



UTC Semi-Annual Performance Report

Federal Agency and Organization Element to Which Report is Submitted:

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

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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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Reporting Period End Date: March 31, 2024

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, 2024.

Table 1: Progress of period 14 activities

Research	Status	% Complete
Conduct annual visit to member institutions – Year 6	Complete	100%
Complete Year 4 projects	Behind schedule	95%
Complete Year 5 projects	Behind schedule	95%
Complete Year 6 projects	On schedule	80%
Complete Year 7 projects	On schedule	50%
Education, Outreach, and Workforce Development Activities		
Student participation in the 2024 TRB conference	Complete	100%
Recruit/select 2024 STI participants	On schedule	50%
Hold the 2024 Dwight David Eisenhower Transportation Fellowship Local Competition	On schedule	50%
Prepare for and hold 2024 STI	On schedule	50%
Technology Transfer Activities		
Conduct 2023 research webinars	Complete	100%
Create and distribute Fall/Winter 2023 newsletter	Complete	100%
Plan and hold the 5th Annual CATM Symposium	Behind Schedule	95%
Create and distribute Spring 2024 newsletter	On schedule	80%
US DOT Reporting Activities		
Update records in RiP database	Behind schedule	50%
Complete and submit PPPR#13	Complete	100%
Complete and submit SF425 for Q23 and Q24	Complete	100%
Complete and submit 2023 recipient share report	Complete	100%
Complete and submit 2023 performance indicator report	Complete	100%

Complete and submit PPPR#14	On schedule	50%
Review year 4 final reports for completed research projects	Behind schedule	83%
Upload year 4 final reports to TRID database	Behind schedule	83%
Review year 5 final reports for completed research projects	Behind schedule	83%
Upload year 5 final reports to TRID database	Behind schedule	83%
Review year 6 final reports for completed research projects	Behind schedule	0%
Upload year 6 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 7 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
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
Evaluation of Web-Based Driving Feedback for Teens and their Parents	Completed/Y4	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/web-based-driving.php
Evaluation of Web-Based Driving Feedback for Teens and Their Parents - Pt.2	Extension Completed/Y7	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/evaluation-of-web-based-driving-feedback-for-teens-and-their-parents.php
Detecting Early-Stage Dementia Using Naturalistic Driving	Completed/Y4	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/detecting-dementia.php
Modeling Future Outbreaks of COVID-19 Using Traffic as Leading Indicator	Completed/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
Pedestrian Auditory Situational Awareness: Tesseract Crosswalk Module	Extension Continuing/Y7	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/pedestrian-auditory-situational-awareness-tesseract-crosswalk-module.php
Real-time Deep Reinforcement Learning for Evacuation under Emergencies	Completed/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	Completed/Y6	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/rural-older-adult-driver-tailored-research.php

ROAD TRIP 2.0 – Transforming the Mobility Landscape for Aging America	Extension Completed/Y7	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/road-trip-2.0-transforming-the-mobility-landscape.php
Improving Air Mobility in Emergency Situations	Completed/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	Completed/Y6	IM, RC, PS, PE	https://www.ncat.edu/cobe/transportation-institute/catm/high-speed-rail-in-the-us1.php
High-Speed Rail in the US: The Intention to Use and Mode Choice Behavior - Additional Funding Opportunity	Extension Completed/Y7	IM, RC, PS, PE	https://www.ncat.edu/cobe/transportation-institute/catm/high-speed-rail-in-the-us-the-intention-to-use-and-mode-choice-behavior.php
Acceptance and Adoption of Shared Autonomous Shuttles for Vulnerable Road Users: A Readiness Study	Continuing/Y6	IM	https://www.ncat.edu/cobe/transportation-institute/catm/acceptance-and-adoption-of-shared-autonomous-shuttles-for-vrus.php
Data Curation and Technology Transfer for Recent ERAU-CATM Projects	Completed/Y7	IM, RC	https://www.ncat.edu/cobe/transportation-institute/catm/data-curation-and-technology-transfer.php
First Responder Transportation Safety Conference	Completed/Y7	IM, TC, PS	https://www.ncat.edu/cobe/transportation-institute/catm/first-responder-transportation-safety-conference.php
A Multiobjective Reinforcement Learning Framework for Equitable Toll Design for Express Lanes	Extension Completed/Y7	IM, RC	https://www.ncat.edu/cobe/transportation-institute/catm/a-reinforcement-framework-for-equitable-toll-design.php

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

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

The Situation Awareness team has completed all research activities. One publication has appeared in Transportation - Part F while another manuscript is under preparation. The final report is also in progress.

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

During the reporting period, the Driving Feedback research team completed data collection, completed data analysis, and submitted the final report. Although most of the quantitative measures did not show differences over experimental phases (i.e., hard braking, overspeed events, late night driving), seatbelt usage did show slight improvement over time. In addition, based on the check-in interview task, the team believes that monetary incentives and app-based feedback have the potential to improve safety, but study limitations may have muted that effect (primarily due to reduced sample size resulting from technical issues, lack of engagement potentially caused by parents and teens already using other monitoring software, and the inability to collect additional safety surrogates, such as speed over speed limit and distracted driving). Parents and teens both appreciated having feedback regarding the teens' driving; however, the app that was used for this study was very basic and parents would have found it more useful if it were more detailed. Some example details suggested during the interviews included: additional information regarding the impact of specific behaviors on incentive payments, additional coaching to help teens understand how to improve their driving behavior, and location-based data.

