UTC Semi-Annual Performance Report

Federal Agency and Organization Element to Which Report is Submitted:

United States Department of Transportation (USDOT)

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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

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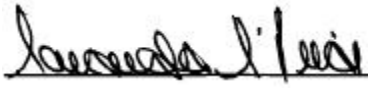

Dr. Maranda McBride, Director, Center for Advanced Transportation Mobility

1. ACCOMPLISHMENTS:

What are the major goals of the program?

The major goals of the Center for Advanced Transportation Mobility (CATM) is to employ multidisciplinary approaches and processes to design, develop, and implement innovative solutions to the transportation needs of vulnerable populations. CATM projects and activities 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 are leveraged to develop and implement comprehensive research, education, workforce development, and technology transfer programs that improve access to transportation for vulnerable users.

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

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

The overall goal of the center is to develop and implement research, education, outreach, workforce development, and technology transfer programs to address the need for improved mobility across multiple modes of transportation – primarily highway, rail, and air. In an effort to accomplish this goal, several activities took place during this reporting period. Table 1 provides a list of these activities and their statuses as of September 30, 2024.

Table 1: Progress of period 15 activities

Research	**Status**	**% Complete**
Complete Year 4 projects	Complete	100%
Complete Year 5 projects	Complete	100%
Complete Year 6 projects	Behind schedule	95%
Complete Year 7 projects	Complete	100%
Education, Outreach, and Workforce Development Activities		
Recruit/select 2024 STI participants	Complete	100%
Hold the 2024 Dwight David Eisenhower Transportation Fellowship Local Competition	Complete	100%
Prepare for and hold 2024 STI	Complete	100%
Technology Transfer Activities		
Plan and hold the 5th Annual CATM Symposium	Complete	100%
Create and distribute Spring 2024 newsletter	Complete	100%
Create and distribute Fall 2024 newsletter	On schedule	75%
US DOT Reporting Activities		
Update records in RiP database	Behind schedule	80%
Complete and submit PPPR#14	Complete	100%
Complete and submit SF425 for Q25 and Q26	Complete	100%
Complete and submit PPPR#15	On schedule	50%
Review year 4 final reports for completed research projects	Complete	100%
Upload year 4 final reports to TRID database	Complete	100%
Review year 5 final reports for completed research projects	Complete	100%
Upload year 5 final reports to TRID database	Behind schedule	95%
Review year 6 final reports for completed research projects	Behind schedule	80%
Upload year 6 final reports to TRID database	Behind schedule	80%

What was accomplished under these goals?

Since this was the last year of our grant, efforts were made during the reporting period to finalize all grant activities in the areas of research, education/workforce development, and technology transfer. A summary of these activities and the associated accomplishments are described below.

Research

Table 2 provides a running list of the 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	Completed/Y4	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/acoustic-situation-awareness.php
Connected electric vehicles: Vehicle-pedestrian communications to enhance vision impaired pedestrian safety	Completed/Y5	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/29-cev-visionimpairedabstract.php
Pedestrian Auditory Situational Awareness: Tesseract Crosswalk Module	Extension Completed/Y7	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/pedestrian-auditory-situational-awareness-tesseract-crosswalk-module.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
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 completed their final report and it was posted to the CATM website during the reporting period. The report can be accessed using this link.

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

The CEV Vision team worked on two studies associated with their project during the reporting period. Study 1: Reaction Time Between Air and Bone Conduction Communication was completed and a publication is in progress. The results of this study indicate auditory interfaces yield comparable reaction time through air and bone conduction modalities with noteworthy differences among bone locations and frequency. Study 2: Immersive Environments for Vulnerable Road User Safety Using Personal Listening Devices at Unsignalized Crosswalks was also completed and a publication is in progress. The results of this study indicate alert signals played through open-ear personal listening devices (PLDs) result in quicker detection. In

situations with limited visual cues, verbal guidance yields faster crossing performance. Findings also suggest that closed-ear PLDs could isolate users from critical environmental cues, leading to increased uncertainty and hesitation during crossings. The final report detailing these results can be accessed using this link.

Pedestrian Auditory Situational Awareness: Tesseract Crosswalk Module (Tesseract)

The Tesseract project was an extension to the CEV Vision project as a technology transfer component. This team demonstrated the technology developed during the Joint CATM and CR2C2 Annual Meeting in April (Figure 1). They also gave an oral presentation during which they disseminated the project outcomes at the 30th International Congress on Sound and Vibration. The full description of this component of the project is included in the CEV Vision final report which, again, can be accessed using this link.

