# UTC Semi-Annual Performance Report

**Federal Agency and Organization Element to Which Report is Submitted:**

United States Department of Transportation (USDOT)

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

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

**Project Title:** Center for Advanced Transportation Mobility

**Center Director Name, Title, and Contact Information**

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**Recipient Organization:**

North Carolina Agricultural and Technical State University

1601 E. Market Street, Greensboro, NC 27411

**Recipient Identifying Number or Account Number:** 270128

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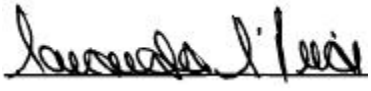
**Report Term or Frequency:** Semi-annual

**Signature of Submitting Official:**



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

1. ACCOMPLISHMENTS:

***What are the major goals of the program?***

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

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

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

The overall goal of the center is to develop and implement research, education, outreach, workforce development, and technology transfer programs to address the need for improved mobility across multiple modes of transportation – primarily highway, rail, and air. In an effort to accomplish this goal, several activities took place during this reporting period. Table 1 provides a list of these activities and their statuses as of September 30, 2023.

***Table 1: Progress of period 13 activities***

| **Research** | **Status** | **% Complete** |
|---|---|---|
| Complete Year 4 projects | Behind schedule | 75% |
| Complete Year 5 projects | Behind schedule | 71% |
| Complete Year 6 projects | Behind schedule | 50% |
| Complete Year 7 projects | On schedule | 10% |
| Conduct annual visit to member institutions – Year 6 | Complete | 100% |
| **Education, Outreach, and Workforce Development Activities** | | |
| Conduct Spring 2023 student-to-student K-12 initiative workshops | Complete | 100% |
| Recruit/select 2023 STI participants | Complete | 100% |
| Prepare for and hold 2023 STI | Complete | 100% |
| Select 2023-24 CATM Transportation Scholarship recipients | Complete | 100% |
| Hold the 2023 Dwight David Eisenhower Transportation Fellowship Local Competition | Complete | 100% |
| Student participation in the 2024 TRB conference | On schedule | 50% |
| Recruit/select 2024 STI participants | Forthcoming | 0% |
| Prepare for and hold 2024 STI | Forthcoming | 0% |
| **Technology Transfer Activities** | | |
| Conduct 2023 research webinars | Forthcoming | 0% |
| Create and distribute Spring 2023 newsletter | Complete | 100% |
| Plan and hold the 5th Annual CATM Symposium | Behind Schedule | 50% |
| Create and distribute Fall/Winter 2023 newsletter | Behind schedule | 0% |

| US DOT Reporting Activities | | |
|---|---|---|
| Update records in RiP database | Complete | 100% |
| Complete and submit PPPR#12 | Complete | 100% |
| Complete and submit SF425 for Q23 and Q24 | Complete | 100% |
| Complete and submit 2023 recipient share report | On schedule | 75% |
| Complete and submit 2023 performance indicator report | On schedule | 75% |
| Complete and submit PPPR#13 | On schedule | 75% |
| Complete and submit SF425 for Q25 and Q26 | Forthcoming | 0% |
| Review year 4 final reports for completed research projects | Behind schedule | 75% |
| Upload year 4 final reports to TRID database | Behind schedule | 50% |
| Review year 5 final reports for completed research projects | Behind schedule | 71% |
| Upload year 5 final reports to TRID database | Behind schedule | 60% |

***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. The accomplishments of those projects with an "Extension" status are combined with the accomplishments of the original 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 |
| Vulnerable Road Users demand-responsive Transit Optimization with healthcare Privatization (VRUTOP) | Completed/Y4 | IM | https://www.ncat.edu/cobe/transportation-institute/catm/vrutop.php |
| Evaluation of Web-Based Driving Feedback for Teens and their Parents | Continuing/Y4 | IM, PS | https://www.ncat.edu/cobe/transportation-institute/catm/web-based-driving.php |
| Detecting Early-Stage Dementia Using Naturalistic Driving | Completed/Y4 | IM, PS | https://www.ncat.edu/cobe/transportation-institute/catm/detecting-dementia.php |
| Analyzing the Role of Air-Transportation in COVID-19 Pandemic Disaster | Completed/Y5 | IM, PS | https://www.ncat.edu/cobe/transportation-institute/catm/24-airtransportationcovid19.php |
| Machine Learning for Dynamic Airspace Configuration towards Optimized Mobility in Emergency Situations | Completed/Y5 | IM, RC | https://www.ncat.edu/cobe/transportation-institute/catm/25-machinelearningabstract.php |
| Modeling Future Outbreaks of COVID-19 Using Traffic as Leading Indicator | Continuing/Y5 | IM, PS | https://www.ncat.edu/cobe/transportation-institute/catm/27-modelingfutureoutbreaks.php |

