



UTC Semi-Annual Progress Report

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(OST-R)

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Center Director Name, Title, and Contact Information

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North Carolina Agricultural and Technical State University
1601 E. Market Street, Greensboro, NC 27411

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Signature of Submitting Official:

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



NORTH CAROLINA AGRICULTURAL
AND TECHNICAL STATE UNIVERSITY



VirginiaTech
TRANSPORTATION
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EMBRY-RIDDLE
Aeronautical University



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1851

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 educational 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, 2019.

Table 1: Progress of period 4 activities

Research	Status	% Complete
Conduct year 3 research proposal solicitation, review, and award process	Complete	100%
Continue making progress on year 1 projects	Behind schedule	80%
Conduct annual visit to member institutions to obtain research status reports – Year 2	Complete	100%
Conduct year 4 research proposal solicitation, review, and award process	Forthcoming	0%
Conduct annual visit to member institutions to obtain research status reports – Year 3	Behind schedule	0%
Education, Outreach, and Workforce Development Activities		
Conduct 2018 Eisenhower Fellowship recruitment process	Complete	100%
Take students to 2018 Southeastern Region UTC conference	Complete	100%
Take students to 2019 TRB conference	Complete	100%
Develop and conduct Spring 2019 student-to-student K-12 initiative workshops	Complete	100%
Distribute applications for 2019-20 CATM Transportation Scholarship program	Complete	100%
Select 2019-20 CATM Transportation Scholarship program awardees	On schedule	80%
Recruit and select participants for 2019 Summer High School Transportation Institute (STI)	On schedule	70%
Hold 27 th Summer High School Transportation Institute	On schedule	20%

Develop and hold Transportation Awareness Day	On schedule	90%
Implement N.C. A&T Transportation Shark Tank Competition	Behind schedule	0%
Develop transportation case for Fall case competition	Behind schedule	25%
Develop teacher/counselor transportation workshops	Behind schedule	0%
Technology Transfer Activities		
Assist with the 2018 Southeastern Region UTC Conference planning	Complete	100%
Develop and hold the 2 nd Annual CATM Symposium	Complete	100%
Create and distribute Fall 2018 newsletter	Complete	100%
Create and distribute Spring 2019 newsletter	On schedule	90%
Develop and hold the 3 rd Annual CATM Symposium	On schedule	10%
Coordinate with NCDOT to plan and hold the NCDOT Research & Innovation Summit	On schedule	60%
US DOT Reporting Activities		
Complete and submit PPPR#3	Complete	100%
Update Technology Transfer Plan	Complete	100%
Complete and submit 2018 performance indicator report	Complete	100%
Complete and submit SF425 for Q8 and Q9	Complete	100%
Complete and submit recipient share report #2	Complete	100%
Review year 2 final research reports for completed projects	Complete	100%
Upload year 2 final research reports to TRID database	Complete	100%
Update records in RiP database	Behind schedule	50%
Complete and submit PPPR#4	On schedule	80%

What was accomplished under these goals?

Several research, education, outreach, workforce development, and technology transfer activities took place within the CATM consortium during the reporting period. Below is a summary of these activities and associated accomplishments.

Research

Table 2 provides a running list of the year 1, 2, and 3 projects that were active at the beginning of the reporting period along with their current 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 of the projects.

Table 2: Funded projects active during reporting period

Project Title	Status/Award Year	Research Priority Area(s)	Project Link
Automated Last Mile Connectivity for Vulnerable Road Users	Continuing/Y1	IM, RC, PS	https://www.ncat.edu/cobe/transportation-institute/catm/1-last-mile-abstract.pdf
Development, Design, and Calibration of the Vulnerable Road User Mobility Assistance Platform (VRU-MAP)	Continuing/Y1	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/catm_documents/3-vrumap-abstract.pdf
Multi-scale Models for Transportation Systems under Emergency Conditions	Continuing/Y1	IM, RC, TS	https://www.ncat.edu/cobe/transportation-institute/catm/catm_documents/4_2-emergencyabstract.pdf
Analysis of the Non-Driving Mobility Needs of People with Disabilities	Continuing/Y2	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/catm_documents/6-mobilityneedsabstract.pdf