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

The Detecting Dementia research team submitted their final report during the reporting period. The report can be found using [this link](#).

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

The COVID Outbreaks team completed and submitted their final report during the reporting period. The report is currently under review and expected to be posted to the CATM website during the next reporting period.

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

The CEV Vision team completed data collection (N = 30) for Study A: Reaction Time Between Air and Bone Conduction Communication Devices. The data is being coded using the inter-rater reliability method. Data will be analyzed and reported over the summer. Pilot results for Study B: Immersive Environments for Vulnerable Road User Safety Using Personal Listening Devices at Unsignalized Crosswalks indicate differences between environmental, personal listening device preference, and signal response. Data collection is still in progress. A paper for the Tesseract: A Portable High-Density Loudspeaker Array for Spatial Sonification and Auralization (the CEV extension project) was accepted into the 30th International Congress on Sound and Vibration. The paper is expected to be presented in July in Amsterdam within the Auralization of Environmental Sounds session.

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

During this reporting period, the Reinforcement team completed the research models, including developing the environment, and developed the A3C model and Deep Q-learning model. They completed the experiment for both static threats and moving threats for single player and multi-players and analyzed the experimental results, which demonstrated the benefits of the A3C algorithm over the Q-learning algorithm, especially for moving threats, with regard to the efficiency of evacuation. The results also showed the impact of environment complexity on the Reinforcement Learning Agent, especially with the moving threats, and that the different reward mechanisms have an impact on the learning efficiencies. The final report was completed and submitted during the reporting period. It is currently under review and expected to be posted to the CATM website during the next reporting period.

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

The ROAD TRIP team completed data analysis for ROAD TRIP 1.0 and worked on finalizing that portion of the final report. For ROAD TRIP 2.0, the study team completed data collection for five participants enrolled in September 2023, replacing researcher-supervised drives before and after the driving consultation meeting with driving data collection via a mobile phone application (Figure 1). Additionally, the team completed data analysis and are currently adding it to the final report.

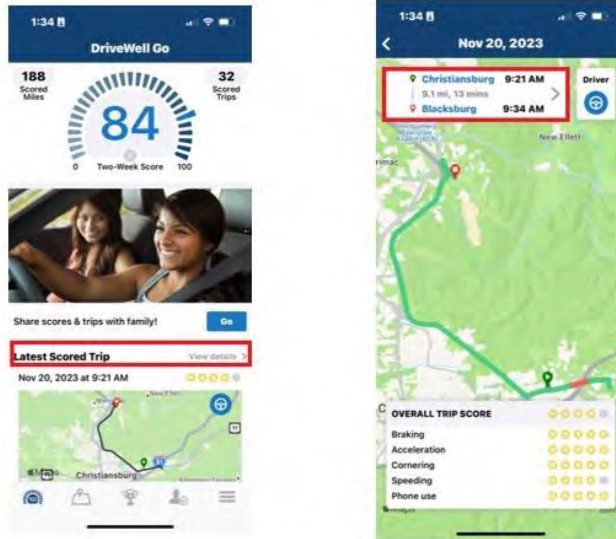


Figure 1: Views of the DriveWellGo's application from Cambridge Mobile Telematics used to collect driving data

Improving Air Mobility in Emergency Situations (Air Mobility)

The Air Mobility team completed and submitted their final report during the reporting period. It is currently under review and expected to be posted to the CATM website during the next reporting period.

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

The High-speed Rail team completed the project and submitted the final report for both the initial project and its extension. They are both currently under review and expected to be posted to the CATM website during the next reporting period. Additionally, a paper was submitted to an academic journal for publication.

Shared Autonomous Shuttles for Vulnerable Road Users: A Readiness Study (SAS Readiness)

The SAS Readiness team obtained IRB approval for the second part of their study and initiated data collection for that portion during the reporting period. Data from approximately 100 participants have been collected thus far. Figure 2 shows a few of the study participants.

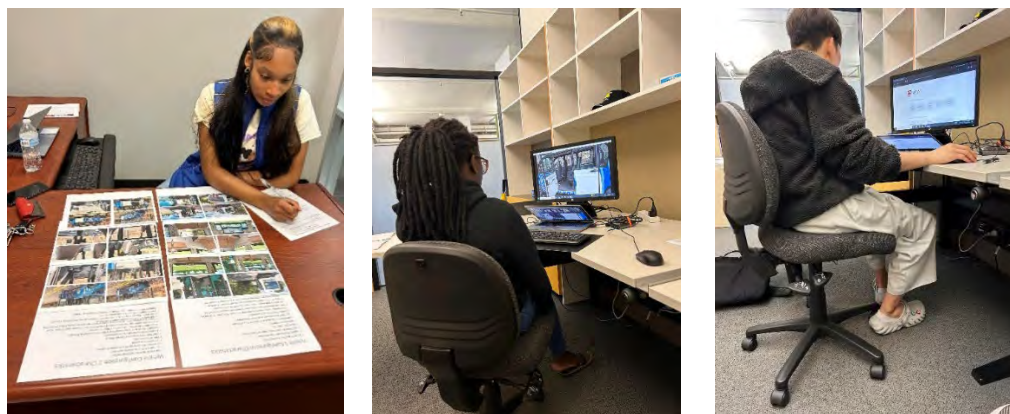


Figure 2: SAS Research Participants

Data Curation and Technology Transfer for Recent ERAU-CATM Projects (Data Curation)

During the reporting period, the Data Curation team published cleaned-up codes and examples on GitHub. They also created and distributed usability surveys for their codes.