| | | | |
|---|---|---|---|
| Connected electric vehicles: Vehicle-pedestrian communications to enhance vision impaired pedestrian safety | Continuing/Y5 | IM, PS | https://www.ncat.edu/cobe/transportation-institute/catm/29-cev-visionimpairedabstract.php |
| Real-time Deep Reinforcement Learning for Evacuation under Emergencies | Continuing/Y6 | IM | https://www.ncat.edu/cobe/transportation-institute/catm/realtime-deep-reinforcement-learning-for-evacuation-under-emergencies.php |
| Rural Older Adult Driver Tailored Research-Integrated Plan | Continuing /Y6 | IM, PS | https://www.ncat.edu/cobe/transportation-institute/catm/rural-older-adult-driver-tailored-research.php |
| Improving Air Mobility in Emergency Situations | Continuing /Y6 | IM, RC | https://www.ncat.edu/cobe/transportation-institute/catm/improving-air-mobility-in-emergency-situations.php |
| High-speed rail in the US – The intention to use and mode choice behavior | Completed/Y6 | IM, RC, PS, PE | https://www.ncat.edu/cobe/transportation-institute/catm/high-speed-rail-in-the-us1.php |
| Acceptance and Adoption of Shared Autonomous Shuttles for Vulnerable Road Users: A Readiness Study | New/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 | New/Y7 | IM, RC | https://www.ncat.edu/cobe/transportation-institute/catm/data-curation-and-technology-transfer.php |
| ROAD TRIP 2.0 – Transforming the Mobility Landscape for Aging America | Extension/Y7 | IM, PS | https://www.ncat.edu/cobe/transportation-institute/catm/road-trip-2.0-transforming-the-mobility-landscape.php |
| High-Speed Rail in the US: The Intention to Use and Mode Choice Behavior - Additional Funding Opportunity | Extension/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 |
| Evaluation of Web-Based Driving Feedback for Teens and Their Parents - Pt.2 | Extension/Y7 | IM, PS | https://www.ncat.edu/cobe/transportation-institute/catm/evaluation-of-web-based-driving-feedback-for-teens-and-their-parents.php |
| First Responder Transportation Safety Conference | New/Y7 | IM, TC, PS | https://www.ncat.edu/cobe/transportation-institute/catm/first-responder-transportation-safety-conference.php |
| Pedestrian Auditory Situational Awareness: Tesseract Crosswalk Module | Extension/Y7 | IM, PS | https://www.ncat.edu/cobe/transportation-institute/catm/pedestrian-auditory-situational-awareness-tesseract-crosswalk-module.php |
| A Multiobjective Reinforcement Learning Framework for Equitable Toll Design for Express Lanes | Extension/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 continued the preparation of the final report for the project and initiated journal manuscript preparations. A supplemental grant was awarded [*Pedestrian Auditory Situational Awareness: Tesseract Crosswalk Module (Tesseract)*] with which the

project team will focus on tech transfer activities for both the Situation Awareness and CEV Vision projects.

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

The VRUTOP team completed the project and submitted the final report. The final report is currently under review and will be posted on the CATM website during the next reporting period.

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

During this performance period, the Driving Feedback team began data collection for 25 participants as part of the extension granted for this project [*Evaluation of Web-Based Driving Feedback for Teens and Their Parents - Pt.2 (Driving Feedback 2)*]. Due to technical issues with data transfer, 10 of the participants were removed early, leaving 15 active participants, all of whom are expected to complete the data collection phase of the project by the end of December 2023. The team also began preparing for interviews with teen participants and their parents. This preparation has included: 1.) IRB submission, 2.) Developing internal scripts and other interview, 3.) Training personnel, and 4.) Contacting participants and scheduling those interested in completing.

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

The Detecting Dementia research team completed data analysis and submitted the final report, which will be posted on the CATM website during the next reporting period.

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

The COVID AirTran team completed the project and submitted the final report during the reporting period. The report is currently under review and will be posted on the CATM website during the next reporting period.

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

During the reporting period, the Machine Learning team completed their project and submitted the final report. The report is currently under review and will be posted on the CATM website during the next reporting period.

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

The COVID Outbreaks team continued work on the final report for this project during the reporting period. An initial draft was completed and is currently being refined.

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

The CEV Vision team obtained supplemental funding [*Pedestrian Auditory Situational Awareness: Tesseract Crosswalk Module (Tesseract)*] to extend the ongoing research efforts. New students were on-boarded to collect data for the project extension.

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

During this reporting period, the Reinforcement team completed literature review; published and presented at the Institute of Industrial and Systems Engineers conference; developed the simulation environment using the local airport in Daytona Beach, FL; and developed and

debugged the reinforcement learning model using Deep Q learning and A3C. The team is comparing the A3C algorithm with DeepQ learning for reinforcement learning under emergent situations. So far, results have demonstrated the benefits of the A3C model in reinforcement learning under emergency, as shown in the learning efficiency for single and multiple agents.

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

In continuation of the original project, the ROAD TRIP team introduced adjustments to the original protocol based on the experiences of the first four participants. These adjustments were aimed at optimizing the benefits of the program to study participants. Six participants completed the study under the adjusted protocol. The team received supplemental funding to extend the project [*ROAD TRIP 2.0 – Transforming the Mobility Landscape for Aging America (ROAD TRIP 2)*] and continued their efforts to expand the footprint of the program. The team replaced the VTTI DAS with a series of three researcher-supervised drives before and after the driving consultation meeting and enrolled 5 additional participants under this protocol. Figure 1 displays the route used for the three researcher- supervised drives taken over the course of the 8-week participation period. The first drive precedes the consultation, the second is taken one week following the consultation, and the third is taken three weeks post-consultation to assess long-term effectiveness of the intervention.