Asymmetric Information Sharing in Dialysis Paratransit Using an Agency Approach	Completed/Y2	IM, PS	https://www.ncat.edu/cobe/transportation-institute/catm/catm_documents/5-paratransit2abstract.pdf
Assessing Pedestrians' Perceptions and Willingness to Interact with Autonomous Vehicles	Completed/Y2	IM	https://www.ncat.edu/cobe/transportation-institute/catm/catm_documents/8-pedestrianperceptionsabstract.pdf
Travelers' Rationality in Anticipatory Online Emergency Response	Continuing/Y2	IM, RC, PS	https://www.ncat.edu/cobe/transportation-institute/catm/catm_documents/7-travelersrationalityabstract.pdf
Particle Dynamics Model for Hurricane Evacuation and Fuel Shortage: Model Based Policy Analysis	Continuing/Y2	IM, RC, PS	https://www.ncat.edu/cobe/transportation-institute/catm/catm_documents/9-particledynamicsabstract.pdf
Multiscale model for hurricane evacuation and fuel shortage	New/Y3	IM, RC, TS	https://www.ncat.edu/cobe/transportation-institute/catm/catm_documents/10-multiscalemodelabstract1.pdf
Real-Time Recommendations for Traffic Control in an Intelligent Transportation System During an Emergency Evacuation	New/Y3	IM, RC	https://www.ncat.edu/cobe/transportation-institute/catm/catm_documents/14-realttimeabstract1.pdf
DRONETIM: Dynamic Routing Of uNmanned-aerial and Emergency Team Incident Management	New/Y3	IM, RC, PS	https://www.ncat.edu/cobe/transportation-institute/catm/catm_documents/12-dronetimabstract1.pdf
VRU-Personalized, Optimum, and Dynamic (POD) Routing	New/Y3	IM	https://www.ncat.edu/cobe/transportation-institute/catm/catm_documents/13-vrupersonalizedabstract1.pdf
Multi-agent Reinforcement Learning-based Pedestrian Dynamics Models for Emergency Evacuation	New/Y3	IM, RC	https://www.ncat.edu/cobe/transportation-institute/catm/catm_documents/11-multiagentabstract1.pdf

IM = Improving mobility of people and goods; RC = Reducing congestion; PS = Promoting safety; ID = Improving durability and extending the life of transportation infrastructure; PE = Preserving the environment; TS = Preserving the existing transportation system

Automated Last Mile Connectivity for Vulnerable Road Users (Last Mile)

The team worked with EasyMile to map multiple autonomous vehicle routes on VTTI's facilities and train a team of VTTI employees to be certified operators of the autonomous vehicle. The mapping and training required several weeks of coordination with EasyMile engineers on site. The research team also developed a survey for local paratransit riders to document their transit needs and began measuring traffic densities and speeds on the road where the Last Mile project will test operation with participants.

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

During the reporting period, the research team worked on improving application functionality, interface, and cross-modality (including developing a functioning prototype on iOS devices), as well as advancing machine learning to improve computer vision. Specific objectives included implementing routing on an outward-facing server, developing crowd-sourced route modifiers, and completing heavy revisions on an iOS implementation with the intention of making iOS the

lead platform for the VRU-MAP application going forward. Many of the objectives were completed, including the crowd-source backend functionality and initial work on the iOS implementation.

Multi-scale Models for Transportation Systems under Emergency Conditions (Emergency)

During the reporting period, researchers conducted a visualization analysis of disruptions due to Hurricane Matthew for air traffic at four airports, developed network optimization models for road restoration problems after a hurricane, and worked on developing and testing a framework that integrates the decision-making models for road restoration and flights rescheduling. In addition, the research team developed decision-making models for the response to regional road restoration and flight rescheduling after a hurricane and developed a framework to integrate these decision-making models.

Analysis of the Non-Driving Mobility Needs of People with Disabilities (Non-Driving Mobility Needs)

All surveys and follow-up interviews were completed during the reporting period. The research team is currently transcribing the interviews for analysis.

