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)

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Project Title: Center for Advanced Transportation Mobility

Center Director Name, Title, and Contact Information

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Recipient Organization:

North Carolina Agricultural and Technical State University

1601 E. Market Street, Greensboro, NC 27411

Recipient Identifying Number or Account Number: 270128

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Report Term or Frequency: Semi-annual

Signature of Submitting Official:

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

1. ACCOMPLISHMENTS:

What are the major goals of the program?

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

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

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

The overall goal of the center is to develop and implement research, education, outreach, workforce development, and technology transfer programs to address the need for improved mobility across multiple modes of transportation – primarily highway, rail, and air. In an effort to accomplish this goal, several activities took place during this reporting period. Table 1 provides a list of these activities and their statuses as of March 31, 2022.

Table 1: Progress of period 9 activities

Research	**Status**	**% Complete**
Complete Year 1 projects	Behind schedule	95%
Complete Year 3 projects	Behind schedule	80%
Complete Year 4 projects	Behind schedule	25%
Complete Year 5 projects	On schedule	17%
Initiate Year 6 projects	Complete	100%
Conduct annual visit to member institutions – Year 6	Forthcoming	0%
Education, Outreach, and Workforce Development Activities		
Initiate the Advancing STEM Education Through Transportation Studies Digital Badge Program	Complete	100%
Student participation in the 2022 TRB conference	Complete	100%
Conduct Spring 2022 student-to-student K-12 initiative workshops	Complete	100%
Student participation in the 2022 SE Region UTC conference	Complete	100%
Recruit/select 2022 STI participants	On schedule	30%
Prepare for and hold 2022 STI	On schedule	30%
Distribute 2022-23 CATM Transportation Scholarship applications	Forthcoming	0%
Select 2022-23 CATM Transportation Scholarship recipients	Forthcoming	0%
Hold the Dwight David Eisenhower Transportation Fellowship Local Competition	Forthcoming	0%
Develop and hold 2022 Transportation Awareness Day	Cancelled	0%

Technology Transfer Activities		
Assist with the 2022 SE Region UTC Conference planning	Complete	100%
Conduct 2021 research webinars	Complete	100%
Create and distribute Fall/Winter 2021 newsletter	Complete	100%
Plan and hold the 2021-22 Annual CATM Symposium	Complete	100%
Create and distribute Spring 2022 newsletter	On schedule	80%
Conduct 2022 research webinars	Forthcoming	0%
Plan 2022-23 Annual CATM Symposium	Forthcoming	0%
US DOT Reporting Activities		
Update records in RiP database	Complete	100%
Complete and submit PPPR#9	Complete	100%
Complete and submit SF425 for Q19 and Q20	Complete	100%
Complete and submit 2021 recipient share report	Complete	100%
Complete and submit 2021 performance indicator report	Complete	100%
Complete and submit PPPR#10	On schedule	75%
Review year 3 final reports for completed research projects	Behind Schedule	80%
Upload year 3 final reports to TRID database	Behind Schedule	80%
Review year 4 final reports for completed research projects	On schedule	25%
Upload year 4 final reports to TRID database	On schedule	25%
Review year 5 final reports for completed research projects	On schedule	17%
Upload year 5 final reports to TRID database	On schedule	17%
Complete and submit 2022 recipient share report	Forthcoming	0%

What was accomplished under these goals?

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

Research

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

Table 2: Funded projects active during reporting period

Project Title	Status/Award Year	Research Priority Area(s)	Project Link
Development, Design, and Calibration of the Vulnerable Road User Mobility Assistance Platform	Continuing/Y1	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/vrumap.php
Multi-agent Reinforcement Learning-based Pedestrian Dynamics Models for Emergency Evacuation	Continuing/Y3	IM, RC	https://www.ncat.edu/cobe/transportation-institute/catm/multi-agent-pedestrian-dynamic-models.php
DRONETIM: Dynamic Routing Of uNmanned-aerial and Emergency Team Incident Management	Continuing/Y3	IM, RC, PS	https://www.ncat.edu/cobe/transportation-institute/catm/dynamic-routing-unmanned-aerial.php
Real-Time Recommendations for Traffic Control in an Intelligent Transportation System During an Emergency Evacuation	Completed/Y3	IM, RC	https://www.ncat.edu/cobe/transportation-institute/catm/real-time-traffic-control-intelligent-system.php

Real-Time Recommendations for Traffic Control in an Intelligent Transportation System During an Emergency Evacuation – Part 2	Continuing/Y4	IM, RC	https://www.ncat.edu/cobe/transportation-institute/catm/real-time-traffic-control-part2.php
Epidemiological Models for Transportation Applications: Secondary Crashes	Continuing/Y4	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/epidemiological-models-secondary-crashes.php
Acoustic Situation Awareness and Its Effects on Pedestrian Safety within a Virtual Environment	Continuing/Y4	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/acoustic-situation-awareness.php
Vulnerable Road Users demand-responsive Transit Optimization with healthcare Privatization (VRUTOP)	Continuing/Y4	IM	https://www.ncat.edu/cobe/transportation-institute/catm/vrutop.php
Evaluation of Web-Based Driving Feedback for Teens and their Parents	Continuing/Y4	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/web-based-driving.php
Detecting Early-Stage Dementia Using Naturalistic Driving	Continuing/Y4	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/detecting-dementia.php
Equitable Dynamic Pricing for Express Lanes	Continuing/Y5	IM, RC	https://www.ncat.edu/cobe/transportation-institute/catm/15-equitabledynamicpricingforexpresslanes.php
Analyzing the Role of Air-Transportation in COVID-19 Pandemic Disaster	Continuing/Y5	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/24-airtransportationcovid19.php
Machine Learning for Dynamic Airspace Configuration towards Optimized Mobility in Emergency Situations	Continuing /Y5	IM, RC	https://www.ncat.edu/cobe/transportation-institute/catm/25-machinelearningabstract.php
Mask-Wearing Behaviors in Air Travel During Coronavirus Pandemic– An Extended Theory of Planned Behavior Model	Continuing/Y5	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/26-maskwearingabstract.php
Modeling Future Outbreaks of COVID-19 Using Traffic as Leading Indicator	Continuing/Y5	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/27-modelingfutureoutbreaks.php
Usability of Urban Air Mobility: Quantitative and Qualitative Assessments of Usage in Emergency Situations	Continuing/Y5	IM, PS, RC	https://www.ncat.edu/cobe/transportation-institute/catm/28-urbanairmobilityabstract.php
Connected electric vehicles: Vehicle-pedestrian communications to enhance vision impaired pedestrian safety	Continuing/Y5	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/29-cev-visionimpairedabstract.php
Real-time Deep Reinforcement Learning for Evacuation under Emergencies	New/Y6	IM	Forthcoming
Rural Older Adult Driver Tailored Research-Integrated Plan	New/Y6	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/rural-older-adult-driver-tailored-research.php
Improving Air Mobility in Emergency Situations	New/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	New/Y6	IM, RC, PS, PE	https://www.ncat.edu/cobe/transportation-institute/catm/high-speed-rail-in-the-us1.php