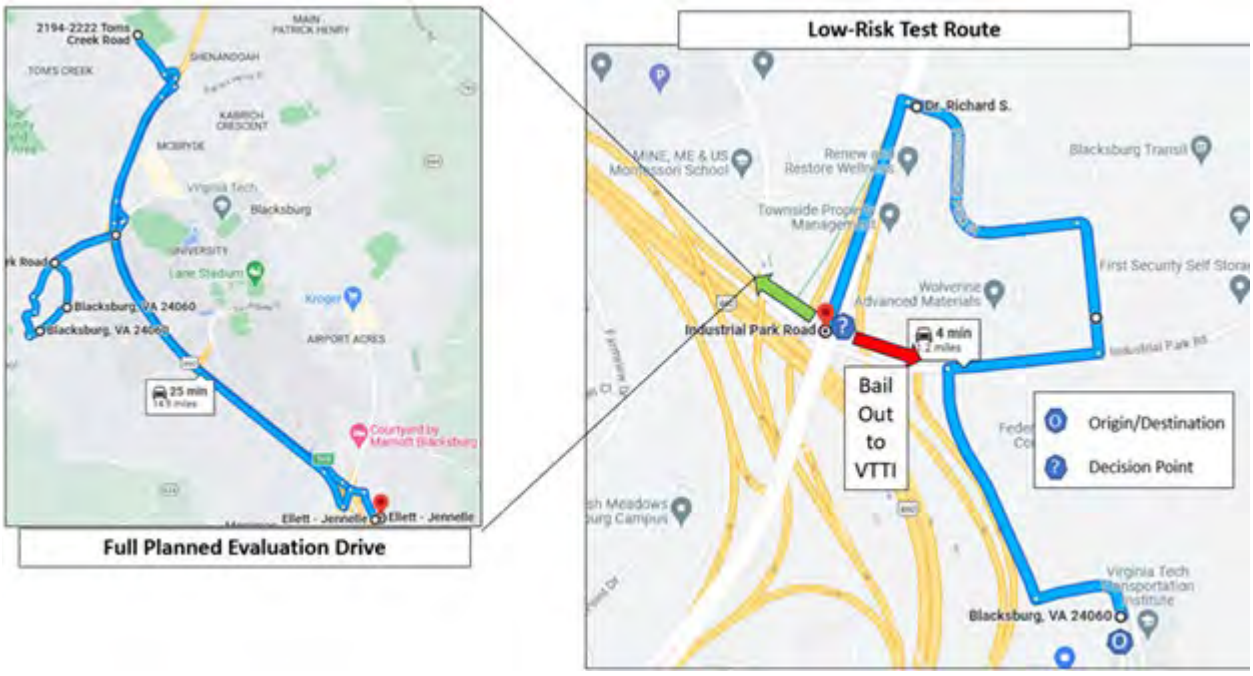



***Figure 1: Route used for three researcher- supervised drives***

Improving Air Mobility in Emergency Situations (Air Mobility)

The Air Mobility team developed a novel algorithm that leverages the spare capability of airports to schedule special evacuation flights when emergent situations, like disasters, are approaching. This algorithm a) satisfies traveler demand based on historic records, b) minimizes the possibility of flights being delayed or cancelled, and c) minimizes the effects on the operation of the national airspace system. The team is now working on determining which flight to borrow so that the cost to passengers is minimized while still satisfying the first objective.

Thus far, the research has shown that borrowing and redirecting flights directly from the destination airport could be the most cost-efficient way to minimize passenger delay. Unfortunately, one of the limitations found thus far is that the existing FAA dataset being used does not show the take-off and landing capability of airports at night.

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

The High-speed Rail team submitted the final report for the initial project, which is currently under review and will be posted during the next reporting period. The team received supplemental funding to extend the project [*High-Speed Rail in the US: The Intention to Use and Mode Choice Behavior - Additional Funding Opportunity (High-speed Rail 2)*]; started initial literature search; selected relevant peer-reviewed studies; and completed the survey questionnaire for pre-test, pilot study, and formal data collection.

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

The SAS Readiness team completed the design of the research methodology including the survey instruments and video components of the study. Data collection was initiated after IRB approval was obtained. Thirty-five participants completed the experimental session thus far.

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

During the reporting period, the Data Curation team initiated work on this project. Table 3 provides the list of projects included in this effort. The team identified and cleaned up the computer codes and data associated with these projects in preparation for dissemination.

***Table 3: CATM projects by the PI team and corresponding software codes and data***

| CATM Project Title | Software Developed | Data |
|---|---|---|
| Particle Dynamics Model for Hurricane Evacuation and Fuel Shortage: Model Based Policy Analysis | Matlab codes for parameter estimation and predictive modeling of fuel shortages | Traffic data and Fuel shortage data during several hurricanes |
| Multiscale Model for Hurricane Evacuation and Fuel Shortage | | |
| Epidemiological Models for Transportation Applications: Secondary Crashes | Matlab and R codes for point-process estimation of probability that a given crash is a secondary crash | Crash data for several Florida highways |
| Discrete Dynamics and Epidemiological Multi-Physics Models for Transportation Applications | Fortran and MPI codes for SIR infection modeling from pedestrian interaction data | Infection disease spread case studies |
| Analyzing the Role of Air-Transportation in COVID-19 Pandemic Disaster. | | |
| Multi-scale models for transportation systems under emergency | Fortran & MPI, Matlab codes for pedestrian movement modeling | Pedestrian dynamics case studies |
| Multi-Agent Dynamic Reinforcement Learning-based Pedestrian Model for Emergency Evacuation | | |

First Responder Transportation Safety Conference (First Responder)

The First Responder team worked with the TRB's Joint-Subcommittee on Emergency Response AMR00(1) and the Rutgers Center for Advanced Infrastructure and Transportation (CAIT) to

develop a two-day conference designed to bring together transportation-safety experts to share new research and best practices for emergency responders. The conference is scheduled for November 1-2, 2023 and will take place at Rutgers University.

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

This project is an extension of the Equitable Dynamic Pricing for Express Lanes (Dynamic Pricing) project which was completed during the last reporting period. Figure 2 displays the framework for reinforcement learning methods for toll design that are being employed in this project. During this reporting period, the Equitable Tolls team achieved their primary objective of developing open-source code for Multiobjective Reinforcement Learning and is progressing towards integrating high-efficiency RL algorithms to enhance the model's learning capabilities. They quantified conflicts among different tolling objectives, emphasizing the necessity for careful consideration of traffic controls across diverse metrics and key performance indicators. Additionally, they highlighted the intricate challenge of balancing equitable access with efficiency in transportation systems, acknowledging that optimizing for efficiency may occasionally come at the expense of equitable access for all travel groups.