Asymmetric Information Sharing in Dialysis Paratransit Using an Agency Approach (Dialysis)

This project was completed in January and the final report was posted on the CATM website. The following is the link to the report which was submitted to the TRID database:

https://www.ncat.edu/cobe/transportation-institute/catm/catm_documents/paratransit2finalreport-dec18.pdf

Assessing Pedestrians' Perceptions and Willingness to Interact with Autonomous Vehicles (Pedestrian Willingness)

This project was completed in January. The findings of this study indicate that, in general, Indian participants are more willing to cross in front of a stopped autonomous vehicle (AV) than Americans, and experience little difference in willingness to cross between the conditions. For Americans, females tended to be significantly less willing to cross in front of a stopped AV than males. This affect was found to be a significant mediator for Americans, specifically fear for males and fear and happiness for females. Participants indicated that they preferred the large textual signal from the AV to indicated that it was safe to cross, and the variables of anger, fear, happiness, surprise, familiarity, fun factor, and wariness of new technology were significant predictors in the statistical model. The final report was posted on the CATM website. The following link to the final report was submitted to the TRID database:

https://www.ncat.edu/cobe/transportation-institute/catm/catm_documents/winterfinalreport-feb19.pdf

Travelers' Rationality in Anticipatory Online Emergency Response (Travelers' Rationality)

During the reporting period, the previous simulation model was tested in different size networks with different scenarios. As a related topic, with the objective of identifying vehicles, the PI received external funds from the NCDOT to identify vehicles on the road potentially for use in emergency management.

Particle Dynamics Model for Hurricane Evacuation and Fuel Shortage: Model Based Policy Analysis (Hurricane Evacuation)

During the reporting period, the research team developed a computational model for fuel shortage based on the SIRS epidemic model and developed an optimal control mathematical model for refueling. The refueling model uses the Bang-Bang Control method and applies a vaccination analogue to assess the best strategies for refueling. In addition, an Anylogic agent-based simulation of highway intersections with six gas stations was performed. One of the major findings of this project during this reporting period is that a control model based on vaccination can be used to estimate refueling levels for minimal evacuation delays during a hurricane evacuation.

Multiscale model for hurricane evacuation and fuel shortage (Multiscale Model)

During the reporting period, the research team began developing strategies for on-the-fly recommendations for fuel storage and supply policy during hurricane evacuations using (1) Gas buddy crowd source data, (b) a control model based on vaccination, and (c) historical evacuation traffic data in FL.

The following projects were initiated in March 2019; therefore, there were no major accomplishments to include for the reporting period:

- Real-Time Recommendations for Traffic Control in an Intelligent Transportation System During an Emergency Evacuation (Real-Time)
- DRONETIM: Dynamic Routing Of uNmanned-aerial and Emergency Team Incident Management (DRONETIM)
- VRU-Personalized, Optimum, and Dynamic (POD) Routing (VRU-Personalized)
- Multi-agent Reinforcement Learning-based Pedestrian Dynamics Models for Emergency Evacuation (Multi-agent)

There was a total of 30 students working as research assistants on projects within CATM 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	4	5	9
Master's	5	3	8
Doctoral	6	7	13
Total	15	15	30

In addition to the research projects currently being funded through the UTC grant, Table 4 lists other transportation research projects that were active during the reporting period and the agencies that fund them. Table 3 includes the students working on these projects as well.

Table 4: Additional transportation research project

Project Title	Funding Agency
Can You Hear It Now? A Study of Personal Listening Devices and Pedestrian Safety	Southeastern Transportation Center
LPA Customer Service Improvement	NCDOT

Education

In addition to the educational activities in which the student research assistants engage during their research projects, several other educational activities took place during the reporting

period. For example, in October 2018, in addition to the students who presented their research (see Figure 1 a), two undergraduate N.C. A&T students attended the University Transportation Center Conference for the Southeastern Region at Clemson University. These students learned from faculty, students, practitioners and public agencies in the southeast about the on-going activities at the Tier 1 UTC's and their plan to further enhance collaboration among the academic community, as well as with the private and public sector agencies in the region.

In November 2018, in addition to the N.C. A&T, VT, and ERAU students who presented their research, six undergraduate N.C. A&T students (Figure 1b) attended the Second Annual CATM Symposium at Virginia Technical Institute along with students, faculty, and researchers from the other consortium institutions - Virginia Tech and Embry-Riddle Aeronautical University. At this symposium the students gained information that was shared about the various activities occurring within UTC program over the previous year. The students got to hear the guest speaker, Mohammed Yousuf, the program manager of US DOT's Accessible Transportation Technologies Research Initiative (ATTRI). The students learned of his work to remove barriers a traveler might encounter on any part of a trip, from the planning stage to arriving at the final destination. His work promotes a new future reality for universal mobility.