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

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

The main mobile app for the VRU-MAP project was fine-tuned with a slight visibility embellishment, to be more inclusive of people with certain types of disabilities such as the visually impaired. The team continued testing the system and anticipate completion of the project in the next reporting period.

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

The Multi-agent team developed the computational model of pedestrian evacuation at the airport, through the integration of a decision-making model and simulated social force model.

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

The DRONETIM team improved the following patent that is currently pending: System and Methods for Efficient Robotics Navigation Through Global Mapping, No. 63/074,889 (provisional application filed and improved).

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

The Multiscale Collaborate team continued the development and validation of a learning and planning approach for large-scale flight dispatch for disaster evacuation. They have completed the development of the flight dispatch algorithm in large-scale evacuation scenarios, namely Learning-to-Dispatch (L2D), a reinforcement learning (RL) based air route dispatching system. They formulated an online flight dispatch and proposed a multivariate reward function in the learning phase. The experiments using the real-world dataset for Hurricane Irma demonstrated the efficacy and efficiency of their proposed schema. The model results were simulated and validated against real-world data.

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

The Detecting Dementia research team secured IRB approval and completed data collection activities for 30 participants during the reporting period.

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

The Driving Feedback research team worked with their collaborators to revise their research design specifications. They continued working on the data pipeline, which included obtaining data sharing approvals with General Motors, collecting preliminary data, transferring data to a secure URL on a VTTI API server as .JSON files, converting these files to .csv, and reviewing data to begin development of an algorithm to automate data transformation into a useable format for analysis and output for participant access.

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

The Secondary Crashes team developed a formulation and code for applying temporal point process modeling to secondary crash problems. The model was fit to detailed crash data for Interstate-4 for the years 2015-17 and was used to estimate the queue time for secondary crashes in various cities along the I4 highway. Weekly traffic variations and the effect of increased traffic during rush hour were incorporated into the model.

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

The VRUTOP team worked on an application of the VRUTOP and VRUPOD projects with the NC Triangle area for submission to the NCDOT 2023 research idea cycle. The team also initiated discussions with the NCDOT Integrated Mobility Team Director in order to obtain a champion for the upcoming NCDOT 2023 proposal.

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

The Situation Awareness team completed the initial observation study and prepared discrimination materials. In addition, the main experiment (i.e., PLDs in VR) was initiated and is near completion. Results thus far indicate that non-verbal gestures between drivers and pedestrians are critical forms of communication. Lastly, key outcomes of the research thus far are that safe street crossings are possible within a 1:1 virtual environment.

Equitable Dynamic Pricing for Express Lanes (Dynamic Pricing)

The Dynamic Pricing research team programed alternate tolling options for their optimization. They determined the rate of differential tolls that address equity gaps by allowing all travelers to have equitable access to reliable travel time on express lanes. The team also determined policy guidance on the types of discounts that can be offered. Their findings indicate that offering a traveler a discount in proportion to their value of time (VOT) can mitigate the impact of delay differential by creating equitable distributions of delay.

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

The COVID AirTran team formulated point process models and developed codes for analyzing the initial spread of COVID-19 through air travel. Further, a novel infection risk model combining social-force-based pedestrian dynamics was formulated. The model was used to study the COVID-19 spread pattern in super-spreading events incorporating pedestrian movement and was validated by a case study of the Singapore flight without mandatory mask usage. Results suggest that the use of high-efficiency N95 or equivalent masks can significantly reduce the risk of secondary infections during a potential super-spreading event. Lower efficiency masks also reduce infections but not to the same extent.

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

The Machine Learning team built a machine-learning model for ATCs workload prediction and conducted data pre-processing. The machine-learning model is a feed-forward artificial neural network that can be used to optimize the ATCs performance metrics, such as sector workload, airspace capacity, and delay time.

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

The Mask-Wearing team worked on a draft of their final report and published a journal article. They submitted another journal article that is currently under review and gave presentations on the project results during a webinar and at a conference during the reporting period.

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

The COVID Outbreaks team continued the development of an SIR Model during the reporting period. They began seeing a pattern between "level of lock-down" and COVID-19 infections.

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

The Urban Air team completed Study 4, which involved interviewing participants on their perspectives on using urban air mobility in response to natural disasters. They finished interviewing, transcribing, and analyzing the data. In general, the qualitative results aligned well with the quantitative findings of Studies 1, 2, and 3.