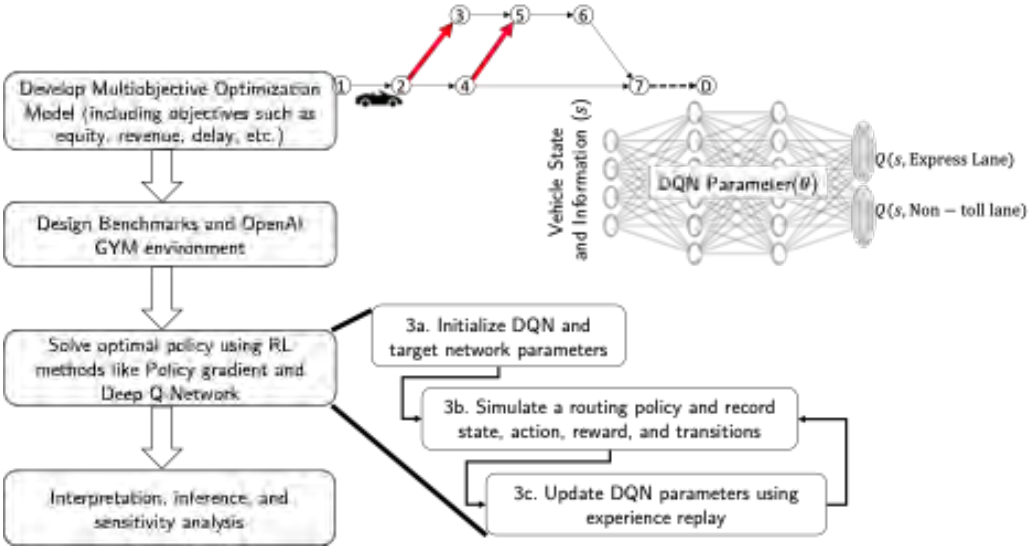



***Figure 2: Framework for reinforcement learning methods for toll design***

Research Assistants

Thirty-three students worked as research assistants on CATM products during the reporting period. Table 4 provides a breakdown of these students by classification and gender.

***Table 4: Demographics of student research assistants***

| Classification | Male | Female | Total |
|---|---|---|---|
| Undergraduate | 7 | 4 | 11 |
| Master's | 14 | 4 | 18 |
| Doctoral | 3 | 1 | 4 |
| **Total** | **24** | **9** | **33** |

Table 5 lists additional transportation research grants directly connected to the center that were active during the reporting period and the primary agencies funding them.

***Table 5: Transportation research grants awarded***

| Project Title | Lead Institution | Funding Agency |
|---|---|---|
| UTC Region 4 Center: The Center for Regional and Rural Connected Communities (CR2C2) | N.C. A&T State University | US Department of Transportation |
| 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 at NC A&T. Major activities included incorporating project insights into courses taught by Dr. Pandey, specifically CIEN 700 - Emerging Technologies in Civil Engineering and CIEN 350 - Introduction to Transportation Engineering, during the Fall 2023 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). Notable upcoming events include the Traffic Bowl trivia competition and a visit to the NCDOT Traffic Management Center, providing students with real-world exposure and enhancing their educational experience.

The MBA Supply Chain Management certificate program at NC A&T was restarted in Fall 2023 after more than 8 years of inactivity. Additionally, two NC A&T Dwight D. Eisenhower Minority Transportation Fellows completed their research papers during the reporting period and three new fellows were selected and initiated their research for the 2023-24 academic year.

During the reporting period, Dr. Parr (ERAU) taught four transportation courses: CIV 311 - Introduction to Transportation (Undergraduate), CIV 443 - Transportation Data Collection (Undergraduate), CIV 520: Railroad Engineering and High-speed Rail (Graduate), and CIV 522 - Advanced Geometric Design of Streets and Highways (Graduate). Dr. Y. Liu created new course material linked to the Air Mobility project for CS540 - Database and Information Retrieval, DS615 - Data Modeling, and MA440 - Data Mining courses. He used the FAA website to teach students how to develop web scrapers to fetch datasets and create simple data visualization (Figure 3). Students were highly motivated and excited to scrape information from government websites and databases.

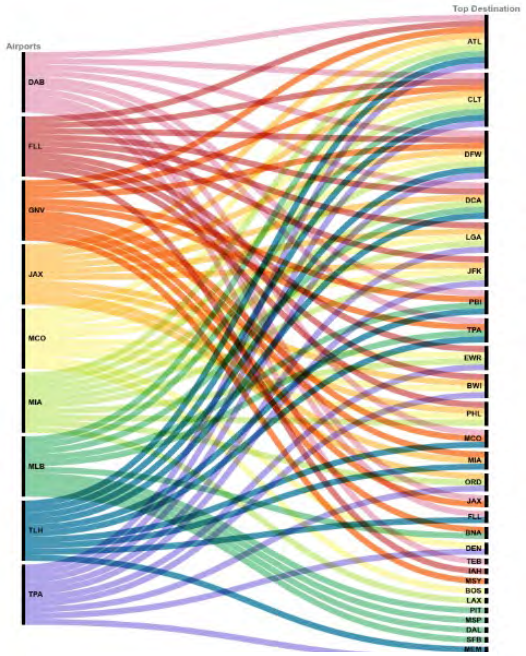



***Figure 3: Data visualization depicting the top 10 air travel destinations from the nine major airports in Florida***

## Workforce Development and Outreach

On July 9, 2023, NC A&T launched their 2 week residential Summer High School Transportation Institute (STI). While this was the 31st year that NC A&T has held this program, this was the first time in more than 10 years that program participants resided on NC A&T's campus for the duration for the program and got to experience life as a college student. During the program, students learned about various aspects of transportation including multimodal and public transportation as well as the role of transportation in supply chain

management. They also engaged in activities such as a bridge building competition; tours to locations such as the Greensboro Transit Authority, Greensboro Distribution Center, Beta Technology Flight Simulator, Port of Wilmington, and NC Maritime Museum; and they learned about the Aggie Autonomous Auto project and drones (Figure 4). Their group project involved the creation of a self-sustaining report network for pedestrian barriers, which involved pitching their research-based idea for a citizen science sidewalk survey.

***Figure 4: 2023 Summer High School Transportation Institute***

Technology Transfer

The Situation Awareness and CEV Vision teams have created technology in the form of a 1:1 VR immersive audio crosswalk simulator that is being modulated to allow for future projects. The technology will be discussed during a CATM webinar scheduled for November 13, 2023.