In January 2019, seven N.C. A&T students attended the 2019 TRB Meeting with other global transportation professionals including policy makers, administrators, practitioners, researchers, and representatives of government, industry, and academia (Figure 1c). The students gained information about all transportation modes, with more than 5,000 presentations in nearly 800 sessions and workshops, addressing topics of interest to policy makers, administrators, practitioners, researchers, and representatives of government, industry, and academic institutions. Senior CATM scholar and Dwight D. Eisenhower Scholarship recipient, Kayla Jefferson, presented a poster on her research paper titled "Assessing Transportation Barriers to Healthcare Access using Analytic Hierarchy Process Modeling" (Figure 1d).

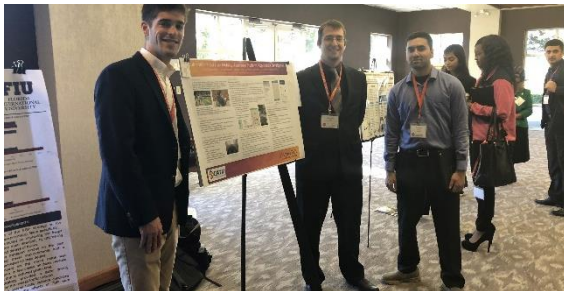


Figure 1: (a: top left) CATM researchers and students at the UTC Conference for the Southeast Region, (b: top right) CATM scholars at the Second Annual CATM Symposium, (c: bottom left) CATM students at the 2019 TRB Annual Meeting, (d: bottom right) Eisenhower Scholar Kayla Jefferson's TBB poster presentation.

CATM supported two graduate and two undergraduate members of the Aggies' Autonomous Auto (A³) team which is representing N.C. A&T State University in the Autodrive Challenge sponsored by GM and SME (Figure 2). During this reporting period, the A³ team placed third in the straight-line challenge among 8 teams from top US and Canadian universities. In the straight-line challenge, the autonomous car developed by the A³ team was required to fully autonomously follow a 2-mile track in the shortest possible time while successfully stopping at stop signs. The next competition is scheduled for May 2019 and it targets enhanced autonomy levels of the self-driving cars such as avoiding dynamic obstacles, safely passing through intersections, navigating challenging road conditions, and performing multiple lane changes.



Figure 2: Aggies Autonomous Auto (A³) team members.

Workforce Development and Outreach

The Student-to-Student Initiative requires N.C. A&T's CATM scholars to visit local high schools to share their transportation/supply chain experiences and career opportunities. One student visited N.C. A&T's Middle College on December 5, 2018 and spoke with 47 high school students. As a result, 29 of those students expressed interest in learning more about the Supply Chain Management major at N.C. A&T. Twenty-three of those students expressed interest in a Supply Chain Management career. On March 15, 2019, three CATM scholars visited Dudley High School and spoke with 23 high school students (see Figure 3). Fifteen of those students were interested in learning more about the Supply Chain Management major and 8 were interested in Supply Chain Management as a career.



Figure 3: CATM students presenting to high school students as part of the Student-to-Student initiative.

The application process for the 2019 Summer High School Transportation Institute (STI) began during this reporting period. The program proposal was submitted in January 2019 and participant applications were distributed to Guilford County high schools in March 2019. In addition, faculty members at ERAU began developing the research internship program for the Gaetz Aerospace Institute high school students. Both of these programs are scheduled to take place in summer 2019.

CATM has teamed up with faculty and staff from the Center for Energy Research and Technology (CERT) to develop a joint Energy Day/Transportation Awareness Day. This event is targeting middle schoolers in Guilford County, North Carolina. Students will have the opportunity to interact with demonstrations and exhibits related to both energy and transportation. Some of the transportation vendors who have already committed resources for this event include the NCDOT, Department of Homeland Security, Greensboro Transit Authority, Triad Aviation Academy, and the UNC Highway Safety Research Center. The event is scheduled to take place on April 9, 2019.