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

The CEV Vision team obtained IRB approval for the initial study survey and prepared for deployment of the survey across the intended population groups.

Rural Older Adult Driver Tailored Research-Integrated Plan (ROADTRIP)

The ROADTRIP team selected assessment instruments as well as intervention strategies. They developed an algorithm for assigning tailored intervention strategies based on each participant's assessment results and naturalistic driving data collected during the first month of study. A specific data acquisition instrumentation package was selected for use in achieving research objectives. A study protocol and associated documents were drafted for submission to the IRB.

Improving Air Mobility in Emergency Situations (Air Mobility)

The Air Mobility team conducted a comprehensive literature review on air mobility in emergency situations, identified opportunities and challenges of applying machine-learning to improve air mobility in emergency situations, performed data gathering, and started data pre-processing and visualization.

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

The High-speed Rail team developed the overall structure of the research project and initiated their literature review.

Research Assistants

Thirty-one 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	3	9
Master's	6	4	10
Doctoral	8	4	12
Total	**20**	**11**	**31**

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

Table 4: Transportation research grants awarded

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

Education

Activities performed by student research assistants that required educational instruction from CATM research affiliates include literature review, IRB protocol development, journal article contributions, computer code development, experimental design development, and data collection. Discussions in the following courses were informed by results from the Dynamic Pricing project: CIEN 700 - Emerging Technologies in Civil Engineering, CIEN 350 - Introduction to Transportation Engineering, and CIEN 754 - Modeling of Transportation Systems. Students were encouraged to participate in various equity-related discussions occurring across the nation through organizations like the Institute of Transportation Engineers (ITE).

Three undergraduate students were awarded scholarships through the Dwight D. Eisenhower Transportation Fellowship Program this reporting period and initiated work on their transportation research papers under the direction of their faculty mentors. Five students competed in the North Carolina Southern District ITE chapter Traffic Bowl Competition in November 2021. The NCA&T team was the only team consisting of all undergraduate students and they came in second place in the competition. Eight undergraduate and one graduate student from NCA&T attended the UTC Conference for the Southeastern Region in March 2022. They submitted write-ups on their experiences and learnings from the conference sessions to receive credit for the Advancing STEM Education Through Transportation Studies (ASETTS) Program. ASETTS students also participated in transportation-related workshops and webinars to increase their knowledge of career opportunities in transportation.

Workforce Development and Outreach

Six undergraduate students participated in the 2022 Southern District ITE Student Leadership Summit. This three-day leadership event was held at Virginia Tech on February 25 - February 27, 2022. This event promoted leadership and professional development for transportation engineering students through technical and professional presentations hosted by invited industry speakers and extensive student-industry networking.

In March 2022, two NCA&T students visited Cummings High School in Burlington, North Carolina to introduced students in career and technical education classes to the education and career paths available in transportation and supply chain management.

Technology Transfer

What opportunities for training and professional development were provided?

Students participating in research projects received training on specific processes, techniques, and software programs associated with their research. Additionally, during the reporting period, the DRONETIM team communicated with the NCDOT traffic incident management staff about new data adaptation for North Carolina and how the current training provided should be modified.

Have the results been disseminated?

Two webinars were conducted by CATM researchers during the reporting period. On October 8, 2021, Dr. Jin Yu Pan (ERAU) discussed the methodology and findings of her research aimed at developing an extended theory of planned behavior model to examine the relationship between potentially relevant factors, like attitude, social norms, risk avoidance, information factors, and the intention to wear masks in an airplane cabin. On December 23, 2021, Dr. Venktesh Pandey (NCA&T) held a webinar detailing his research focused on investigating the equity issues associated with dynamic pricing for highway express lanes.

The VRU-MAP team submitted a short essay to a safety magazine, introducing some of the results associated with their project. Members of the Detecting Dementia team met with a medical resident to describe this study to broaden his outlook on geriatrics.

The fourth Center for Advanced Transportation Mobility (CATM) Research Symposium was a virtual even held on February 7 and 8, 2022. The symposium was an opportunity for students, faculty and researchers from the three consortium member institutions to share and learn about transportation-related research information. The principal investigators or graduate students involved in the research projects, partially or fully funded by CATM, presented the progress or final conclusions of their studies. Greg D. Winfree, J.D. was the keynote speaker for the first day of the symposium. Mr. Winfree is the director of Texas A&M University's Transportation Institute and has a prestigious background in transportation law and the U.S. Department of Transportation. Mr. Winfree gave an informed and interesting talk on "The Transformation of Transportation: The Road Ahead." Rory A. Cooper, Ph.D. was the keynote speaker on the second day of the symposium. Dr. Cooper is the founder, director and CEO of the Human Engineering Research Laboratories, a joint venture of the University of Pittsburgh, the U.S. Department of Veteran Affairs and the University of Pittsburgh Medical Center. He currently serves as FISA/PVA distinguished professor, past chair, in the Department of Rehabilitation Science and Technology and professor of bioengineering, physical medicine and rehabilitation and orthopedic surgery at the University of Pittsburgh. Dr. Cooper spoke with experience and passion about "Accessible Autonomous Vehicles and Transportation Systems – The Need for Greater Inclusion of People with Disabilities." Recordings of the Virtual CATM Symposium can be found on the CATM website (link).

Various project results were disseminated at conferences and symposia during the reporting period. These presentations and papers are listed in the Outputs section of this report. Elements of the DRONETIM, Situation Awareness, COVID AirTran, and COVID Outbreaks projects and CATM Scholar activities were also highlighted in the Fall 2021 CATM Newsletter.