First Responder Transportation Safety Conference (First Responder)

The First Responder team along with the TRB's Joint-Subcommittee on Emergency Response AMR00(1) and the Rutgers Center for Advanced Infrastructure and Transportation (CAIT) held the two-day conference and submitted the final report during the reporting period. The report is currently under review and expected to be posted to the CATM website during the next reporting period.

A Multiobjective Reinforcement Learning Framework for Equitable Toll Design for Express Lanes (Equitable Tolls)

During this reporting period, the Equitable Tolls team updated the current code base to PyTorch, ensured the latest code base aligns with open-source code principles, tested the code on four different networks, and compared pricing algorithms. The following specific objectives have been met: (a) designing an open-source platform that integrates advancements in multiobjective reinforcement learning literature for designing discounts for express lanes and (b) testing the transferability and usefulness of the tool across multiple datasets and development platforms. The results of the study highlight the critical issue of ensuring equity in managed lanes, highlighting the importance of equitable access to transportation infrastructure. Separating travelers based on their "money values of time", we see that we can reduce the equity gap among the travelers; however, it comes with a huge loss in revenue, which might not be acceptable in all cases. Offering discounts on tolls has also been seen to minimize the equity gap and reduce total system travel time for all. Given the unique characteristics of each network, including their dynamics and the diverse groups of travelers they serve, the outcomes of these analyses can vary. Therefore, tailored tolling approaches may be necessary to accommodate the specific needs of each system. Recommendations and outcomes include: 1) Instead of solely aiming to minimize equity gaps, implementing personalized tolling can maintain high revenue while also reducing travel times for low-income travelers. 2) Since equity remains a significant concern for many stakeholders, and achieving it can be expensive, partnerships with government bodies or nonprofit organizations focused on enhancing urban mobility and access should be considered. The final report for the project was drafted. The findings based on this project will be presented at the 2nd Conference on Advancing Transportation Equity, to be held in Baltimore, MD in July 2024.

Research Assistants

Twenty-four 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	8	3	11
Master's	7	4	11
Doctoral	1	1	2
Total	16	8	24

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

Education

Throughout the reporting period, the Equitable Tolls team successfully integrated project findings into classroom learning. Major activities included incorporating project insights into courses taught by the PI, specifically CIEN 700: Emerging Technologies in Civil Engineering, CIEN 453: Transportation Design, and CIEN 350: Introduction to Transportation Engineering during the Spring 2024 semester. The students engaged in discussions informed by the project's outcomes, fostering an encouraging learning environment. Additionally, students were encouraged to actively participate in national equity-related discussions facilitated by organizations like the Institute of Transportation Engineers (ITE).

Eleven NC A&T students attended the 2024 TRB Annual Meeting (Figure 3). Two TRB Minority Fellows from NC A&T gave poster presentations during the conference. Victoria Lanier, a senior Industrial and Systems Engineering major with a minor in Supply Chain Management, presented research titled “Optimizing Bike Infrastructure for Sustainable Urban Mobility: A Joint Mode and Route Choice Equilibrium Approach.” Byron Hall, a Mechanical Engineering graduate student and both a DDETFP and TRB Minority Fellows scholar, presented “Mounting and Control of Autonomous Vehicles.” DDETFP scholar Mikal Ali, a junior Civil Engineering major, presented “Differential Design of Discounts for Mileage-based User Fees.” Anusha Neupane, a former DDETFP scholar and senior Civil Engineering major, presented “Subscription Models for Differential Access to Real-time Information.”