Figure 1: Mobile Tesseract device demonstrated at the 2024 Joint CATM and CR2C2 Annual Symposium in April

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

The SAS Readiness team continued running participants for the study during the reporting period. Preliminary analyses on the data were conducted and the results were presented at the Joint CATM and CR2C2 Symposium in April, the Applied Human Factors and Ergonomics (AHFE) Conference in July, and the Advancing Minorities' Interest in Engineering (AMIE) Conference in September. Experiments and data collection are ongoing to collect enough data for inferential statistical analyses with sufficient statistical power to warrant generalization of the results. However, one of the key findings of the preliminary analysis of the experiment is that actual intent to use SASs decreased after the participants learned more about the shuttles through the video interventions. It is believed this is because the participants learned about some of the limitations of the shuttles, such as the slow speed. These findings should not be generalized at this point as more data needs to be collected to increase the statistical power of

the results. Additional analyses will be conducted once a sufficient amount of data has been collected.

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

During this reporting period, the Equitable Tolls team primarily compiled their results into the final report and submitted a paper based on this work that was accepted for presentation at the 2025 Transportation Research Board Annual Meeting. All objectives of the projects were completed including: (a) designing an open-source platform that integrates advancements in multi-objective 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 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", the team saw that the equity gap can be reduced among the travelers, although 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. The final report including detailed recommendations can be found by accessing this link.

Additionally, several projects completed during the previous reporting period had activity which are summarized below.

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

During the reporting period, the Driving Feedback research team worked to combine the efforts of the report for the National Surface Transportation Center for Excellence and submitted this combined document as the final report for CATM. The objective of this project was to evaluate the impact of providing post-hoc driving feedback and monetary incentives on teen driving performance. While the team was not able to find significant results in the quantitative data, the qualitative data from participant and parent check-in interviews was promising, indicating that these types of interventions could provide benefit. The final report detailing these results can be accessed using this link.

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

The COVID Outbreaks report was finalized and posted during the reporting period. The report can be accessed using this link.

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

During this reporting period, the Reinforcement team presented the results of this project during the Joint CATM and CR2C2 Symposium in April. The final report providing detailing the results from this project can be accessed using this link.

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

The ROAD TRIP team completed this project during the last reporting period and submitted the final report containing the results from both phases of this project during the current reporting period. The report has been posted to the CATM website and can be accessed using this link.

Improving Air Mobility in Emergency Situations (Air Mobility)

The Air Mobility team completed the work on this project and submitted their final report during the last reporting period. The report was finalized during this reporting period and has been posted to the CATM website. The final report detailing the results can be accessed using this link.

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 during the last reporting period. The final reports were posted to the CATM website during this reporting period and can be accessed using the following links: initial project, extension. Additionally, a paper was published in a peer reviewed journal.

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

During the reporting period, the final report written by the Data Curation team was published on the CATM website. This report can be accessed using this link.

First Responder Transportation Safety Conference (First Responder)

The final report submitted by the First Responder team was posted to the CATM website during the reporting period. It can be accessed using this link.

Research Assistants

Sixteen 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	6	2	8
Master's	4	2	6
Doctoral	1	1	2
Total	**11**	**5**	**16**

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: Affiliated transportation research grants

Project Title	Lead Institution	Funding Agency
Advancing STEM Education Through Transportation Studies (ASETTS)	NC A&T State University	National Science Foundation

Education

Throughout the reporting period, the CEV Vision team had total of eight students engaged in their work, enrolling in a range of undergraduate and graduate research credits. In addition, the Tesseract and other audio equipment are being used by undergraduate researchers to further explore the topic and will be incorporated as teaching tools for ISE 5644: Human Audition and Design in the Spring 2025 semester. The Air Mobility research team used the project's results to teach students how to develop web scrappers to collect data using FAA and DoT websites.

Workforce Development and Outreach

From July 7th to July 24th, the NC A&T Summer High School Transportation Institute (STI) offered an enriching and transformative experience for 17 high-achieving rising juniors and seniors. Because the 2024 STI was a residential program held on the NC A&T campus, this year participants were not only from North Carolina but also South Carolina, Georgia, Florida, New York, Texas, Maryland, and Virginia. Students were selected based on their expressed interest in transportation and STEM, as well as their academic performance, extracurricular engagement, and community involvement. The program provided students with a comprehensive introduction to multiple aspects of the transportation and STEM fields as well as a taste of the NC A&T Aggie college experience, including dorm life, campus food, and recreational facilities. Through classroom instruction, group projects, and field trips, students learned about transportation technologies, supply chain management, the various modes of transportation, and more (see Figure 2 and Figure 3). Personal development activities, like public speaking, were integrated into the program as well to help students build essential transferable skills for their future academic and professional careers.