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

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

- Continue research project specific activities
- Hold at least two research webinars
- Distribute the Spring 2022 newsletter
- Recruit for NC A&T's 30th Summer High School Transportation Institute
- Recruit applicants for the 2022-23 DDETFP and 2022-23 CATM Scholars
- Plan the next Transportation Awareness Day
- Plan the next CATM Symposium

2. PARTICIPANTS & COLLABORATING ORGANIZATIONS:

Organizations that have been involved as partners

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

Table 5: List of partners

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

Dept. of Civil Engineering	Daytona Beach, FL	Collaborative Research	Scott Parr, Ph.D.	ERAU
Aerospace Engineering	Daytona Beach, FL	Collaborative Research	Namilae Sirish, Ph.D.	ERAU
Computer Science	Pensacola, FL	In-Kind Support	Dr. Ashok Srinivasan	University of West Florida
National Surface Transportation Safety Center for Excellence	Blacksburg, VA	Financial Support	Dr. Jon Hankey	Virginia Tech
Civil Engineering	Clemson, SC	Collaborative Research	Dr. Pam Murray-Tuite	Clemson University
Civil and Environmental Engineering	Baton Rouge, LA	Collaborative Research	Dr. Brian Wolshon	Louisiana State University
Civil, Environmental and Geomatics Engineering	Boca Raton, FL	Collaborative Research	Dr. Evangelos Kaisar	Florida Atlantic University
General Motors	Detroit, MI	In-Kind Support	Dan Glaser	
Florida Department of Transportation	Tallahassee, FL	In-Kind Support	Paul Jodoin	

Other collaborators or contacts involved

During the reporting period, members of the VRUTOP project worked with Kai Monast at the Institute for Transportation Research and Education (ITRE) at N.C. State University on a NCDOT Center of Excellence last mile project that provided necessary data for the VRUTOP project. Members of the Dynamic Pricing project collaborated with Dr. Md Sami Hasnine at Howard University to develop models for travel behavior in response to real-time information that can be applied to highway express lanes. Additionally, the Dynamic Pricing project PI has been collaborating with Dr. Tarun Rambha at the Indian Institute of Science in Bangalore on the development of optimization models for ridesharing systems.

Drs. Maranda McBride and Joseph Huscroft started mentoring the 2021 NC A&T Dwight D. Eisenhower Transportation Fellows as they initiated work on their research papers.

3. OUTPUTS:

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

Publications, conference papers, and presentations

Journals

- Chilukuri, D.M., Yi, S., & Seong, Y. (2022). A robust object detection system with occlusion handling for mobile users. Computational Intelligence. January. 1-27. DOI: 10.1111/coin.12511 (published). Acknowledgement of federal support: yes.
- Darko, J., Folsom, L., Park, H., Minamide, M., Ono, M., & Su, H. (2022). A sampling-based path planning algorithm for improving observations in tropical cyclones. *Earth and Space Science*, *9*(1), e2020EA001498 (published). Acknowledgement of Federal Support: no.

- Motagi,S., Namilae, S., Gbaguidi, A., Parr, S., & Liu, D. Point-process modeling of secondary crashes. (under review). Acknowledgement of Federal Support: yes.
- Yang, Y., Yu, J., Liu, D., Lee, S., Namilae, S., Islam, S., Gou, H., and Park, H. Multi-agent collaboration for emergency evacuation using reinforcement learning for transportation systems. IEEE Journal on Miniaturization for Air and Space Systems (under revision). Acknowledgement of Federal Support: yes.

Books and Non-Periodical, One-Time Publications

- Seong, Y., Dadzie, E., Yi, S., & Alabi, M. Artificial Intelligence in Nondestructive Condition Assessment of Concrete Structures: Detecting Internal Defects and Improving Prediction Performance Using Prediction Integration and Data Proliferation Techniques. In Nam, CS (Ed). Human Centered Artificial Intelligence: Research and Applications. Academic Press (in press). Type of publication: book chapter. Acknowledgement of Federal Support: no.
- Seong, Y.. Product Safety in US - A perspective safety for inclusiveness and social responsibility. Safety Korea: For Safe and High Quality Product. National Technology Safety Standard Agency (in press). Type of publication: short essay. Korea Acknowledgement of Federal Support: no.
- Song, H., Hopkinson, K., Cola, T., Alexandrovich, T., & Liu, D, (2022). Aviation Cybersecurity: Foundations, principles, and applications, ISBN: 978-1839533211, Scitech Publishing (published). Type of publication: book. Acknowledgement of Federal Support: yes.

Other Publications, Conferences, and Presentations

- Antin, J.F. (2022) Older Adult Mobility, Awareness, Safety & Health. The Future of Accessible Vehicles and Transportation Systems Symposium, Uniformed Services University of the Health Sciences and Walter Reed National Military Medical Center, March 2022 (presented). Acknowledgement of Federal Support: yes.
- Antin, J. F., Hankey, J., & Wotring, B. W. (2022). Rural older adult driver tailored research-integrated plan (ROAD TRIP). CATM Virtual Symposium 2022, February 2022 (presented). Acknowledgement of Federal Support: yes.
- Antin, J. F., Hankey, J., & Wotring, B.W. (2022). Rural older adult driver tailored research-integrated plan (ROAD TRIP). State of the Science Virtual Symposium 2022, Febaruary 2022 (presented). Acknowledgement of Federal Support: yes.
- Dam, A., Oberoi, P., Pierson, J., Jeon, M., & Patrick, R. (2021). Acoustic situation awareness and its effects on pedestrian safety within a virtual environment. International Community for Auditory Display (ICAD) (published). Acknowledgement of Federal Support: yes.
- Darko, J., Folsom, L., Deshpande, N., Park, H. (2022). Unmanned Aerial and Ground Emergency Vehicles in Traffic Incident Management: An Anticipatory Assignment Model. The 101st Annual Meeting of TRB, Paper #22-03332, Washington, D.C., January 2022, (presented). Acknowledgement of Federal Support: yes.
- Darko, J., Park, H. (2021). A Proactive Dynamic-Distributed Constraint Optimization Framework for Unmanned Aerial and Ground Vehicles in Traffic Incident Management. 2021 6th International Conference on Intelligent Transportation Engineering (ICITE 2021). October, 2021 (presented). Acknowledgement of Federal Support: yes.
- Darko, J., Folsom, L., Deshpande, N., Park, H. (2022). Integrating pedestrian accessibility with public transit routing in a multimodal trip planning framework. The 101st Annual Meeting of TRB, Paper #22-03342, Washington, D.C., January 2022 (presented). Acknowledgement of Federal Support: yes.
- Koliou, K., Parr, S., Kaisar, E., Murray-Tuite, P., & Wolshon, B. (2022). COVID-19's effect on truck traffic and freight movement. 7th UTC Conference for the Southeastern Region, Boca Raton, FL, March 2022 (presented). Acknowledgement of Federal Support: yes.
- Liu, Y., Wang, J., Chen, Y., Niu, S., Lv, Z., Wu, L., Liu, D., & Song, H. (2021). Blockchain enabled secure authentication for unmanned aircraft systems. 2021 IEEE Globecom Workshops (GC