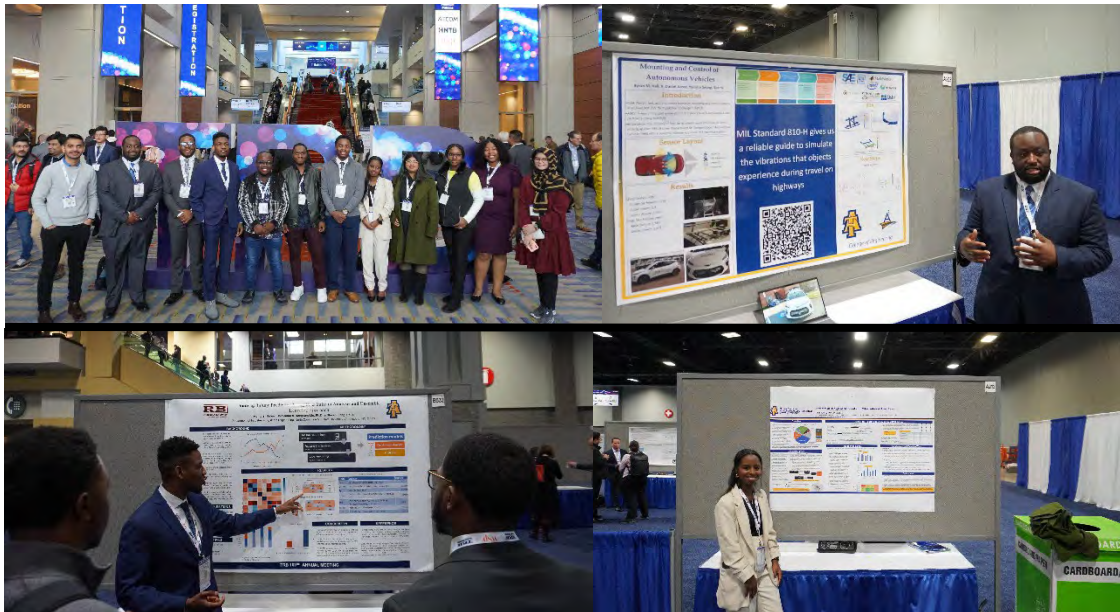


Figure 3: NC A&T students and faculty advisor at 2024 TRB Annual Meeting

On Oct. 26, 2024, students and faculty from NC A&T's Civil Engineering department visited Greensboro's Triad Traffic Management Center (Figure 4). The center is one of three N.C. Department of Transportation traffic management centers. Participants were able to observe how the center handles vehicle incidents, manage traffic flow, and uses science to manage traffic signs and signals. Additionally, participants received a tour of the center's control room, where all the center's program message boards and traffic monitors that showcase the flow of traffic throughout the city are displayed.



Figure 4: NC A&T Students visiting the NCDOT Traffic Management Center in Greensboro, NC

Fourteen NC A&T students participated in the North Carolina HBCU Smart Cities Challenge during the reporting period (Figure 5). The 5-month challenge, developed and facilitated by the Pathway Community Foundation, required students from multiple North Carolina HBCUs to build a smart city application that enhances a NC community. Officials from Charlotte, Winston-Salem, Rocky Mount, and Morrisville provided real-life challenges and mentored the teams as they worked on their projects. During the course of the challenge, HBCU students learned about IoT, ICT, Web3, AI, and other emerging technologies and used their knowledge to create innovative solutions to real-world problems within North Carolina. Ten of the NC A&T students who participated in the final pitch competition in March 2024 focused on a transportation project.



Figure 5: NC HBCU Smart Cities Challenge Teams

Workforce Development and Outreach

During the reporting period, a group of 9 students attended the Autodrive Challenge II Winter Workshop held in Ann Arbor MI (Figure 6). The students were given opportunities to learn more about the challenge’s rules and guidelines, discuss strategies to establish their plans to meet the requirements, and further accomplish the goals of designing Level 3 and 4 autonomous vehicles. They developed plans for various categories including perception, CAN, etc.



Figure 6: NC A&T students attending Autodrive Challenge II Winter Workshop

Technology Transfer

What opportunities for training and professional development were provided?

Researchers from ERAU worked with TRB’s Joint-Subcommittee on Emergency Response AMR00(1) and the Rutgers University Center for Advanced Infrastructure and Transportation (CAIT) to host an Emergency Responders Transportation Safety Summit in November 2023. Over 70 attendees, including individuals from responder agencies and State DOTs, participated in the two-day conference on transportation safety for first responders. The event brought together first responder agencies, technology developers, training experts and transportation officials to showcase the latest, cutting-edge technology advancements in transportation safety for first responders. These include tools and systems that help first responders better navigate

and operate in complex transportation environments, such as advanced GPS and mapping tools, specialized communications systems, and enhanced situational awareness technologies. In addition to technology demonstrations, the conference also highlighted the latest training programs and resources that are available to first responder agencies. These include specialized training programs that focus on transportation safety, as well as online training resources that can be accessed by first responders in the field. Overall, the conference was a valuable opportunity for first responder agencies to learn about the latest advancements in transportation safety technology and training and to explore new strategies for enhancing the safety and effectiveness of their operations in transportation environments.

The Tesseract virtual environment technology has been transferred to the CEV Vision project for use in additional transportation data collection. Demonstrations were performed using the technology and ideas for formal training are being discussed.

The findings from the Driving Feedback study were presented to General Motors - one of the project's collaborators. Cleaned-up codes and examples from several projects completed by ERAU researchers were published on GitHub and usability surveys for the codes were created and distributed to obtain feedback from potential users on their ability to utilize them.

For the ROAD TRIP project, the addition of research methodology to include a series of three researcher-supervised drives necessitated expansion of the study team. New team members were trained in assessment protocols and drive observation protocols.

Additionally, students were trained to perform research tasks specific to their projects. This research experience has led some students to pursue advanced graduate degrees (i.e., PhD).

Have the results been disseminated?

In November 2023, Dr. Rafael Patrick, Mr. Tanner Uptegrove, and their team gave a webinar on their pedestrian safety research as it pertains to situation awareness and auditory-based human-technology interfaces. Their engaging webinar included a live demonstration of the to-scale acoustically immersive mixed reality crosswalk testbed developed for the study. The recording of this webinar can be viewed by clicking on [this link](#).

The Detecting Dementia project final report was posted on the CATM website and can be accessed by clicking on [this link](#). In addition, the ROAD TRIP project along with the 2023 Summer High School Transportation Institute activities were both featured in the Winter 2023 CATM Newsletter. Copies of the CATM newsletters can be obtained by clicking on [this link](#).

The Emergency Responders Transportation Safety Summit project was advertised and disseminated through conference and CATM webpage postings.