During the reporting period, the codes and data for recent CATM-sponsored projects have been cleaned up by the Data Curation team and example scenarios were created. The team plans to post the codes in Github and send out links to many stakeholders interested in this work to increase visibility and facilitate technology transfer of the research results for multiple CATM projects.

Over the course of the reporting period, the Equitable Tolls research team developed an optimization model built on top of the mesoscopic simulation model for express lanes programmed in Python. The model focuses particularly on multiobjective reinforcement learning. It has been documented and will be made available in the final project report. In addition, the research team has integrated other choice models as a part of this effort.

***What opportunities for training and professional development were provided?***

The First Responder team has been working with the TRB's Joint-Subcommittee on Emergency Response AMR00(1) and the Rutgers Center for Advanced Infrastructure and Transportation (CAIT) to develop a two-day conference which will bring together transportation-safety experts to share new research and best practices for emergency responders. The conference will take place on November 1-2, 2023.

In preparation for the check-in interviews, the Driving Feedback staff were given basic training regarding how to conduct structured interviews. The addition of the ROAD TRIP 2.0 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.

Newly on-boarded students involved in research learned how to conduct literature reviews and/or write components of technical papers. Special emphasis was placed on the format and quality of the work being submitted. Students have been trained to use relevant software and programming tools as necessitated by their projects. These tools include Python programming, bash scripting, Github source code management, and working with Linux operating systems.

***Have the results been disseminated?***

In addition to the publications and presentations listed in the Outputs section of this report, Dr. Antin delivered a presentation on the ROAD TRIP project at the Lifesavers' Conference held April 2-3, 2023. Furthermore, the Driving Feedback and Air Mobility projects were both featured in the Spring 2023 CATM Newsletter. The 2022-23 Dwight D. Eisenhower fellowship recipients, CATM scholars, and Student-to-Student activities were also highlighted in the newsletter. Copies of the CATM newsletters can be obtained by clicking on this link.

***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 through publications and presentations
- Host research webinars
- Distribute the Fall/Winter 2023 newsletter
- Hold the 5th Annual CATM Symposium
- Recruit applicants for NC A&T's 32nd Summer High School Transportation Institute
- Recruit applicants for the 2024-25 DDETFP

2. PARTICIPANTS & COLLABORATING ORGANIZATIONS:

***Organizations that have been involved as partners***

Table 6 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 6: 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, Ph.D. | NC A&T |
| Dept. of Computational Science and Engineering | Greensboro, NC | Collaborative Research | Hyoshin (John) Park, Ph.D. | NC A&T |
| Dept. of Mechanical Engineering | Greensboro, NC | Collaborative Research | Sun Yi, Ph.D. | NC A&T |
| Dept. of Electrical and Computer Engineering | Greensboro, NC | Financial Support, In-kind Support | Ali Karimoddini, Ph.D. | NC A&T |
| Dept. of Civil, Architectural, and Environmental Engineering | Greensboro, NC | Collaborative Research | Venktesh Pandey, Ph.D. | NC A&T |
| Dept. of Industrial and Systems Engineering | Blacksburg, VA | Collaborative Research | Rafael Patrick, Ph.D.; Charlie Klauer, Ph.D.; Myounghoon Jeon, Ph.D. | Virginia Tech |
| Virginia Tech Transportation Institute | Blacksburg, VA | Collaborative Research | Jon Antin, Ph.D | Virginia Tech |
| Dept. of Graduate Studies, College of Aviation | Daytona Beach, FL | Collaborative Research | Dahai Liu, Ph.D.; Jing Yu Pan, Ph.D. | ERAU |
| Aerospace Engineering | Daytona Beach, FL | Collaborative Research | Namilae Sirish, Ph.D. | ERAU |
| Dept. of Mathematics | Daytona Beach, FL | Collaborative Research | Yongxin Li, Ph.D. | ERAU |
| Dept. of Civil Engineering | Daytona Beach, FL | Collaborative Research | Scott Parr, Ph.D. | ERAU |
| General Motors | Detroit, MI | In-Kind Support | Dan Glaser | |
| University of Maryland | Baltimore, MD | Collaborative Research | Houbing Song, Ph.D. | |

### *Other collaborators or contacts involved*

During the reporting period, members of the First Responder team collaborated with Patrick Szary from Rutgers University and Jacob Valentine from Virginia Tech. Both will be presenting at the Emergency Responder Transportation Safety Research Summit in November, which is being hosted by the Center for Advanced Infrastructure and Transportation (CAIT). In addition, the Equitable Tolls team collaborated with Dr. Ali Hajbabaie from North Carolina State University, Dr. Md. Sami Hasnine from Virginia Tech, Dr. Hyoshin Park who is now at Old Dominion University, and Dr. Tarun Rambha at the Indian Institute of Science in Bangalore.

3. OUTPUTS:

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

***Publications, conference papers, and presentations***

Journals

- Dam, A., Oberoi, P., Pierson, J., Jeon, M., & Patrick, R. N. (2023). Technological and social distractions at unsignalized and signalized campus crosswalks: a multi-stage naturalistic observation study. Transportation Research Part F: Traffic Psychology and Behaviour, 97, 246-267. Published. Acknowledged Federal Support: yes.