Figure 2: Photos from the 2024 NC A&T STI Opening Ceremony, drone demo, and WMATA Operations Center tour

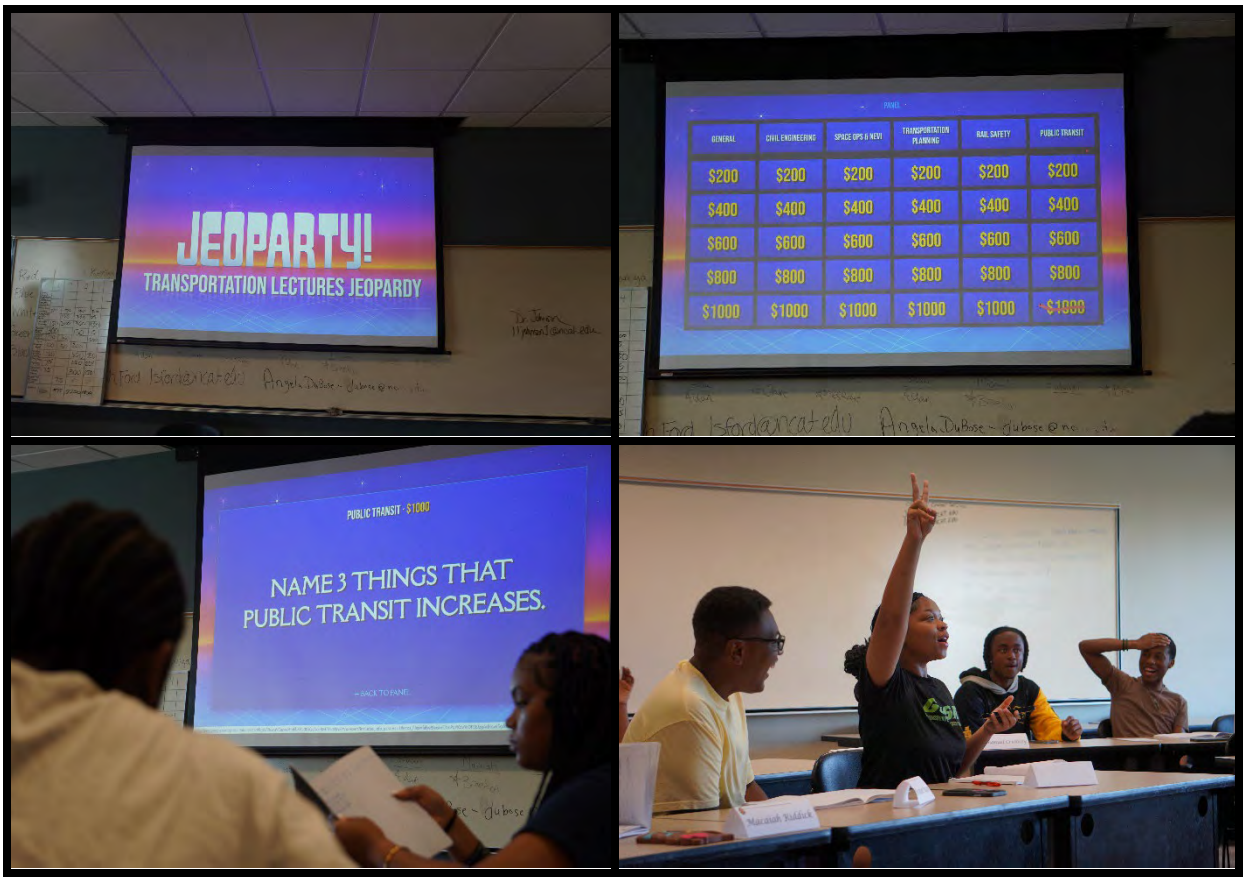

Figure 3: 2024 NC A&T STI students engage in a spirited Transportation Jeoparty Game

Technology Transfer

The CEV Vision team modified and utilized the high-fidelity testbed environment developed for their project to conduct Study 2 of their project. This testbed is modeled from a university campus, in which a pedestrian can engage in simulated street crossing scenarios developed as a part of the Situation Awareness project.