Wkshps), doi: 10.1109/GCWkshps52748.2021.9682054, 1-6 (published). Acknowledgement of Federal Support: yes.

- Motagi, S., Namilae, S., Gbaguidi, A., Parr, S., & Liu, D. (2022). Modeling secondary crashes using temporal point processes. 7th UTC Conference for the Southeastern Region, Boca Raton, FL, March 2022 (presented). Acknowledgement of Federal Support: yes. Acknowledgement of Federal Support: yes.
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- Radlbeck, J., & Klauer, S. (2022). Evaluation of web-based driving feedback for teens and their parents. CATM Virtual Symposium 2022, February 2022 (presented). Acknowledgement of Federal Support: yes.
- Wu, Y., Namilae, S., Liu, D., Scotch, M., & Srinivasan, A. (2022). Incorporating pedestrian movement in computational models of COVID-19 spread during air-travel. IEEE Aerospace Conference, March 2022 (presented). Acknowledgement of Federal Support: yes.
- Wu, Y., Namilae, S., & Liu, D. (2022). Analyzing the role of air transportation in COVID -19 pandemic UTC - CATM Virtual Symposium 2022, February 2022 (presented). Acknowledgement of Federal Support: yes.
- Zhang, K., Yang, Y., Xu, C., Liu D., & Song, H. (2021). Learning-to-Dispatch: Reinforcement learning based flight planning under emergency. 2021 IEEE International Intelligent Transportation Systems Conference (ITSC), Indianapolis, IN, pp. 1821-1826. doi: 10.1109/ITSC48978.2021.9564684 (published). Acknowledgement of Federal Support: yes.
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Websites or other internet material

- CATM Website: https://www.ncat.edu/cobe/transportation-institute/catm/index.php
- CATM Fall 2021 Newsletter: https://www.ncat.edu/cobe/transportation-institute/_files/pdfs/fall2021nwsltrada.pdf
- CATM Facebook Page: https://www.facebook.com/NCATCATM/
- CATM Virtual Symposium Day 1 (Feb 7, 2022): https://video.vt.edu/media/CATM%20Virtual%20Research%20Symposium%202022/1_d8eqpt0l
- CATM Virtual Symposium Day 2 (Feb 8, 2022): https://video.vt.edu/media/CATM%20Virtual%20Research%20Symposium%202022/1_t4knnhej
- Webinar titled “Mask-Wearing Behaviors in Air Travel During Coronavirus Pandemic – An Extended Theory of Planned Behavior Model”: https://www.youtube.com/watch?v=4WxzsRmcaa8
- Webinar titled “Modeling Approaches for Equitable Dynamic Congestion Pricing”: https://www.youtube.com/watch?v=ApIrkZ7YDxY&t=1s

Technologies or techniques

- VRU-MAP project: The core of the project is the development of a novel navigation platform supporting improved mobility for people with disabilities. The eventual goal of the project is to make this platform available for sharing or partnership to support broader development and instantiation. A machine learning-based algorithm was developed to detect road signs. This idea was utilized by another project - AUTODRIVE CHALLENGE 2 led by NCA&T. In addition, an NCA&T graduate student developed a prototype of a perception algorithm.
- Situation Awareness project: The project has produced a 1:1 virtual environment that maps to an audio immersive environment located within the ICAT Perform Studio at the Blacksburg Virginia Tech campus. The tool was developed using Unreal Engine and allows for dynamic real-world street crossings within a virtual environment using an Oculus Quest 2 headset.
- COVID AirTran project: A survey of recent on-flight outbreaks indicates that some aspects of COVID-19 spread, such as long-distance superspreading, cannot be explained without also considering the movement of people. Another factor that could be influential but has not gained much attention yet is the unpredictable nature of passenger behavior. The team developed a novel infection risk model that is linked with pedestrian dynamics to more accurately capture these aspects of infection spread.

Inventions, patent applications, and/or licenses

- DRONETIM project patent filed: System and Methods for Efficient Robotics Navigation Through Global Mapping, No. 63/074,889, Provisional Application Filed and Improved. Acknowledgement of Federal Support: yes.

Other products

Audio/Video Products

- Situational Awareness project: A Virtual Reality and Audio Immersive Environment has been developed.

Computer Code

COVID AirTran project: Two codes have been developed through this work. The codes will be published in the form of supplementary data and included in journal publications.