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 2024 newsletter
- Host the NC A&T's 32nd Summer High School Transportation Institute

- Recruit applicants for the 2024-25 DDETFP
- Hold the 5th 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	Younho Seong, PhD	NC A&T
Dept. of Mechanical Engineering	Greensboro, NC	Collaborative Research	Sun Yi, PhD	NC A&T
Dept. of Civil, Architectural, and Environmental Engineering	Greensboro, NC	Collaborative Research	Venktesh Pandey, PhD	NC A&T
Dept. of Industrial and Systems Engineering	Blacksburg, VA	Collaborative Research	Rafael Patrick, Ph.D; Charlie Klauer, Ph.D; Myounghoon Jeon, PhD	Virginia Tech
Virginia Tech Transportation Institute	Blacksburg, VA	Collaborative Research	Jon Antin, PhD; Andrew Alden, PhD Brian Wotring	Virginia Tech
National Surface Transportation Safety Center for Excellence	Blacksburg, VA	Financial Support	Jon Hankey, PhD	Virginia Tech
Dept. of Graduate Studies, College of Aviation	Daytona Beach, FL	Collaborative Research	Dahai Liu, PhD; Jing Yu Pan, PhD; Sean Crouse, PhD	ERAU
Dept. of Mathematics	Daytona Beach, FL	Collaborative Research	Yougxin Li, PhD	ERAU
Dept. of Civil Engineering	Daytona Beach, FL	Collaborative Research	Scott Parr, PhD	ERAU
Aerospace Engineering	Daytona Beach, FL	Collaborative Research	Namilae Sirish, PhD	ERAU
Rutgers University CAIT Center	New Brunswick NJ	In-Kind Support	Patrick Scary	Rutgers University
General Motors	Detroit, MI	In-Kind Support	Dan Glaser Suzanne Johansson	
New Jersey DOT	Trenton, NJ	In-Kind Support	Salvatore Cowan	

Other collaborators or contacts involved

Dr. Scott Parr collaborated with CAIT, the Region 2 UTC led by Rutgers University. CAIT hosted the Emergency Responders Transportation Safety Summit at Rutgers University. Dr. Venkatesh Pandey continued his collaboration with Dr. Ali Hajbabaie from North Carolina State University on parts of the Equitable Tolls project.

CATM collaborated with the Pathway Community Foundation to help recruit students for and support the NC HBCU Smart Cities Challenge. Pathway Community Foundation is committed to innovation and community empowerment. Their mission “is to unite aspiring students, dedicated educators, and forward-thinking city officials in shaping the cities of tomorrow. [They] believe diversity, creativity, and collaboration can address complex urban challenges. By leveraging cutting-edge technology and fostering inclusive, innovative thinking, [they] empower students to become catalysts of positive change in their communities.”

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

- Motagi, S., Namilae, S., Gbaguidi, A., Parr, S., & Liu, D. (2023). Point-process modeling of secondary crashes. *Plos one*, 18(12), e0295343. Acknowledged Federal Support – Yes.

Books and Non-Periodical, One-Time Publications

- None this reporting period

Other Publications, Conferences, and Presentations

- Tiamiyu, R., Bowens, C., and Pandey, V. (2024). Personalized Pricing for Express Lanes: A Model-driven Approach for Achieving Long-Term Fairness. Accepted for Presentation at the 2nd Conference on Advancing Transportation Equity, Jul 15-18, 2024, Baltimore, MD. Acknowledged Federal Support - Yes.
- Tiamiyu, R., Bowens, C., and Pandey, V. (2024). Personalized Pricing for Express Lanes: A Model-driven Approach for Achieving Long-Term Fairness. Submitted for Presentation at the TRB Conference on Managed Lanes. Acknowledged Federal Support - Yes.
- Liu, Y. (n.d.) Improving Air Mobility for Pre-Disaster Planning with Neural Network-Accelerated Genetic Algorithm. Submitted to the 10th International Symposium on Security and Privacy in Social Networks and Big Data (NSS-SocialSec 2024). Acknowledged Federal Support - Yes.
- Liu, Y. (n.d.) A Cost-Aware Approach for Flight Resources Optimization During Pre-Disaster Evacuation. Submitted to the 10th International Symposium on Security and Privacy in Social Networks and Big Data (NSS-SocialSec 2024). Acknowledged Federal Support - Yes.

Websites or other internet material

- CATM Website: <https://www.ncat.edu/cobe/transportation-institute/catm/index.php>
- CATM Fall 2023 Newsletter: <https://www.ncat.edu/cobe/transportation-institute/catm/catm-documents/winter2024newsletter-final.pdf>
- Software and Codes for ERAU CATM projects: <https://ammg-at-erau.github.io/> - see “Software and Codes” tab

- Webinar titled “Auditory Situational Awareness for Vehicle-Pedestrian Communication Systems: Tesseract Crosswalk Module”: <https://www.youtube.com/watch?v=1VSTpuSNTeE>
- Emergency Responders Transportation Safety Summit webpage: <https://cait.rutgers.edu/event/emergency-responder-summit/>

Technologies or techniques

- CEV project: This project has resulted in the development of the Tesseract system which is a portable virtual reality system that can be used for pedestrian safety demonstrations.
- 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

- Reinforcement project: The research team adopted the Gym toolkit to develop the simulation environment. Additionally, the moving threats model employed in their project was developed by adapting a fire spreading model.