Technology Transfer

The 2nd Annual CATM Symposium took place at VTTI on November 5, 2018 (Figure 4). The keynote speaker for the symposium was Mohammed Youseuf, program manager for the Accessible Transportation Technologies Research Initiative (ATTRI) within the Federal Highway Administration's Office of Operations and Research & Development. The progress that has been made for each CATM funded research project was presented at the symposium along with the education and workforce development initiatives that took place over the last year.



Figure 4: 2nd Annual CATM Symposium. Pictured from left to right: Jon Antin, Mohammed Youseuf, Andy Alden, Dahai Liu.

CATM staff submitted a proposal to host the first NCDOT Research & Innovation Summit during the reporting period. The proposal was awarded and planning was initiated in January 2019. The summit is scheduled to take place on Tuesday, May 7, 2019 at the Alumni-Foundation Event Center on the campus N.C. A&T State University from 8:30 am to 5:30 pm. The purpose of this summit is to bring together transportation professionals from the public sector (federal, state, and local), private sector, and academia to discuss innovative research and ideas that address transportation-related issues.

What opportunities for training and professional development has the program provided?

The primary training and professional development activities that took place during the reporting period occurred within the individual research teams. For instance, in the Travelers' Rationality project team, student researchers engaged in Transmodeler transportation simulator software training sessions to learn how to utilize the technology for their research project. In addition to the training research associates are receiving from their research advisors, graduate students working on the Multiscale Model project interacted with undergraduate and high school students to educate them on the research process. Elements of the DRONETIM project were used as a case example in a graduate level computational science and engineering course focused on transportation (CSE 885) in the spring semester. Students in this same class also learned about fixed and flexible public transit as well as the discrete choice modeling route planning approach for pedestrians, which are both components of the VRU-Personalized project. Two students involved in the VRU-Personalized project finished their term projects which will be further developed to TRB2020 submission. Additionally, as part of the operator certification process, VTTI personnel learned how to educate riders about the vehicle's capabilities. VTTI will include this information in the protocols for educating paratransit users as part of the Last Mile project.

Have the results been disseminated?

In addition to the conference papers and presentations provided in the Outputs section of this report, the following is a list of dissemination activities that took place for individual research projects during the reporting period.

- Researchers from each project presented their studies at the 2nd Annual CATM Symposium in November 2018.
- Results of the Hurricane Evacuation project were communicated via a Florida TV news report and news articles.
- The Multiscale Model project was discussed in a news article in an ERAU college news letter sent to industry and alumni.
- A one-page project description on the Emergency project was submitted for the Annual UTC Report to Congress.
- A poster for the Emergency project was submitted for the UTC Spotlight conference.
- The final reports for the Pedestrian Willingness and Dialysis projects were posted to the CATM website and the links were sent to the TRID database.

- Information about the CATM activities were communicated to various stakeholders through the N.C. A&T Transportation Institute/CATM Fall 2018 electronic newsletter, CATM Facebook page, and the CATM website.
- The EasyMile Autonomous Shuttle was displayed at the grand opening of VTTI's "Automation Hub" facility. Visitors from the local community as well as VA State Agency representatives viewed the shuttle and learned more about its use in the Last Mile project.

In addition, brochures and applications for the 2019 Summer High School Transportation Institute (STI) were disseminated through the guidance counselor offices at all of the schools within the targeted counties around Greensboro, NC. The application and brochure were also available for anyone to download from the Transportation Institute website. Hardcopies were available in the Transportation Institute office.

The CATM and Eisenhower scholarship opportunities were emailed to N.C. A&T supply chain management students in March. Announcements were placed on the N.C. A&T electronic communications network in the College of Business and Economics' buildings and hard copies were made available in the Transportation Institute office.

CATM Symposium save-the-date and registration notifications were sent out to key stakeholders in October 2018 and NCDOT Research & Innovation Summit save-the-date and registration cards were sent out to a targeted group of over 500 North Carolina transportation researchers and practitioners in individuals in March 2019.

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.
- Collect and review quarterly research progress reports to gauge the need for mitigation or contingency plans.
- Hold CATM's first Transportation Awareness Day.
- Host the NCDOT Research & Innovation Summit.
- Prepare RFP for Year 4 internal grant competition.
- Review and post final reports for completed projects.
- Hold N.C. A&T's 27th Summer High School Transportation Institute.
- Select the 2019-20 Eisenhower Fellowship Scholars.
- Select the 2019-20 TRB Fellowship Scholars.
- Select 2019-20 CATM Scholars.
- Organize the 3rd Annual CATM Symposium.
- Participate in the 2019 UTC Conference for the Southeastern Region.
- Create the Fall 2019 newsletter.
- Conduct transportation industry and research laboratory visits for students.
- Continuously update the CATM website and social media outlets with newsworthy information.
- Select case for Transportation Case Competition.
- Plan N.C. A&T Transportation Shark Tank Competition.