What opportunities for training and professional development were provided?

On April 17th and 18th, CATM hosted a joint UTC symposium with the Center for Regional and Rural Connected Communities (CR2C2 – the Region 4 UTC under the BIL which is also led by NC A&T). The event, which took place at the NC A&T Alumni Foundation Event Center, brought together leading experts from academia, industry, and government to explore the latest developments in transportation research, with a focus on research and innovations impacting VRUs as well as rural and underserved communities. The event featured presentations and discussions on a wide range of topics, including the research, workforce development, and technology transfer activities conducted within both CATM and CR2C2. One of the highlights of the symposium was a plenary session presented by Randa Radwan, PhD, senior advisor for Safety & Mobility at the Office of the Assistant Secretary for Research and Technology (Figure 4). The topic of her presentation was “Leveraging Technology for Equitable and Safe Mobility,”

which delved into the potential of emerging technologies to create safer and more accessible transportation systems, especially for rural and underserved populations.

Figure 4: Randa Radwan, PhD giving the keynote presentation at the 2024 Joint CATM and CR2C2 Symposium

The PI of the SAS Readiness project worked with an MBA student throughout the summer teaching her the art of initiating a literature review, conducting statistical analyses, and preparing data visualizations for presentations. The Equitable Tolls team offered several opportunities for students to train themselves in the skills associated with their research and various areas of professional development. This included a bi-weekly training session over the summer where writing skills were also emphasized and an internal peer review was done. The Master's degree student working on the Teen Feedback project was given the opportunity to present the findings from their study at the Joint CATM and CR2C2 Symposium and the Tesseract team demonstrated their mobile Tesseract Crosswalk Module to symposium participants.

Have the results been disseminated?

During the Joint CATM and CR2C2 Symposium, 20 oral presentations were made by CATM researchers. Additionally, a deployment forum and demonstration took place through which participants had the opportunity to learn about the ongoing autonomous shuttle research taking place at NC A&T, witness autonomous vehicle demonstrations, and explore the rural AV test track and research facilities at NC A&T's Gateway Research Park. The symposium also emphasized the critical role of transportation education and workforce development. A review of the programs hosted and facilitated by CATM was presented at the symposium during which the importance of connecting students and young professionals with existing leading professionals in the field was emphasized. Details about the symposium agenda can be accessed through the CATM Symposium webpage using this link.

In addition to the presentations made at the Joint CATM and CR2C2 Symposium, the CEV Vision team disseminated their research at the ICSV30 conference and through Human IMPaC-T Lab demonstrations on the Virginia Tech campus. The SAS Readiness team presented preliminary results of their research during the 2024 Applied Human Factors and Ergonomics (AHFE) Conference in July and the Advancing Minorities' Interest in Engineering (AMIE)

Conference in September. The Equitable Tolls team gave a presentation to high school students during the STI program at NC A&T in July.

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

While this is the last semi-annual report that will be submitted for this grant, the following is a list of tasks that will be completed to close out the grant.

- Review all outstanding spending and cost share reports and submit the final invoice
- Post remaining final reports on the CATM website
- Update the status of all remaining projects in RiP
- Submit any outstanding final reports to the TRID database
- Complete and submit a final newsletter summarizing CATM's activities since 2016

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;	Virginia Tech
Virginia Tech Transportation Institute	Blacksburg, VA	Collaborative Research	Jon Antin, 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
General Motors	Detroit, MI	In-Kind Support	Dan Glaser Suzanne Johansson	

Other collaborators or contacts involved

Drs. Venktesh Pandey and Maranda McBride are currently a part of the leadership team and are collaborating with researchers of the Region 4 UTC – CR2C2. Dr. Pandey is also collaborating with Md. Sami Hasnine (Virginia Tech) and Hyoshin Park (Old Dominion University) on related transportation research projects.

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

- Pan, J.Y. (2024). High-Speed Rail in the US—Mode Choice Decision and Impact of COVID-19. *Sustainability*, *16*(10), 4041-. https://doi.org/10.3390/su16104041. Acknowledged Federal Support: Yes.