Books and Non-Periodical, One-Time Publications

- Nothing to report

Other Publications, Conferences, and Presentations

- Acharya K., Velasquez A., Liu Y., Liu D., Sun L, Song H. (2023, August). Improving Air Mobility in Emergency Situation with Neural Network-Accelerated Genetic Algorithm. In 2023 Thirty-Fifth Annual Conference on Innovative Applications of Artificial Intelligence (IAAI-23). Under review. Acknowledged Federal Support: yes.
- Antin, J., Wotring, B. (2023). Detecting Early-Stage Dementia Using Naturalistic Driving. CATM Final Report. Awaiting Publication. Acknowledged Federal Support: yes.
- Feng, K., Liu, D., Liu, Y., Liu, H., & Song, H. (2023, August). GraphDAC: A Graph-Analytic Approach to Dynamic Airspace Configuration. In *2023 IEEE 24th International Conference on Information Reuse and Integration for Data Science (IRI)* (pp. 235-241). IEEE. Published. Acknowledged Federal Support: yes.
- Zhou, Y., Yang, Y., Song, H., Sirish, N. and Liu, D., (2023), A Survey of Machine Learning Algorithms and Techniques for Evacuation Under Emergency, Proc. of IISE Annual Conference & Expo, May 20-23, 2023, New Orleans, LA. Published. Acknowledged Federal Support: yes.

***Websites or other internet material***

- CATM Website: https://www.ncat.edu/cobe/transportation-institute/catm/index.php
- CATM Spring 2023 Newsletter: https://www.ncat.edu/cobe/transportation-institute/_files/pdfs/2023springnwsltrada.pdf
- CATM Facebook Page: https://www.facebook.com/NCATCATM/
- Data and source code of the paper GraphDAC: A Graph-Analytic Approach to Dynamic Airspace Configuration: https://github.com/KeFenge2022/GraphDAC
- Emergency Responders Transportation Safety Research Summit website: https://cait.rutgers.edu/event/emergency-responder-summit
- Driving Feedback Website: https://www.vtti.vt.edu/teenfeedback/

***Technologies or techniques***

- Situation Awareness project: A 1:1 VR immersive audio crosswalk simulator is being modulated to allow for project sharing.
- Reinforcement project: An A3C model integration with RL models using Python.
- ROAD TRIP 2.0 project: 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 driving consultation meetings.
- Air Mobility project: A novel algorithm that leverages the spare capability of airports to schedule special evacuation flights when emergent situation, like disasters are approaching.
- Air Mobility project: Web scrapers for automated data collection from FAA databases.

***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:

- Situation Awareness project: The following has been learned thus far during this project: Pedestrians distracted by technology, such as smart phones, are more likely to check both ways before crossing but less likely to continue checking during crossing. Pedestrians prefer when drivers initiate non-verbal crosswalk communication when crossing. Social distractions are a greater threat to pedestrian safety than technological distractions. A three-staged approach – naturalistic observation, surveys, focus groups – provides a comprehensive understanding of local pedestrian culture and the role of crosswalk infrastructure.
- Reinforcement project: Project findings will significantly impact evacuation under emergency, especially in venues such as airports and when the threats are not static but moving, such as fire.
- 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 and the safety of those sharing the roadways with them.
- Air Mobility project: Because the students engaged in this project thoroughly analyzed passenger airline transportation demand as well as the capabilities of national airspace systems via real data, they now have a clearer understanding of what is going on and why issues can occur.
- High-speed Rail project: While achieving success in many countries in the world, HSR is still new in the US, but it is likely to experience fast development in the near future. The findings of this study will reveal American's perceptions of HSR as a viable option for domestic travel as well as their intentions to use HSR. The understanding of HSR from travelers' perspectives is important, especially for policy makers to develop suitable strategies for HSR development and deployment in the US.
- First Responder project: This team is working directly with emergency responder agencies to share an understanding of transportation as it relates to their safety while working on or near the roadway.
- Equitable Tolls project: This project, with a dedicated focus on equity issues, has significantly contributed to nationwide discussions on social justice within transportation systems. The project has sparked insightful conversations, amongst the research group and there is an upcoming workshop on "Mathematical Foundations for Equity in Transportation Systems" by the Institute of Pure and Applied Mathematics where the PI plans to discuss and share the findings. These discussions center on the intersection of equity issues with various elements of transportation, deepening understanding and fostering awareness of the critical importance of addressing social justice within the realm of transportation.

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:

- Nothing to report.

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 development of the 1:1 crosswalk testbed was disseminated to an international community of auditory display researchers and designers and is expected to lead to further research and development of pedestrian safety simulation displays.
- Reinforcement project: A3C integration with the reinforcement learning is relatively new; therefore, this project provides a good application for this area.
- ROAD TRIP project: The initial iteration of this research highlighted the connection between increased mobility and the 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 holds the promise of contributing to the development of a portable, highly scalable program that can be implemented on a broader basis.
- Air Mobility project: The project has been utilizing students from data science, a non-transportation major, to participate and become familiar with the workflow and procedures of modeling a transportation system. One of them even leveraged this project experience and was offered a position with Frontier Airlines.
- 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 in Europe and Asia. There is a substantial gap in the research regarding HSR in the US. While some studies focused on challenges and opportunities in HSR development in the US, there has been limited research examining HSR development from travelers' perspectives. The findings of this study can fill this important research gap.
- SAS Readiness project: The objective of this project is to evaluate the perceptions individuals have regarding shared autonomous shuttles. Perceptions regarding safety, risk, ease of use, usefulness, relative advantage, and general trust associated with these vehicles can be used to determine the design characteristics needed to increase likelihood of adoption.
- Equitable Tolls project: This work has advanced the body of knowledge in optimization-based methods tailored to address equity concerns within transportation projects, especially 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 used to address transportation issues:

- Situation Awareness project: Findings from this study can serve as guidelines to develop external human machine interfaces (eHMIs) for automated vehicles and appropriate countermeasures to reduce pedestrian distractions at crosswalks, particularly throughout the campuses of higher education institutions.
- Reinforcement project: The results from this project can be used as a real time decision-aid for evacuation under extreme emergency.
- ROAD TRIP project: The project methodology includes a novel application that combines assessments of driving knowledge, driving history, physical activity, social isolation measures, and naturalistic driving data or supervised driving observations to develop solutions that address mobility challenges faced particularly by older adults.
- Air Mobility project: In this project, complex air mobility issues are addressed in a completely data-driven and computation-based manner, which can be used as examples in the future revolution of addressing transportation issues. Students engaged in this project studied the most cost-and-time efficient way of scheduling evacuation flights using computation driven methods. These observations and experiences can help them make prompt decisions when emergencies occur in the future.