2. PARTICIPANTS & COLLABORATING ORGANIZATIONS:

Organizations that have been involved as partners

Not including the center staff at N.C. A&T and the various students involved in CATM activities, Table 5 provides a list of the individuals who have been involved in the center activities as partners during the reporting period and their associated organizations.

Table 5: List of partners

Organization Name	Organization Location	*Partner's Contribution to the Project	Name (First and Last)	Partner University
Dept. of Economics	Greensboro, NC	Collaborative Research	Ryoichi Sakano, Ph.D.	N.C. A&T
Dept. of Marketing, Transportation, and Supply Chain	Greensboro, NC	Collaborative Research	Omar Woodham, Ph.D.	N.C. A&T
Dept. of Management	Greensboro, NC	Collaborative Research	Mary Lind, Ph.D. & Rhonda Hensley, Ph.D.	N.C. A&T
Dept. of Industrial and Systems Engineering	Greensboro, NC	Collaborative Research	Xiuli Qu, Ph.D.; Lauren Davis, Ph.D.; & Younho Seong, Ph.D.	N.C. A&T
Dept. of Computational Science and Engineering	Greensboro, NC	Collaborative Research	Hyoshin (John) Park, Ph.D.	N.C. A&T
Dept. of Electrical and Computer Engineering	Greensboro, NC	Collaborative Research	Ali Karimoddini, Ph.D. & Abdollah Homaifar, Ph.D.	N.C. A&T
Dept. of Mechanical Engineering	Greensboro, NC	Collaborative Research	Sun Yi, Ph.D.	N.C. A&T
Virginia Tech Transportation Institute	Blacksburg, VA	Facilities	Jon Antin, Ph.D.	Virginia Tech
Virginia Tech Transportation Institute	Blacksburg, VA	Collaborative Research	Andrew Alden, Ph.D.; Kevin Grove, Ph.D.; Justin Owens; Andrew Miller; & Erin Mabry, Ph.D.	Virginia Tech
Dept. of Human Development	Blacksburg, VA	Collaborative Research	Carolyn Shivers	Virginia Tech
Institute for Transportation Research and Education (ITRE)	Raleigh, NC	Financial Support, Collaborative Research	James Martin, P.E. & Brittany Gaustad	N.C. State University
Dept. of Psychology	Birmingham, AL	Collaborative Research	David Schwebel, Ph.D. & Despina Stavrinou, Ph.D.	UAB - Birmingham
Dept. of Graduate Studies, College of Aviation	Daytona Beach, FL	Collaborative Research	Dahai Liu, Ph.D.; Jennifer Thropp, Ph.D.; & Scott Winter, Ph.D.	ERAU
Dept. of Aerospace Engineering	Daytona Beach, FL	Collaborative Research	Namilae Sirish, Ph.D.	ERAU
Civil Engineering	Daytona Beach, FL	Collaborative Research	Scott Parr	ERAU
Aerospace Engineering	Daytona Beach, FL	Collaborative Research	Richard Prazenica	ERAU

Blacksburg Transit	Blacksburg, VA	Collaborative Research	Tim Witten	
EasyMile	Denver, CO	Collaborative Research	Lauren Isaac	

Other collaborators or contacts involved

Drs. Ahren Johnston, Laquanda Leaven-Johnson, and Joseph Huscroft served as the Dwight D. Eisenhower Transportation Fellowship faculty research mentors for the N.C. A&T Eisenhower Fellows. Dr. Mohammed Yousuf of the Turner-Fairbank Highway Research Center was the keynote speaker for the 2nd Annual CATM Symposium and Dr. Miguel Perez of the Virginia Tech Safe-D National UTC also spoke at the symposium. Additionally, the Dialysis project team has contacted and collaborated with individuals at more than 13 North Carolina county transit offices and dialysis clinics as well as the North Carolina Public Transportation Authority.