Books and Non-Periodical, One-Time Publications

- None this reporting period

Other Publications, Conferences, and Presentations

- Acharya, K., Velasquez, A., Liu, Y., Liu, D., Sun, L., and Song, H. (2024). Improving Air Mobility for Pre-Disaster Planning with Neural Network Accelerated Genetic Algorithm. arXiv preprint arXiv:2408.00790. Accepted for Publication by IEEE ITSC 2024. Acknowledged Federal Support: Yes.
- Karimoddini, A., and McBride, M. (2024). Design and Deployment of Shared Autonomous Vehicles. 2024 Advancing Minorities' Interest in Engineering (AMIE) Annual Conference, Greensboro, NC, Sep 15-18, 2024. Presented. Acknowledgement of Federal Support: yes.
- McBride, M. (2024). Impact of Exposure on Shared Autonomous Shuttle Perceptions. Applied Human Factors and Ergonomics International Conference (AHFE 2024), Nice, Italy, Jul 24-28, 2022. Presented. Acknowledgement of Federal Support: yes.
- McBride, M. (2024). Shared Autonomous Shuttle Perception Study. Joint CATM and CR2C2 Symposium, Greensboro, NC, Apr 17-18, 2024. Presented. Acknowledgement of Federal Support: yes.
- Tiamiyu, R., and Pandey, V. (2025). Sequential day-to-day credit spending model under incentives on express lanes. To be presented at the 2025 Annual Meeting of the Transportation Research Board, Washington, DC. Acknowledgement of Federal Support: yes.
- Flores-Fletes, A., Tiamiyu, R., Pandey, V., and Rambha, T. (2025). Invited student paper: Delivery vehicle routing problem with real-time parking information. To be presented at the 2025 Annual Meeting of the Transportation Research Board, Washington, DC. Acknowledgement of Federal Support: yes.
- Radlbeck, J., Baker S., Swannell, B., Wiersma, E., Young, T., Feirabend, N, Turturici, M., and Klauer, C. (2024). Evaluation of the Impact of App-based Feedback and Monetary Incentives on Teen Driver Safety – CATM Final Report. Published. Acknowledgement of Federal Support: yes.

- Tasnia, R., Ali, M., Hridoy, D. N., Pandey, V., Hasnine, S., and Park, H. (2024). Impacts of Real-Time Information on Express Lanes Route Choices: Insights from a Joint Revealed and Stated-Preference Survey in Washington, DC and Charlotte, NC. American Society of Civil Engineers' International Conference on Transportation and Development (ICTD 2024), Atlanta, GA. Jun 15–18, 2024. Presented. Acknowledgement of Federal Support: yes.
- Zhou, Y., Yang, Y., Liu, Y., Liu, D., Namilae, S. and Song, H. (2024). Real Time Deep Reinforcement Learning for Evacuation under Emergency. Joint CR2C2 and CATM Annual Symposium, April 17-18, 2024. Presented. Acknowledgement of Federal Support: yes.
- Wotring, B. M., Antin, J., and Hankey, J. (2024). Rural Older Adult Driver Tailored Research-Integrated Plan (ROAD TRIP) – CATM Final Report. Published. Acknowledgement of Federal Support: yes.

Websites or other internet material

- CATM Website: https://www.ncat.edu/cobe/transportation-institute/catm/index.php
- CATM Spring 2024 Newsletter: https://www.ncat.edu/cobe/transportation-institute/catm/catm-documents/catm-spring2024newsletter.pdf
- Joint CATM and CR2C2 Symposium Website: https://www.cr2c2.com/technology-transfer-and-collaboration/annual-regional-conferences/annualconferences-2024
- Site host the data and code of the paper, Improving Air Mobility for Pre-Disaster Planning with Neural Network Accelerated Genetic Algorithm: https://github.com/lotussavy/ITSC-2024.

Technologies or techniques

- CEV Vision project: The Tesseract, a high-fidelity testbed environment representative of a university campus, in which a pedestrian can engage in simulated street crossing scenarios, was developed for the work and demonstrated at the 2024 CATM and CR2C2 Joint Symposium.
- ROAD TRIP project: This project has developed an algorithm 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 graphic and recommendations are shared with study participants during a driving consultation meeting. The methodology developed here was designed to be scalable to support deployment on a national level given sufficient funding support.

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:

- CEV Vision project: Electric vehicles (EVs) are continuously being developed to detect VRUs and other vehicles as obstacles to be avoided. Due to increased demand and design of EVs and their reduced sound outputs compared to traditional engines, the safety of VRUs should be a vital consideration in the pursuit of transportation technological advancement. Therefore, in sum, it is recommended that personal listening device vehicle-to-pedestrian (PLD V2P) communication systems be designed with VRUs in mind, accounting for individual differences and preferences, and be done in such a way that prioritizes early warning of unsafe situations allowing VRUs ample time to detect and react to hazardous crossing situations.

