications will also be submitted to disseminate the results to share with the community.
- ROAD TRIP project: This research, which combines driving research and community outreach, has the potential to broaden the future contributions of student researchers exposed to the research beyond traditional research-driven policy and technology outcomes to include the ability to realize practical, discrete results in the lives of older adults in rural areas that enhance their driving experience and increase their overall life satisfaction by extending their mobility. The research team is reaching out to students across disciplines (e.g., public health, gerontology, pre-med) to join the program. The hands-on experience these students will gain while interacting with study participants will inform their professional practice far beyond their involvement in this particular effort.
- ASETTS program: Students in the NC A&T ASETTS program engaged in activities such as a VTTI tour, NCSITE annual meeting, traffic bowl competition, guest lectures, and webinars to expand their knowledge of transportation and related career options.
- Education and Workforce Development activities: The activities that take place at NC A&T are geared primarily towards exposing minority students to transportation career opportunities. In this way, we assist in the diversification of the transportation workforce. These programs include the Dwight David Eisenhower Minority Fellowship Program through which students are exposed to transportation as they conduct research on a transportation topic of their choice. The CATM Scholars program requires scholarship recipients to engage in transportation activities such as

conferences, tours, and seminars/webinars to expose them to a wide range of transportation career opportunities. In addition, they are strongly encouraged to relay their knowledge to high school students through student-to-student presentations. NC A&T students involved in the AutoDrive Competition Program (Figure 4) are learning a lot by applying related technology and scientific knowledge to the self-driving car they are creating.

Figure 4: AutoDrive project team members

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	0 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	4 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/DELAYS/PROBLEMS:

VRUTOP project: The project completion date was moved to the end of July due to a delay in real-world data preparation from the NCDOT due to registration issues in Medicaid.

Teen Feedback project: The IRB application for this project was submitted on 1/6/2023 and approved by the Virginia Tech Institutional Review Board on 1/24/2023. An amendment to the

IRB was submitted on 2/13/2023 for minor changes to recruitment materials and consent documents and was approved on 2/14/2023.

Machine Learning project: In the beginning, the Machine Learning team wanted to use reinforcement learning (RL) agents to do the clustering. However, they found that the reward function could be very difficult to define. In addition, the RL algorithm encounters too many stability issues, and it becomes undeployable in the real world. Therefore, they developed their own adaptive spectral clustering algorithm to address the issue perfectly. The final report submission for this project is delayed because the previous PI and his students left ERAU and the new PI needs time to organize the report.

COVID Outbreaks project: The student working on the project unexpectedly left ERAU and the PI had to find a replacement and get them trained in order to complete the project.

CEV Vision project: There was a mandatory change in the survey administration tool (Qualtrics to QuestionPro), which resulted in a need for IRB amendments and VT Controller approval of digital human subject compensation, both of which are now approved.

Reinforcement project: This project must be extended one semester because the original PI and his students left ERAU. The new PI is working intensively to move the project towards completion.

ROAD TRIP project: Based on data collected and outcomes for the first four participants, the research team made a number of changes to the project approach, including shortening the duration of participation to 3 months and expanding eligibility to include drivers residing in semi-urban areas.

Overall: During the pandemic, there were significant delays in student hiring and reductions in spending on activities such as travel. As a result, we have a significant amount of funds that have not yet been spent. Therefore, a no-cost extension will be requested and some of the remaining funds will be distributed to CATM researchers to conduct additional data collection on previously funded projects to strengthen the results of their studies and support an increase in their dissemination efforts.

7. SPECIAL REPORTING REQUIREMENTS

Nothing to report for this period.