Researchers associated with the Travelers’ Rationality project have been communicating with Ali Haghani who is affiliated with Morgan State University’s Urban Mobility and Equity Center. Haghani has been developing an emergency management strategy to match and complement CATM’s emergency management research. They plan to propose a connected vehicle-based emergency management project idea to their UTC.

The Non-Driving Mobility Need research team worked with a number of disability advocacy organizations to disseminate their survey, including Autism Speaks, the National Organization on Disability, the National Foundation for the Blind, among others. The Last Mile research team collaborated with Blacksburg Transit to get their assistance with identifying and recruiting paratransit users to participate in the Last Mile research project.

CATM researchers, Jon Antin, Andy Alden, John Park, Kevin Grove, Justin Owens, and Mary Lind collaborated with Nancy Brossoie of VT, EasyMile, Blacksburg Transit, Warm Hearth Village, TransDev, and VDOT on a \$5M FHWA Automated Driving Systems grant proposal. In addition, Andy Alden of VTTI collaborated with John Park of N.C. A&T on three proposals - two related to use of unmanned aerial vehicles for support of ground traffic operations including emergency vehicles and one on the implementation of low speed autonomous vehicles in a retirement community to link with nearby transit and other important destinations such as health care facilities. Jon Antin collaborated on a separate CATM proposal with John Park of N.C. A&T.

3. OUTPUTS:

The major outputs that are expected to result from the activities within CATM include the development of an assistive technology for VRUs, the development of an optimization model to support emergency related decision-making processes, and design recommendations to improve human safety when interacting with automated vehicles. While the major studies that contribute to these outputs have not yet been completed, the research activities summarized in the Accomplishments section illustrate the progress that has been made. In addition, the following subsections provide references to documented evidence of this progress.

Publications, conference papers, and presentations

The following is a list of products associated with the CATM activities.

Journals

- Namilae, S. Multiscale model for hurricane fuel shortage, PLOS One (under review).
- Park, H., Waddell, D., Haghani, A. Online emergency vehicle dispatching with look-ahead on a transportation network. Transportation Research Part C: Emerging Technologies. Accepted with Minor Revision. Acknowledged federal support.
- Park, H., et al., Travelers' rationality in anticipatory online emergency response, in preparation to be submitted to Transportation Research Part A: Policy and Practice. Acknowledged federal support.
- Park, H., Haghani, A., Gao, S., Knodler, M.A., Samuel, S. (2018). Anticipatory sensor location problem in connected vehicle environment. Transportation Science. 52 (6), 1299-1326. December. Acknowledged federal support.
- Yu, X., Gao, S., Hu, X., and Park, H. A Markov Decision Process Approach to Vacant Taxi Routing with E-hailing. Transportation Research Part B: Methodological, 121, 114-134, 2019 published. Acknowledged federal support.

Conference Papers and Presentations

- Alden, A. (2018). Automated Vehicles and Weather. Presented at the American Meteorological Summit, Washington, DC, October 23, 2018.
- Chilukuri, D., Yi, S. & Seong, Y. (2018). Computer vision for VRUs. Poster presented at the 6th Annual University Transportation Centers Conference for the Southeastern Region, Clemson, SC. Acknowledged federal support.
- Chilukuri, D., Yi, S. & Seong, Y. (2018). Computer vision for VRUs. Poster presented at the 2nd Annual CATM Symposium, Blacksburg, VA. Acknowledged federal support.
- Danisewicz, J., Ibrahim, F., Singh, S., Miller, A. & Owens, J.M. (2018). Vulnerable Road User Mobility Assistance Platform: Application Development. Poster presented at the 6th Annual University Transportation Centers Conference for the Southeastern Region, Clemson, SC. Acknowledged federal support.
- Danisewicz, J., Ibrahim, F., Singh, S., Miller, A. & Owens, J.M. (2018). Vulnerable Road User Mobility Assistance Platform: Application Development. Poster presented at the 2nd Annual CATM Symposium, Blacksburg, VA. Acknowledged federal support.
- Glass C, Davis L, and Qu X, (2018). Visualizing the Impact of Severe Weather Disruptions to Air Transportation, Proceedings of the 2018 IEEE International Conference on Big Data, Dec 10-13, Seattle, Washington. Acknowledged federal support.
- Islam, S., Namilae, S., Liu, D. (2018). Is hurricane fuel shortage an epidemic? Analysis of data from Hurricane Irma and Hurricane Florence. SE UTC Conference, Clemson, SC, October 24, 2018. Acknowledged federal support.
- Islam, S., Namilae, S., Liu, D. (2018). Particle Dynamics Model for Hurricane Evacuation and Fuel Shortage: Model Based Policy Analysis. Presentation at the 2nd CATM Symposium, Blacksburg, VA, November 5, 2018. Acknowledged federal support.
- Lind, M. (2018). Asymmetric Information Sharing in Dialysis Paratransit Using an Agency Approach. Presentation at the 49th Annual Meeting of the Decision Sciences Institute, Chicago, IL, November 14, 2018. Acknowledged federal support.
- Mhatre S, Qu X, and Davis L, (Accepted). A MILP model for road restoration after a natural disaster, accepted by the 2019 IISE (Institute of Industrial and Systems Engineers) Annual Research Conference, May 19-22, Orlando, Florida. Acknowledged federal support.
- Miller, A., Owens, J.M., Seong, Y., & Yi, S. (2018). Project Update: Vulnerable Road User Mobility Assistance Platform. Talk presented at the 6th Annual University Transportation Centers Conference for the Southeastern Region, Clemson, SC. Acknowledged federal support.