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:

- Situation Awareness project: This project has brought awareness to personal listening device distractions during unsignalized crosswalk crossings on a university campus.
- Driving Feedback project: Based on the check-in interviews and questionnaire responses from this study, it appears that parents and teens are open to app-based feedback and monetary incentives to improve teen driver safety. Many parents and teens in the study were already using driver monitoring software, such as Life360 and GM's Smart Drive, which shows that such software has the potential to be an effective tool if implemented properly.
- CAV Vision project: The work brings awareness to the use of auralization to increase safety for vulnerable road users - especially at unsignalized crosswalks.
- Reinforcement project: Applying the A3C model helps researchers further understand the nature of evacuation processes under emergency conditions and can be used to inform the public of the time pressure and high levels of uncertainty involved under such circumstances.
- ROAD TRIP project: Expanding the suite of methodologies used to develop research-based driving intervention plans to study participants holds the promise of equipping a broader spectrum of older adults with essential tools for extending their mobility and enhancing their safety, as well as those sharing the roadways with them.
- High-speed Rail project: HSR is still a new phenomenon in the US, but it is likely to experience fast development in the near future. The findings of this study can further the understanding from the previous HSR project conducted by the same team by providing insights into the role of environmental factors in the use of HSR in the US. This understanding is timely, as the US is moving toward a more balanced, sustainable transport system.
- SAS Readiness project: During the experimental process, participants have the opportunity to learn more about the capabilities of shared autonomous shuttles. They also walk away with a better understanding of the safety and security measures built into the vehicles to reduce the likelihood of a serious accident.

- Emergency Responders project: The conference associated with this project focused on sharing technologies and techniques for improving first responder safety with their respective agencies.
- Equitable Tolls project: This study, which has a dedicated focus on equity issues, has significantly contributed to nationwide discussions on social justice within transportation systems.

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:

- Situation Awareness project: Signs instructing "Hokies to Look Up" before crossing have been placed around campus. There is no proof of a direct relationship between the placement of these signs and this study; however, the signs appeared during data collection around campus.
- Driving Feedback project: Since the check-in interviews and questionnaire responses from this study indicate a willingness of parents and teens to use app-based driving feedback, DMVs might consider requiring the use of such programs during the early stages of driving for teens to improve safety by bringing attention to their unsafe driving practices.
- Reinforcement project: The results of this project can provide data-driven insights for training programs, improving readiness and response times during actual emergencies. For policymakers and emergency planners, adopting A3C-based simulations can lead to more informed decision-making, enabling the design of evacuation protocols that are both safer and more efficient. Furthermore, these results can guide the development of policies that prioritize investments in technology-driven safety improvements, ensuring that transportation systems are resilient against a wide range of emergency scenarios.

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

- Situation Awareness project: The work has led to the increased awareness of distracted pedestrians and their use of personal listening devices. Furthermore, the work has provided support for using virtual environments for the safe investigation of VRU street crossing behavior.
- Driving Feedback project: A technical report has been submitted to CATM and a second technical report was submitted to National Surface Transportation Safety Center for Excellence (NSTSCE). Both will be made publicly available. The research team believes that the qualitative plus quantitative data lends strong support that app-based feedback and monetary incentives can be effective tools to improve teen driver safety.
- Reinforcement project: By illustrating A3C's effectiveness in managing dynamic threats and facilitating smooth evacuation flows, this study advocates for the integration of advanced computational models into the emergency response strategies of airports and other critical infrastructure. This project has demonstrated the benefits of applying supervision Reinforcement Learning (RL) under emergent situations. It provides real time optimization to identify the most efficient paths and strategies for safe and quick evacuation, reducing potential bottlenecks.
- ROAD TRIP project: The initial iteration of this research highlighted the connection between increased mobility and positive health outcomes related to reduced social isolation and greater accessibility of essential goods and services. The subsequent exploration of alternatives to cost- and researcher-intensive naturalistic data collection methods in ROAD TRIP 2.0 has contributed further to the development of a portable, highly scalable program that can be implemented on a broader basis.
- High-speed Rail project: As it pertains to the US, there have been a very limited number of studies examining HSR development from travelers' perspectives. The findings of this study can help shed light on this issue and help US residents better understand the pros and cons of HSR.
- SAS Readiness project: This project is expected to shed light on dispositional and situational factors that are likely to impact the adoption of SASs. Since the implementation of SASs is a costly undertaking, it is essential that proper research be conducted to determine the likely uptake of these vehicles in the event that they are made widely available.

- Data Curation project: Codes associated with CATM research have been published in GitHub, along with examples, for others to utilize to further advance this field of research.
- Equitable Tolls project: This work has advanced the body of knowledge in optimization-based methods tailored to address equity concerns within transportation projects, particularly while balancing multiple objectives. This contribution extends to the development of models that effectively identify equity issues and optimize discounts for the overall welfare of the system.

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

- Situation Awareness project: The work has provided insights into non-verbal communication techniques between pedestrians and drivers.
- Driving Feedback project: Although the data that was collected during this project does not definitively demonstrate the effectiveness of feedback and incentives for teen drivers, future work based on these concepts that controls for monitoring software already used by parents and teens, along with additional safety surrogates, such as speeding over speed limit and distracted driving, could provide additional insight into how these tools might be used to improve teen driver safety.
- Reinforcement project: Utilizing the rapid adaptability of machine learning algorithms like A3C, the modern transportation system could dynamically optimize the shortest and safest evacuation routes in real time when emergency situations occur. The optimization is not limited to airport evacuation, but also expands to natural disasters or urban crises in an area. A3C's ability to adapt quickly to the changing environment, such as traffic congestion, road closures, or hazardous conditions, can allow the agents (e.g., passengers, pedestrians, vehicles, etc.) reroute efficiently for a safer and less congested path.
- ROAD TRIP project: The development of a less researcher-intensive approach to collecting the data for this project using a mobile phone application rather than the researcher-supervised drives previously used to collect driving data further advances the scalability of the program.
- Air Mobility project: The team used real data to teach students how to use highly programatic methods to optimize transportation systems. They applied explainable AI to time series prediction to support the optimization and scheduling of transportation systems.