- SAS Readiness project: This project has made people more aware of the advantages and limitations of shared autonomous shuttles. As future models of these vehicles are designed, it is important to consider the perceptions of potential users and better implement features that meet the needs and desires of target user populations.
- Reinforcement project: This research has advanced the understanding of transportation issues by developing real-time decision-making systems for emergency evacuations in aviation environments, using advanced algorithms like Asynchronous Advantage Actor Critic (A3C). The study demonstrates the superiority of A3C over traditional models, improving the efficiency and scalability of evacuation routes, and providing valuable insights for enhancing real-world evacuation planning and safety protocols under complex and dynamic conditions.
- High-speed Rail project: HSR has been a research interest for many years, but the research has been mainly conducted in successful HSR countries, especially Europe and Asia. There is a need for more research regarding HSR in the US. The findings of this study can fill this important research gap. HSR could have many economic and environmental benefits for the US. Especially, high-speed rail can significantly reduce greenhouse gas emissions by shifting people from cars and airplanes to a more energy-efficient mode of transportation, contributing to climate change mitigation efforts. This CATM project and the findings from the project, especially through publications, can increase awareness of the challenges facing the transportation system in the US, leading to changes in travel behaviors.
- Air Mobility project: This team has demonstrated the feasibility of using explainable AI to understand sequence flight delay prediction models.

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:

- Reinforcement project: This research has the potential for the development of new policies or regulations by demonstrating the effectiveness of real-time decision-making systems and advanced algorithms, such as Asynchronous Advantage Actor Critic (A3C), in improving emergency evacuation strategies. These findings emphasize the need for updated safety protocols and evacuation planning in aviation, highlighting the practical benefits of adopting machine learning models to manage emergencies more effectively. Such advancements could inform future rulemaking or revisions to existing aviation safety regulations, particularly concerning airport and aircraft evacuation procedures.

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

- CEV Vision project: The main findings of this project were that in a controlled setting with a direct connection, listeners respond comparably, in terms of reaction times, through air and bone conduction modalities with some differences based on bone transducer location and frequency. In situations with limited visual cues, such as nighttime road usage, verbal guidance yields faster crossing performance; however, the use of an alert signal played through open-ear PLDs yields faster detection. This indicates the value of using PLDs that afford awareness of the surrounding environment either through passthrough or unoccluded means.
- Driving Feedback project: This work has helped to understand teen motivation and the ability of monetary incentives to act as a motivator to promote safe driving. This work has also helped to understand the prevalence of current driver monitoring apps already being used by teens and parents.
- Reinforcement project: This research has expanded the body of knowledge by demonstrating the application of advanced machine learning algorithms, such as the A3C, in optimizing emergency evacuation processes in aviation environments. The study's comparative analysis with traditional models like Deep Q-Networks (DQN) provides new insights into the scalability, adaptability, and efficiency of these algorithms in real-time emergency situations. This work contributes to both the

fields of transportation safety and machine learning by offering practical solutions to improve evacuation planning and decision-making under complex, dynamic conditions.
- Air Mobility project: This research team provided a new framework that integrates neural network and evolution algorithms to solve transportation problems reliably.

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

- CEV Vision project: Findings show that the use of closed-ear PLDs could isolate users from critical cues in the environment, especially in low-vision situations resulting in increased uncertainty and crossing hesitation which could lead to hazardous crossing predicaments. Consequently, the use of open-ear PLD capabilities offers benefits of intelligible perception of navigational aids and environmental awareness.
- SAS Readiness project: The results of this project are expected to indicate the likelihood of certain target populations to utilize shared autonomous shuttles. Additionally, the results should inform the design community of the different features that are attractive to specific user groups and those that are likely to deter usage of these types of shuttles.
- Reinforcement project: This research has improved processes, technologies, and techniques for addressing transportation issues by developing a real-time decision-making system using advanced algorithms like A3C. It enhances emergency evacuation efficiency in aviation by optimizing routes and reducing evacuation times under high-stress conditions. The study's use of machine learning techniques has refined the ability to model and predict passenger movement, significantly improving the scalability and adaptability of evacuation strategies, which can be applied to various transportation scenarios involving emergencies.
- ROAD TRIP project: The methodology developed in the context of this research integrates data collected across domains and via multiple methodologies to inform personalized recommendations for the research subject. It is the first known instance of combining assessments of driving knowledge and history and physical activity and measures of social isolation with analysis of naturalistic driving data or supervised driving observations to provide targeted solutions to specific mobility challenges faced by older adults. Our development of a less researcher-intensive approach using a mobile phone application rather than researcher-supervised drives to collect driving data further advanced the scalability of the program.