4. OUTCOMES:

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

- VRU-MAP project: Through outreach such as the 2022 CATM symposium, past CATM and regional UTC symposia, and a UTC Spotlight Newsletter, as well as through engagement with numerous students at both VT and NCA&T, the VRU-MAP team has worked to increase awareness of the transportation needs of people with disabilities.
- Multi-agent project: An adaptive routing strategy per individual passenger is required to safely reduce the congestion effect among other agents and ultimately produce shorter evacuation times. While the previously developed social force model is trained by real-world data to provide a realistic simulation of pedestrian behaviors under emergent situations, a dynamic routing model has also been developed to suggest the best options to evacuate faster.
- DRONETIM project: The result of the project has helped incident management operators determine which incident has priority and what incident response resource should be allocated at different times of the day.
- Multiscale Collaborate project: The models developed for this project, which are based on a machine learning algorithm, provide an adaptive dispatching framework for optimal coordination

of the limited resources. These models provide a new way to look at emergency evacuation issues and can lead to effective real-time scheduling policies when emergencies occur.

- VRUTOP project: This research focuses on improving the transit service of vulnerable road users while addressing recent trends in Medicaid transformation, particularly service performance changes before and after the COVID-19 pandemic.
- Situation Awareness project: Street crossing can introduce very dangerous situations for both drivers and pedestrians. The current research found that this is the case for university crosswalks, which present an added level of complexity associated with the use of distracting devices such as personal listening devices. Study findings show that non-verbal communication between both parties is critical for safe crossings and that some locations provide better opportunities for safer crossing based on the ability to make contact with the driver before initiating the crossing.
- Dynamic Pricing project: The project's focus on equity issues is very relevant to the nationwide discussions on social justice. This project has led to discussions around associating equity issues with different elements of transportation systems.
- COVID-AirTran project: In this study, a novel infection risk model that is linked with pedestrian dynamics is used to accurately capture various aspects of COVID-19 infection spread. Passenger movement during boarding and deplaning, as well as in-plane movement, are modeled with the social force model and agent-based model, respectively. Results suggest that the use of high-efficiency N95 or equivalent masks can significantly reduce the risk of secondary infections during a potential superspreading event. Lower efficiency masks also reduce infections but not to the same extent. Social distance policies, like keeping the middle seat vacant, are not only effective in themselves, the independent masking and social distancing strategies can combine and compound the efficiency of mitigation.
- Machine Learning project: The objective of this project is to develop a prototype for dynamic airspace configuration (DAC) using machine learning (ML) techniques, to achieve optimized mobility in emergency situations. The purpose of this study is to enable dynamic airspace configuration (DAC) to optimize air mobility in emergency evacuation. The anticipated outcome is a prototype that would demonstrate the ML-augmented capability supporting DAC.
- Mask Wearing project: The findings of this study identified key factors that influenced the intention to wear a mask when flying during COVID-19, thus increasing the understanding and awareness of mask use in the air transport context.
- Urban Air project: This study is one of the first to assess urban air mobility vehicles' use in response to natural disasters. In general, the findings indicate overwhelming support by the participants for their use. These findings provide evidence that there is likely strong support if municipalities would purchase these vehicles to use within this context. This usage may be another opportunity for UAM manufacturers to demonstrate the capabilities of their aircraft.
- Air Mobility project: The objective of this project is to develop a system for providing pre-alert for passengers and airport staff when emergency events occur and adjusting the original schedule for the recovery of disrupted air mobility. Project activities thus far have offered deep insights into the opportunities and challenges of applying machine learning to improve air mobility in emergency situations.
- 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 Americans’ acceptance of HSR as a viable option for domestic travel as well as their intention to use HSR. The understanding of HSR from travelers’ perspectives is important especially for policy makers to develop suitable strategies for HSR development in the US.

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

- Multi-agent project: It is important to note that in an airport evacuation scenario, policies and regulations will dictate where police officers and security guards would be placed along the evacuation path to guide pedestrians to ensure they follow the optimal guided path.
- DRONETIM project: In response to new FAA regulations, the developed proactive data-driven model estimates the importance of the information and decides where the emergency response vehicles and unmanned aerial vehicles should be located. Various incident management policies will be generated through simulation for the operator to easily make decisions during emergency.
- Multiscale Collaborate project: Making flight plans under emergent situations presents a significant challenge for aviation authorities, as scheduling efficiency relies heavily on many dynamic factors including human, environmental, and traffic loads. The framework developed for this project has provided both a theoretical and empirical basis to provide a real time decision aid for flight planning under emergent situations. These models may be used to inform real-world, real-time decision support for evacuation policies.
- VRUTOP project: Compared to the existing fixed transit system, this project will provide guidelines for new scheduling and routing policies for service vehicles considering the Medicaid transformation toward private control.

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

- VRU-MAP project: Machine learning algorithms were used and modified to reduce noise in perception and increase accuracy. This project has resulted in numerous presentations at CATM and regional UTC conferences, several journal articles, and a DOT newsletter.
- Multi-agent project: The findings of this project will lead to a multidisciplinary computational framework for understanding and modelling the human decision-making process and resulting actions in emergency evacuations.
- DRONETIM project: This project developed a distributed constraint optimization problem (DCOP) framework to allocate resources to highway incidents under static environments, simplifying dynamic behavior in distinct unconnected decisions. It further extended DCOP so it is proactive and can anticipate future changes in the environment and consider dependencies between resource availability in near-future requests and the service time of each immediate incident request. This is a new data-driven optimization process that proactively adapts to environmental changes in the transportation system.
- Multiscale Collaborate project: The model aims to formulate flight dispatch under emergency as a weighted graph matching problem. Spatial temporal quantization and combinatorial optimization approaches were applied to train the machine-learning model for prediction of efficiency of the different policies for the flight dispatch.
- Secondary Crashes project: This research adopted temporal point process models from other research areas to develop a new approach for analyzing secondary crashes.
- VRUTOP project: Transit service tools have had difficulties in capturing essential parameters that would allow them to adjust to dynamic environments. This project includes data mining and data-driven optimization of paratransit service that incorporates such parameters.
- Situation Awareness project: The current work has led to increases in the body of knowledge pertaining to the psychology of pedestrian-driver behavior. Such knowledge relates to the use and timing of non-verbal gestures, the perceived effects of personal listening device (PLD) usage, and the reduction of one's acoustic situation awareness due to PLD use during street crossings.
- Dynamic Pricing project: The project's work has contributed to optimization-based methods for addressing equity concerns associated with express lane pricing as well as model development for the identification of equity issues and optimization of discounts for system welfare.
- COVID AirTran project: A novel infection risk model was developed and combined with social-force-based pedestrian dynamics. The model was validated using recent superspreading events on airplanes and used to study policies that reduce air travel infection spread.