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.
- Driving Feedback project: This study has provided research experience for a Master's student with interest in continuing similar research in the future.
- 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 recruited students across disciplines (e.g., public health, gerontology, pre-med) to join the program. By engaging in the project tasks, the students gained a deeper understanding of the mobility challenges faced by senior citizens. They are expected to utilize this knowledge in their professional practice and perhaps even their personal lives as they interact with drivers over the age of 60 years old.
- Equitable Tolls project: This project has significantly contributed to enlarging the pool of trained transportation professionals by actively mentoring and training six dedicated students. This number includes four undergraduates and two graduate students, each equipped with essential skills for success in the field. Graduate students: Ridwan Tihamiyu has focused on designing and modifying the simulation model code, integrating revenue-maximizing toll elements. Rifa Tasnia has excelled in code verification and literature review processes. Undergraduate students: Christian Bowens and Mikal Ali have actively engaged in simulations and experiments to quantify equity issues, bringing valuable insights. Anusha Neupane has verified open-source code

principles and conducted experiments on equity issues, contributing to the project's core. Finally, Isaiah Sanders has led a comprehensive literature review on multiobjective control methods.

- Autodrive project: The Aggie Autonomous Auto team consists of more than 20 students. These students meet regularly (at least once/week, some are constantly working in the lab). Their tireless work demonstrates and results in more students vying to be part of the autonomous vehicle design and improvement effort.
- ASETTS program: NC A&T undergraduate students majoring primarily in civil engineering and supply chain management were exposed to education and career opportunities in transportation through multiple activities (e.g., Traffic Bowl, NCDOT tour, TRB annual meeting, research experiences, etc.). Surprisingly, most of the students who participated in the HBCU Smart Cities challenge were not in traditional transportation majors. However, these students learned how to apply skills gained in their respective academic programs to solve transportation problems.

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

- Situation Awareness project: This project is expected to expand the use of virtual environments for safe VRU research.
- Driving Feedback project: The findings from this study were presented to General Motors. It was discussed that using monitoring and feedback apps with more refined metrics can better support improvements in teen driving safety.
- CEV Vision project: The Tesseract provides a tool for studying VRU situation awareness using a high-fidelity immersive audio environment.
- Reinforcement project: Using the A3C algorithm is innovative as it pertains to modeling evacuation under emergency. The team has successfully bridged the gap identified in the literature review regarding the practical application of advanced computational models, specifically the A3C algorithm, in simulating real-world evacuation scenarios.
- First Responder project: Various technologies were introduced and/or demonstrated during the summit with the expectation that participants will adopt those that are relevant for their practice.

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	1
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	5
		Number of peer-reviewed journal papers published	2	2
		Number of newsletter articles, conference papers, and technical reports published	10	4

5. IMPACTS:

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

- SAS Readiness project: The results of this project are expected to provide support either for or against the implementation of shared autonomous shuttles in areas such as college campuses. Before expending the resources required to make the necessary infrastructure changes, it is important to ascertain whether the level of usage of such vehicles will be worth the investment required.
- Equitable Tolls project: The findings from this project suggest that, while maximizing revenue and efficiency in managed lanes is a priority for investors, ensuring equitable access to these infrastructures is crucial. Instead of solely aiming to minimize equity gaps, implementing personalized tolling can maintain high revenue while also reducing travel times for low-income travelers.

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?

- Driving Feedback project: This research points to best practices for the use of apps regarding not only the types of information that parents find useful, but also the impact of monetary incentives.
- CEV Vision project: This work has the potential to impact how personal listening devices are used in future connected communities for VRU awareness. In addition, the work will provide recommendations for devices, signals, and signaling methods. Lastly, the Tesseract has the potential to impact the use of portable high density acoustic environments for research, training, and outreach activities (see Figure 7).
- High-speed Rail project: The findings from this project will enhance the understanding of passengers’ use of HSR, which is still new in the US, as well as the role of environmental factors in the use of HSR. The findings can inform both the industry and government in developing guidelines and strategies to prepare for the development of HSR in the US.
- Equitable Tolls project: The potential short-term impacts of this project include an improved understanding of traffic control strategies through research and open-source code development, benefiting researchers and practitioners and resulting in more effective traffic management. The project’s aim to make research findings widely accessible fosters collaboration, knowledge sharing, and advancements in transportation systems and multiobjective optimization. These impacts will be realized at the end of the project.



Figure 7: CATM Director engaging in the Tesseract portable multimodal auditory demonstration

What is the impact on the body of scientific knowledge?

- Driving Feedback project: The limitations of this study provide insight into how to improve the data collection processes for future work. Future research on app-based feedback and monetary incentives should consider the following: 1) Reliability of the data stream: this study removed 10

of 25 participants from the study due to failures with data transfer. This issue could not be resolved during the study and would likely be persistent with future participants unless data transfer methods are modified. Future research could involve additional monitoring equipment installed in participant vehicles, or a different method for data transfer from third parties. 2) Prior use of teen driver monitoring software by participants should be controlled for. If a similar intervention is introduced to participants prior to their participation, a true internal baseline period becomes impossible. In addition, if other software is being used during the study period by participants, they may be less likely to use the software provided as the primary intervention. 3) The safety surrogates collected should be more exhaustive. Without the ability to collect speed over speed limit and instances of distracted driving, there may be significant safety benefits that may exist but cannot be observed.