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

- Research projects: As in previous reporting periods, undergraduate and graduate students working on CATM research projects receive training and hone their skills in both discipline-specific and interdisciplinary research methods. These skills can be used to solve complex transportation issues upon entry into the workforce.
- Driving Feedback project: This project provided significant experience for a master’s degree student that has since graduated and is now working full-time in transportation research.
- Reinforcement project: This research has provided a framework for training professionals in data-driven decision-making, simulation modeling, and optimization techniques. These skills are crucial for addressing complex transportation issues, ultimately expanding the knowledge base and technical competencies of professionals in the field.
- 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 to include the ability to realize practical, discrete results in the lives of older adults. The research methodology is designed to be usable by students across disciplines (e.g., public health, gerontology, pre-med) to reach a wider audience that extends beyond the sample used for the original research.
- STI program: This program is designed to introduce high school students (primarily those in underrepresented racial groups) to transportation careers options. By exposing these students prior to entry into college, the expectation is that several of them will choose to pursue a career

in transportation. It is through meaningful and memorable exposure to transportation careers and professionals that we will help grow a more diverse transportation workforce.

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

- Reinforcement project: This research demonstrated the practical application of advanced machine learning models, such as the A3C, for real-time emergency evacuation planning. The effectiveness of A3C in optimizing evacuation routes and improving response times under dynamic conditions has prompted the integration of similar algorithms into evacuation simulation tools and decision-support systems in aviation and other transportation sectors, enhancing safety practices and operational efficiency.

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	6
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	16
		Number of peer-reviewed journal papers published	2	3
		Number of newsletter articles, conference papers, and technical reports published	10	12

5. IMPACTS:

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

- SAS Readiness project: This project is ongoing, so the findings have not yet been implemented. However, the implementation of SASs is said to have the capability of reducing congestion and (in the case of electric vehicles) decreasing transportation emissions. Additionally, for pedestrians SASs are expected to improve their mobility. However, due to the current limitations of some of these vehicles, this project will help determine if the SASs available today can effectively meet the needs of the target populations. It is essential that this be determined before the costly efforts associated with implementation are initiated.

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?

- CEV Vision project: The work has the potential to impact how PLDs are used in future connected communities for VRU awareness. In addition, the work provides 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.
- SAS Readiness project: The results of this study are expected to provide information that will help organizations designing and deploying SASs in a more cost-efficient and effective manner by taking into consideration current perceptions of the target populations. Design modifications and marketing techniques can be developed to address or compensate for issues identified to increase likelihood of usage.
- 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 for 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 in the near future.
- Reinforcement project: This research has the potential to impact commercial technology and public use by demonstrating the effectiveness of machine learning algorithms like A3C in real-time evacuation planning, which can be transferred to government agencies and industries for enhancing public safety protocols. The practical results of this study, such as improved evacuation models and decision-making systems, can be adopted by airports, airlines, and emergency management agencies to optimize safety procedures. While there are no specific instances of commercialization thus far, the integration of these algorithms into emergency management tools and evacuation simulations presents potential opportunities for commercialization or industry-wide adoption of new safety practices.

What is the impact on the body of scientific knowledge?

- CEV Vision project: The work provides recommendations for low-vision pedestrians and other VRUs who employ PLDs and when crossing unsignalized crosswalks. These recommendations can improve pedestrian safety by reducing the frequency street crossing injuries and fatalities.
- SAS Readiness project: The preliminary results from the project indicate that certain perceptions of currently available SASs may not be as desired. The final project results should provide a clearer indication of the magnitude of various perceptions among targeted user groups and whether there are differences based on the targeted user characteristics. Armed with this information, SAS designers can develop vehicles that better fit the needs and desires of targeted user groups and SAS product marketing teams can customize marketing materials to increase likelihood of adoption.
- 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.
- Driving Feedback project: The findings from this project could be used to inform future research given the demand for teen feedback and monitoring, and the potential for motivation through self-funded monetary incentives for safe driving behaviors in teens. While the current results did not show definitive benefit, they could be used as a basis for future research on this topic.
- Reinforcement project: This research has expanded the base of knowledge in fields like simulation, optimization, and human factors, particularly when it comes to understanding human behavior during emergency evacuations. By using advanced machine learning techniques like the

A3C, the study has improved how people's movements in high-stress situations are modeled and predicted. These findings contribute to the theory of decision-making and crowd behavior, helping to optimize evacuation strategies. Additionally, the research provides valuable insights for teaching and training in fields like transportation safety and emergency management, offering new methods to approach real-time problem-solving during crises.