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

- Reinforcement project: In one particular instance, the graduate student working on this project is majoring in data science, but he is receiving cross-training in aviation, computer science, and transportation engineering. He has decided to pursue a doctoral degree concentrating in these areas. Through these research experiences, more instances such as these are expected to occur as students in various degree programs realize how their skills can be used in the transportation field.
- ROAD TRIP project: The ROAD TRIP research team is seeking students outside of the typical transportation-related degree programs to join their program. This includes students majoring in public health, gerontology, and pre-med. Through their engagement in the project, these students will see how their areas of interest fit within the transportation career field.
- Air Mobility project: This research team is engaging students majoring in data science, a non-transportation major. The students are becoming familiar with the workflow and procedures of modeling a transportation system. One of them has already been offered a position with Frontier Airline and it is likely that he is just the first of many who will obtain offers from transportation organizations.
- Equitable Tolls project: This CATM project has significantly contributed to enlarging the pool of trained transportation professionals by actively mentoring and training six dedicated students this reporting period. This includes four undergraduate and two graduate students, each equipped with essential skills for success in the field. The undergraduate students have actively engaged in simulations and experiments to quantify equity issues, bringing valuable insights. One of the students verified open-source code principles and conducted experiments on equity issues, contributing to the project's core. Another undergraduate student led a comprehensive literature review on multiobjective control methods. One of the graduate students has been focusing on designing and modifying the simulation model code and integrating revenue-maximizing toll elements. The other has excelled in code verification and the literature review processes. Overall the students have been trained in valuable professional and soft skills that will enable them to thrive in transportation-related careers.
- ASETTS program: NC A&T undergraduate students majoring in civil engineering and supply chain management had the opportunity to conduct research over the summer. During their research experience, they learned about various tools and techniques used in transportation research. Two student papers were submitted to the 2024 Transportation Research Board (TRB) Annual Meeting. Additionally, three research articles are currently under preparation by ASETTS students.
- STI program: Twenty high school students participated in the 2023 STI program at NC A&T. At the beginning of the 2-week program, students rated their interest in transportation careers from “0 - Not at all” to “5 - Definitely Interested,” with only 3 indicating they were definitely interested in a career in transportation. By the end of the program, 11 of 20 students indicated an increase in their interest in a transportation career, with the number of students indicating that they were definitely interested in pursuing a transportation career doubling.

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

- Situation Awareness project: Results from this project have already been used to develop dissertation topics for ongoing projects. It is expected that the tools and techniques utilized in this research project will be adopted by future researchers as well.
- SAS Readiness project: By gaining a clearer understanding of how shared autonomous shuttles are perceived by the general public, designers can better equip the vehicles with the attributes that are most likely to attract users and the organizations deploying them can develop customized marketing campaigns based on knowledge obtained through this study to increase SAS adoption.
- First Responder project: The technologies shared at the conference are expected to be adopted by the attending first responder agencies.

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

***Table 7: CATM Outcome Performance Measures***

| Outcome # | Goals | Research Performance Measures | Target per year | Current Status |
|---|---|---|---|---|
| **Outcome #1** (technology focused) | Adoption of new technologies to help vulnerable road users identify suitable transportation services | Number of technology transfer activities that offer implementation or deployment guidance | 2 | 3 |
| **Outcome #2** (technology focused) | Enhanced decision-making techniques that improve the efficiency and effectiveness of emergency evacuation processes | Number of decision-making technology training courses or webinars developed and delivered | 2 | 2 |
| **Outcome #3** | Automated vehicle design guidelines based on an increased understanding and awareness of human perceptions of and interactions with automated vehicles | Number of human factors guideline documents published | 2 | 1 |
| **Outcome #4** | Dissemination of research results through presentations, publications, conference papers, and technical reports | Number of presentations and workshops given | 6 | 9 |
| | | Number of peer-reviewed journal papers published | 2 | 1 |
| | | Number of newsletter articles, conference papers, and technical reports published | 10 | 13 |

5. IMPACTS:

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

- CEV Vision project: The results of this project are expected to impact the safety of both pedestrians and road users. By ensuring effective communication between individuals crossing the road and vehicles on the road, the likelihood of accidents and resulting congestion will decrease.
- Air Mobility project: This project involves the investigation of the most cost-and-time efficient means of scheduling evacuation flights using computation driven methods. These methods can be applied to real world scenarios to reduce the impact of flight delays.
- SAS Readiness project: Effective use of technologies such as shared autonomous shuttles can result in decreases in congestion and pollution and increases in first- and last-mile mobility, particularly for individuals who commonly use public transportation.

***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?***

- Air Mobility project: The project team has developed a novel algorithm that leverages the spare capability of airports to schedule special evacuation flights when emergent situations, like disasters are approaching. This algorithm: a) Satisfies the travelers demand based on historic records, b) Minimizes the possibility of being delayed or cancelled, and c) Minimizes the effect to the operation of national airspace system.

- High-speed Rail project: This project will enhance the understanding of passengers' acceptance of HSR in the US and their intention to use HSR once it becomes a viable option for domestic travel. The findings can inform both industry and government organizations as they develop 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 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 by the end of the project.