- CEV Vision project: The work provides recommendations for VRUs who use personal listening devices and low-vision pedestrians when crossing unsignalized crosswalks.
- Reinforcement project: The A3C in evacuation studies offers a powerful tool for improving safety measures through more informed, data-driven decisions. For simulation and modeling, this technique allows for the creation of dynamic models that more accurately reflect real-world conditions by incorporating a wide range of factors, including the layout of the airport and the individual behaviors of agents. This leads to simulations that can predict outcomes under various scenarios. The resulting model's ability to test numerous strategies and configurations in simulation environments enables the optimization of evacuation plans. It can determine the most effective routes and strategies to evacuate people quickly and safely, minimizing risks and potential injuries. This optimization also includes the placement and management of resources, such as emergency exits, signage, and personnel.
- ROAD TRIP project: The methodology utilized in this research can help improve health outcomes for older adults by developing effective mobility solutions customized for the user. Functional assessments of the user and naturalistic driving data will serve as inputs for these individualized solutions.
- High-speed Rail project: There is little research on the intention to use HSR in the US, especially considering the impact of environmental factors. The findings of this study can provide empirical evidence from the lens of travelers in the US. As such, this study can expand the knowledge base of HSR use, incorporating environmental factors and a sustainability perspective.
- SAS Readiness project: The results of this project are expected to reveal whether certain dispositional and/or environmental factors have an impact on an individual's decision to utilize advanced transportation technologies, such as shared autonomous shuttles. By identifying such relationships, it may be possible to develop interventions that can increase the adoption rate of these vehicles to a level that justifies the investment required to implement them on a broader scale.
- Equitable Tolls project: This project will make contributions to the fields of traffic management and transportation equity. In simpler terms, the work aims to make journeys smoother and fairer. By developing smarter traffic control strategies, the team envisions less congestion, shorter travel times, and fewer delays, ultimately improving how individuals move around. Additionally, this project targets making transportation fairer by ensuring everyone, regardless of income, gets an equal share of accessibility.

What is the impact on transportation workforce development?

- Driving Feedback project: This work provided an opportunity for a Master's student to gain valuable research experience in naturalistic driving, data analysis, report writing, presenting results, and other research related tasks that will improve their ability to provide significant contributions in future research.
- ROAD TRIP project: This research, which combines driving research and community outreach, has the potential to broaden 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.

- Air Mobility project: During the course of this project, one graduate student was supervised who completed her capstone project in explainable AI for time series prediction in aviation. Other graduate students involved in this project completed two project-based papers, which are currently under review. The titles of the papers are “Improving Air Mobility for Pre-Disaster Planning with Neural Network-Accelerated Genetic Algorithm” and “A Cost-Aware Approach for Flight Resources Optimization During Pre-Disaster Evacuation.”
- Equitable Tolls project: This work has actively contributed to transportation workforce development through several key avenues. Firstly, it has provided valuable opportunities for research and teaching in transportation and related disciplines. The engagement of both undergraduate and graduate students in hands-on tasks, ranging from code development to systematic experiments, fosters a practical understanding of transportation challenges. Furthermore, the team’s commitment to mentorship and training extends to underrepresented groups, improving their skills and aptitudes in transportation research and related professions. In terms of educational materials, this project has disseminated knowledge through open-source code principles and comprehensive user guides.
- ASETTS program: NC A&T students continued to gain exposure to various facets of transportation through the ASETTS program activities. Such activities included a(n) "Peek into Transportation Industry" panel discussion, NCDOT Triad Traffic Management Center field trip, Future of Transportation Technologies in Greensboro seminar, HBCU Smart Cities Challenge, and Traffic Bowl transportation trivia competition.
- Education and Workforce Development activities: Other activities that NC A&T students participated in during the reporting period include the Dwight David Eisenhower Minority Fellowship Program, TRB Fellowship program, and the AutoDrive Competition. Each of these programs allow students to conduct research in a specific area of transportation and, in some case, apply their findings in a hands-on manner.

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	0 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:

CEV Vision project: By department mandate, student proposals require that data analysis not be completed until after the proposal has been approved by the committee. The student’s proposal

is expected to occur early in summer. This will delay project completion to around August or September. However, to expedite project completion, the IRBs for this project have been approved and data collection is already in progress.

ROAD TRIP project: As part of the team's continuing efforts to expand the footprint of the program, the research team replaced the series of researcher-supervised drives before and after the driving consultation meeting with driving data collection via a mobile phone application. Additionally, the research team developed an approach to replace the researcher-supervised drive with a cell phone application that collects vehicle kinematic data. The team plans to explore that with enrolled participants in the next project period.

High-speed Rail project: The budgeted publication fee (\$3000) is still unspent, due to the researcher perceiving this fund can be used later (since peer-review and revision typically take several months and, if the submission is rejected, it takes more time to conduct additional submission). Communication was made with CATM's director, who clarified that this fund will be available until the middle of May 2024. The researcher is actively seeking publication opportunities for this paper and the other paper from the previous (related) CATM project within this timeframe, with the hope that one of them can use the fund for the publication fee.

Overall: During the reporting period, CATM has been operating without a Communications Specialist. This has led to a back-up in the proof reading, finalizing, and posting of project final reports. It is expected that the backlog of final reports will be cleared up during the summer.

7. SPECIAL REPORTING REQUIREMENTS

Nothing to report for this period.