- ROAD TRIP project: The methodology developed in the context of this research has the potential to revolutionize our nation's approach to extending mobility, thus improving health outcomes for older adults with personalized interventions based upon analysis of individual functional assessment and naturalistic driving data.
- High-speed Rail project: The findings of the peer-reviewed publication can make theoretical contribution as there is only limited research of HSR in the US. The findings will enhance the understanding of passengers' use of HSR, which is still new in the US. The findings can inform both the industry and government as they create guidelines and strategies to prepare for the development of HSR in the US.

What is the impact on transportation workforce development?

- SAS Readiness project: This project engaged a graduate student from a degree program that is not typically associated with transportation. Through the summer, this MBA student learned more about the empirical research process and how her interests and skills can be utilized in the transportation field. By providing opportunities to engage non-transportation students in transportation-related research, there arises the potential to expand the transportation workforce by helping such students see how they can also support our transportation systems through work that fits within their areas of interests.
- Equitable Tolls project: This work provided valuable opportunities for both undergraduate and graduate students to engage in research. Through hands-on tasks, ranging from code development to systematic experiments, these students obtained a practical understanding of transportation challenges. The mentorship and training efforts of this team extend to underrepresented groups, improving their skills and aptitudes in transportation research and related professions. This project has also resulted in the dissemination of knowledge within the transportation workforce through open-source code principles and comprehensive user guides.
- Driving Feedback project: This project provided opportunities for a master's student to present the results of the study through the Joint CATM and CR2C3 Symposium. The student also gained experience with report writing, study design, and logistics.
- Reinforcement project: This research has the potential to positively impact transportation workforce development by creating new opportunities for research and teaching in transportation and related fields, particularly through its application of advanced machine learning techniques like A3C in emergency management. It has introduced cutting-edge technologies and methodologies that can be integrated into educational programs, providing students and professionals with hands-on experience in transportation safety and optimization. The study's findings and models have the potential to inform the development of new educational materials, which can be disseminated to practitioners, educators, and students, inspiring a new generation to pursue careers in transportation science and technology.
- ROAD TRIP project: Because this project combines driving research and community outreach, it has the potential to broaden future contributions of student researchers exposed to the research beyond traditional research-driven policy and technology outcomes. This includes 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: The web scrapper technology developed in this project was integrated into the teaching materials of two data science courses (MA540: Database and Information Retrieval, DS615: Data Modeling) to train students majoring in Aerospace Engineering and Data Science. Additionally, the machine learning models from this project were utilized in other courses campus-wide to provide opportunities for students to learn machine learning with real transportation data.
- Education and Workforce Development activities: The NCAT STI was hosted by the Transportation Institute from July 7th to July 24th. This year's program offered an enriching and

transformative experience for 17 high-achieving rising juniors and seniors from North Carolina, South Carolina, Georgia, Florida, New York, Texas, Maryland, and Virginia. Through classroom instruction, group projects and field trips, students learned about supply chain management, transportation technologies, the various modes of transportation, and more. Personal development activities, like public speaking, were integrated into the program, helping students build essential skills for their future academic and professional careers. This year the students were exposed to cutting-edge research in autonomous vehicle technology and were given the opportunity to explore self-driving cars and obtain hands-on experience with the autonomous vehicle systems developed at NC A&T. The tour also featured a driving simulator, where students participated in driving scenarios and engaged with the technology used in autonomous vehicle research. These experiences expose students earlier in their academic career to encourage them to pursue transportation-related degrees when they apply to college.

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:

SAS Readiness project: The data collection for this project proceeded more slowly than anticipated and some data had to be discarded due to validity concerns. Therefore, the data collection process is currently ongoing. Once the data collection is completed and the data analyzed, the final report will be written, uploaded to the CATM webpage, and submitted to TRID.

7. SPECIAL REPORTING REQUIREMENTS

Nothing to report for this period.