### What is the impact on the body of scientific knowledge?

- Situation Awareness project: Since pedestrians prefer when drivers initiate non-verbal crosswalk communication when crossing, driverless car communication will be a challenge warranting further exploration. This research will aid in the discovery of the effective methods of communication between driverless vehicles and pedestrians.
- Detecting Dementia project: Degraded driving performance can be an early indicator of pre-mild cognitive impairment (pre-MCI). The analysis of the results of this study reveals that that those with pre-MCI demonstrate modest differences compared to cognitively normal individuals in terms of mobility-related metrics, especially when driving vehicles equipped with L2 technology. It is feasible that as these technologies become more widespread, those with and without pre-MCI may utilize them with greater frequency. In addition, this study showed that driving safety may one day be able to serve as the "canary in the coal mine" for the detection of pre-MCI.
- Reinforcement project: This project has resulted in the innovative development and application of supervised learning using an A3C algorithm in the transportation field.
- ROAD TRIP project: The project methodology can revolutionize the approaches currently used to extend mobility and improve health outcomes for older adults by providing personalized interventions based upon analysis of individual functional assessment and naturalistic driving data.
- Air Mobility project: The research team has developed a novel algorithm that leverages the capability of airports to schedule special evacuation flights when emergent situations arise to minimize the effects on travel. This algorithm optimizes the loss and cost for both government entities and passengers.
- High-speed Rail project: The findings of this study can provide empirical evidence of the intention to use HSR in the US, especially when the impact of environmental factors are considered. As such, this study can expand the knowledge base of HSR use, incorporating both environmental factors and a sustainability perspective.
- 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 road trips smoother and fairer. By developing smarter traffic control strategies, the research team envisions less congestion, shorter travel times, and fewer delays, ultimately improving how individuals traverse the roadways. Additionally, these efforts are intended to make transportation fairer by ensuring everyone, regardless of income, gets an equal share of accessibility.

### *What is the impact on transportation workforce development?*

- ROAD TRIP project: The research team engaged an undergraduate intern in all aspects of both phases of the study. This afforded this particular student the opportunity to learn about data collection and analysis and to assist with researcher training activities. Additionally, this research exposes student researchers to research-driven policy and technology outcomes including 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 reporting period, students from data science, a non-transportation major, became familiar with the workflow and procedures associated with modeling transportation systems. New material focusing primarily on aviation was developed for and used in data science graduate (DS615 - Data Modeling, CS540 - Database and Information Retrieval) and undergraduate (MA440 - Data Mining) core courses. Graduate research assistants learned to apply scientific research methods to address transportation issues and the PI provided supervision for student capstone projects.
- Equitable Tolls project: This work has actively contributed to transportation workforce development through several key avenues. First, 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 PI'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.
- Education and Workforce Development activities: NC A&T continues its efforts to expose minority students, in particular, to various transportation career opportunities. During the reporting period, two students received TRB Minority Fellowship awards and submitted the initial draft of their research papers for review. Two Dwight David Eisenhower Minority Transportation Fellows submitted their final transportation research papers. Three new students were selected for the Dwight David Eisenhower Minority Transportation Fellowship Program and are currently working on their transportation research papers. Currently a total of 32 students (Undergrad: 14, MS: 7, and PhD: 11) are working on the Autodrive project (Figure 5) and continue to hone their technical skills as they apply their scientific knowledge to refinement of the Aggie Autonomous Auto.


***Figure 5: AutoDrive project team members***

Additionally, approximately 80 ASETTS students earned points towards at least one of the five transportation badges during the 2022-23 academic year: Transportation Awareness and Engagement Badge: 37 activity completions, Transportation Core Skills Badge: 149 activity

completions, Transportation Community Badge: 5 activity completions, Transportation Research Badge: 11 activity completions, Transportation Leadership Badge: 2 activity completions.

Table 8 contains the center-specific performance measures for impacts, the target per year, and the status of each goal.

***Table 8: CATM Impact Performance Measures***

| Impact # | Goals | Research Performance Measures | Target per year | Current Status |
|---|---|---|---|---|
| **Impact #1** (technology focused) | Increase in the number of vulnerable road users able to acquire transportation services that fit their special needs | Number of instances of vulnerable road user technology adoption or commercialization | 2 | 0 created/ 0 adopted |
| **Impact #2** (technology focused) | More effective and efficient emergency transportation management processes | Number of instances optimization models or technologies are utilized or commercialized | 3 | 4 created/ 0 adopted |
| **Impact #3** | Increase the body of knowledge for human factors in automated vehicles | Number of instances of research changing behavior, practices, decision making, policies (including regulatory policies), or social actions | 2 | 1 |

6. CHANGES/DELAYS/PROBLEMS:

Driving Feedback project: In addition to the quantitative data being collected directly from participants, this project team has also begun scheduling some active participants and their parents to complete 1-on-1 interviews over Zoom to collect qualitative data regarding their experiences so far with the feedback app. An IRB amendment was submitted to the Virginia Tech IRB to allow the team to conduct interviews with active participants and their parents regarding their experience with the feedback app and provide monetary incentives.

CEV Vision project: The graduate research assistant working on this project left the project and a new set of students had to be recruited and on-boarded over the summer to complete the work. IRB updates were also submitted and approved.

ROAD TRIP project: As part of their continuing efforts to expand the footprint of the program, the research team replaced the VTTI DAS with a series of researcher-supervised drives before and after the driving consultation meeting. 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 its capabilities with enrolled participants in the next project period.

Air Mobility project: The project team found that reinforcement learning may not be a good fit for these projects, particularly when the problem itself can be modelled as a non-sequential decision-making or optimization problem. They are currently exploring other techniques that may produce more optimal results.

High-speed Rail project: Hiring graduate students was slower than expected due to limited availability of qualified students and longer than expected paperwork time for student employment.

Overall: A no-cost extension was granted for CATM and some of the remaining funds were distributed to CATM researchers to conduct additional data collection on previously funded projects to strengthen the results of their studies and support an increase in their dissemination efforts. During the summer, CATM's Communication Specialist resigned and efforts to find a replacement have thus far been unsuccessful. As a result, several final reports that were submitted after her departure have not yet been finalized and posted to the CATM webpage. This issue will be resolved by the end of the calendar. A mass media student was recently hired and is being trained to assist with some of the other dissemination activities for CATM.

## 7. SPECIAL REPORTING REQUIREMENTS

Nothing to report for this period.