- Mask-Wearing project: By identifying key determinants of the intention to wear a mask during flight, this study contributes to the knowledge of mask use in global pandemics.
- Urban Air project: This study has produced the first empirical evidence of consumers' willingness to support the use of urban air mobility vehicles for use in response to natural disasters.
- High-speed Rail project: While there are some studies focused on challenges and opportunities in HSR development in the US, there have been very few studies examining HSR development from travelers' perspectives. The findings of this study can fill this important research gap.

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

- VRU-MAP project: The focus of this project is the development of a novel technology to assist travelers with disabilities. When complete, it will form the foundation of a platform that can be expanded to support further research and potential commercialization/deployment to provide real-world benefit to this vulnerable population.
- Multi-agent project: When applied to a simulated airport emergency evacuation, the integrated modelling technique will reduce the total overall evacuation time of pedestrians in an emergency airport situation.
- DRONETIM project: This project improved the way unmanned aerial vehicles are utilized in incident management to provide critical information to emergency vehicle routing and predicting short-term traffic state during non-recurring and recurring congestion.
- Multiscale Collaborate project: Innovative machine learning models were created that combine off-line learning and on-line planning to address flight dispatch issues under emergent situations.
- Secondary Crashes project: This research developed a new method to analyze secondary crashes.
- VRUTOP project: The privatization of Medicaid will change the patterns of users of transit systems making it difficult to improve the efficiency of the service. This project improves the process of optimizing the operation of paratransit service.
- Situation Awareness project: Prior to this project, the process of syncing a virtual reality environment with a real-world audio system was limited and unclear. This project serves as an example of this process for experimental purposes.
- COVID AirTran project: Project results suggest that social distance policies, like keeping the middle seats vacant, are not only effective in themselves, the independent masking and social distancing strategies can combine and compound the efficiency of mitigation.
- Machine Learning project: The objective of this project is to identify, apply, and evaluate ML techniques that can be related and applied to Dynamic Airspace Configuration (DAC). ML for DAC will result in a more efficient allocation of airspace as a capacity management technique.
- CEV Vision project: This project has initiated the process of developing a realistic audio immersive environment to be used for simulated training of vehicle-to-person communication systems for the visually impaired.

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

- Research projects: Undergraduate and graduate students working on the CATM research projects receive training and hone their skills in both discipline-specific and interdisciplinary methods that they can use to solve complex transportation issues upon entry into the workforce.
- VRUTOP project: This project provides training in the operation of paratransit, transportation data management, traffic demand modeling, and transportation mesoscopic simulations.
- ASETTS program: NCA&T undergraduate students majoring in civil engineering and supply chain management were exposed to education and career opportunities in transportation through the ITE Student Leadership Summit, SEUTC Conference, TRB Annual Meeting, CATM Symposium, and various transportation webinars. Students who were enrolled in the ASETTS program also received points towards the digital badge associated with each activity.

- Student-to-Student program: High school students were introduced to various opportunities in transportation and supply chain management during presentations delivered by current supply chain management students at NCA&T.

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

- Multi-agent project: This project can make use of advanced surveillance systems now available for practical applications in pedestrian trajectory research.
- DRONETIM project: The concept of this project will adapt to human control changes in response to various incident severity levels as unmanned aerial vehicles become more autonomous.
- VRUTOP project: The data-driven optimization technique associated with this project helps address issues related to the uncertain nature of many transportation systems.
- Situation Awareness project: This work has led to the adoption of virtual reality as a tool for street crossing evaluation. Although other projects have explored this concept, the current project addresses the need for a 1:1 physical crossing with full visual and audio immersion.
- CEV Vision project: This project utilizes virtual reality and immersive audio to gain a better understanding of user capabilities and limitations associated with the use of vehicle-to-person communication systems.

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	0
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	4
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	19
		Number of peer-reviewed journal papers published	2	2
		Number of newsletter articles, conference papers, and technical reports published	10	6

5. IMPACTS:

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

- Multi-agent project: The overall maximum evacuation time savings resulting from the optimal navigation model developed for this project was 10.6%. This research's optimally guided path planning model incorporates the social force model's density map and assigns highly congested areas to negative reward states. By integrating the two models, mobility in emergency evacuation situations can be further optimized.
- VRUTOP project: The results of this project are expected to provide a new service tool for paratransit. This tool is designed to improve access to healthcare in underserved areas using public transportation and Mobility as a Service.
- Situation Awareness project: The goal of this project is to develop a portable standalone system that can be used remotely for transportation research by a wider and more diverse audience.

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

- VRU-MAP project: The algorithms developed for this project have been utilized in another project supported by one of the largest automobile companies in the US. The team is striving to ensure the techniques can be well recognized and used for future development of autonomous vehicles.
- Multi-agent project: The team intends to apply this integrated modelling technique in airport security manager training using airport emergency evacuation simulations. Video data will be used to confirm real-time pedestrian traffic density and provide a new model to guide pedestrians.
- DRONETIM project: The research is expected to result in a data-driven decision aid tool for traffic operators dealing with traffic incident management.
- VRUTOP project: This project is expected to lead to more effective transportation service operator training because it adapts to possible changes in system delay due to wait or load time of a previous pick up.
- Situation Awareness project: The current research is expected to provide a testbed for effectiveness and overall system performance. The development of a real-world tool affords researchers and practitioners the ability to test out new technology and/or train the use of current technology. Lastly, the tool has the potential for commercialization based on intended use-cases.
- Dynamic Pricing project: It is envisioned that the developed algorithms for discount optimization would be useful for organizations and companies responsible for express lane pricing operations.
- Mask-Wearing project: The findings of the study will enhance the understanding of mask-wear intentions and behaviors of passengers flying during COVID-19. This will provide policy makers and airlines information needed to formulate public health strategies to ensure inflight safety, hence helping the airline industry recover more quickly from the pandemic.
- Urban Air project: Project findings may help urban air mobility manufacturers demonstrate the effectiveness and capabilities of their aircraft, while also serving the public good in response to natural disasters.
- CEV Vision project: The research will provide a thorough needs analysis associated with vehicle-to-person communication systems designed for vulnerable road users with reduced vision. Additionally, the research seeks to perform human factors feasibility assessments of such technologies under realistic but safe operational conditions.
- 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 the industry and government in developing guidelines and strategies to prepare for the development of HSR in the US.

What is the impact on the body of scientific knowledge?

- VRU-MAP project: The work underlying this project, particularly the findings of a related project evaluating the transportation needs of people with disabilities, extend the understanding of the special needs and demands of this population along with potential methods to address these needs.
- Multi-agent project: This project opens up new related research paths associated with the integration of the deep reinforcement model and social force model in pedestrian evacuation in transportation systems.
- DRONETIM project: Future traffic events are proactively anticipated using data driven optimization methods to efficiently allocate incident response resources.
- Multiscale Collaborate project: The model developed for this project will aid in real-time evacuation planning and decision-making for a wide range of air travel scenarios.
- Secondary Crashes project: The proposed model provides a novel approach to identify secondary crashes using the self-exciting point process model. The model can be used to create policies and countermeasures aimed to reduce the risk of secondary crashes.
- VRUTOP project: Unexpected paratransit system delays can be handled using the integration of the data-mining model developed for this project and the optimal pick-up and drop off model can help reduce operating costs.
- Situation Awareness project: Acoustic situation awareness is a topic of varying interest but has become more relevant with the development of acoustically invisible vehicles, such as electric cars. Therefore, it is imperative to understand the limitations and capabilities of pedestrians using personal listening devices around such vehicles.
- Dynamic Pricing project: This project contributed optimization-based methods for addressing equity concerns associated with the appropriate design of toll discounts.
- COVID AirTran project: In this project, a novel infection risk model was developed that is linked with pedestrian dynamics to accurately capture critical aspects of infection spread. The model was used to evaluate what-if scenarios on the relative effectiveness of policies and procedures such as masking, social distancing, as well as synergistic effects by combining different approaches in airplanes and other contexts.
- Mask-Wearing project: In terms of public safety during a pandemic, the research findings can expand the knowledge base of behavioral intention of air travelers.
- CEV Vision project: A critical research goal is to determine the human-related latency associated with the detection of vehicle-to-pedestrian communication system alerts. This information should be used when developing such systems to ensure desired levels of effectiveness and technology acceptance.
- High-speed Rail project: This study fills an important research gap by investigating passengers' choice among car, air, and HSR for domestic travel in the US and key determinants of American passengers' intention to use HSR.

What is the impact on transportation workforce development?

- Research projects: Today's transportation workforce is composed of individuals from diverse fields of study. The various projects in which students are engaged are providing hands-on experience in an array of multidisciplinary transportation-related methods and tools. Students also receive opportunities to present and discuss their research in academic and professional settings including at conferences/symposia and through journal articles.
- DRONETIM project: A former MS student was hired by the NCDOT incident management team as a result of his involvement in this project. Having experience dealing with incident data mining and integrated optimization methods provided key skills that made him more marketable in the transportation workforce.
- Dynamic Pricing project: Undergraduate and graduate research assistants involved with this project, all from underrepresented backgrounds, have been trained to use relevant software and programming tools. The students have shown consistent improvement during this reporting

period and are becoming adept at understanding research problems, asking the right questions, and using the tools to solve research problems.

- CEV Vision project: The portable tool developed for this project can be used in educational settings for K-12 students to attract at them early to careers in transportation.
- ROADTRIP project: This research, which combines driving research and community outreach, has the potential to broaden the future contributions of the student researcher engaged in 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.
- Education and Workforce Development activities: The activities that take place at NCA&T are geared primarily towards exposing minority students to transportation career opportunities. In this way, we assist in the diversification of the transportation workforce.

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	3 created/ 0 adopted
Impact #3	Increase the body of knowledge for human factors in automated vehicles	Number of instances of research changing behavior, practices, decision making, policies (including regulatory policies), or social actions	2	1

6. CHANGES/PROBLEMS:

Multiagent project: There was a change in the scope of the ERAU contribution to the project whereby it now focuses more on Robotics in pedestrian evacuation at the airport.

Detecting Dementia project: The team was able to leverage ongoing naturalistic driving data collection focused on drivers' use of Advanced Driver Assistive Systems to expand their study.

Driving Feedback project: Delays in obtaining data sharing approvals from the collaborating organization, has prevented the team from viewing preliminary data to inform study procedures prior to data collection. Several approvals from General Motors are still pending, but are expected early in the next reporting period. Once approvals are obtained, the team will complete and submit the IRB application, revise the data processing plan, and recruit participants.

7. SPECIAL REPORTING REQUIREMENTS

Nothing to report for this period.