- Milner, M. N., Winter, S. R., Rice, S., Rice, C., Ragbir, N., & Baugh, B. (Accepted). Identifying influencing factors affecting pedestrians' willingness to interact with driverless vehicles. Presentation at the 10th International Conference on Applied Human Factors and Ergonomics, Washington, D.C. Acknowledged federal support.
- Namilae, S. (2018). Is Hurricane Fuel Shortage an Epidemic? Poster presentation at the 2nd CATM Symposium, Blacksburg, VA, November 5, 2018. Acknowledged federal support.
- Owens, J.M., Miller, A., Seong, Y., & Yi, S. (2018). Project Update: Vulnerable Road User Mobility Assistance Platform. Talk presented at the 2nd Annual CATM Symposium, Blacksburg, VA. Acknowledged federal support.
- Park, H. (2019). Sensor Deployment for Reduction of Arterial Traffic Congestion. The 98th Annual Meeting of TRB2019, #19-04832. Presented and published. Acknowledged federal support.
- Park, H., Haghani, A. (Accepted). Connected Vehicle Sensor Location Model for Traffic Congestion Mitigation, Tenth Triennial Symposium on Transportation Analysis, Hamilton Island, Australia, June 17-21, 2019. Acknowledged federal support.
- Park, H., Haghani, A. (2019). Stochastic Dynamic Sensor Location Problem with Efficient Solutions. Under review, The 98th Annual Meeting of TRB2019, #19-04783. Presented and published. Acknowledged federal support.
- Pugh, N., Park, H. (Accepted) Morning Peak Hour Speed Prediction using Deep Learning Neural Networks, IEEE SoutheastCon 2019, Huntsville, AL, April 11-14, 2019. Acknowledged federal support.
- Pugh, N., Park, H. (Accepted). Prediction of Secondary Crash Likelihood considering Incident Duration using High Order Markov Model, IEEE SoutheastCon 2019, Huntsville, AL, April 11-14, 2019. Acknowledged federal support.
- Shivers, C., Owens, J.M., & Miller, A. (2018). Project Update: Analysis of the Non-Driving Mobility Needs of People with Disabilities. Talk presented at the 2nd Annual CATM Symposium, Blacksburg, VA. Acknowledged federal support.
- Waddell, D., Pugh, N, Park, H. (2019). Visualization-based Dynamic Dispatching of First Responders. The 98th Annual Meeting of TRB2019, #19-05569. Presented and published. Acknowledged federal support.
- Waddell, D., Pugh, N., Shirzad, K., Park, H. (2019). Simulation-Based Optimization of Emergency Response Considering Rationality of Travelers. The 98th Annual Meeting of TRB2019, #19-05975. Presented and published. Acknowledged federal support.

Books and Non-Periodical, One-Time Publications

- Nothing to report

Websites or other internet material

- CATM Website: <https://www.ncat.edu/cobe/transportation-institute/catm/index.php>
- CATM Facebook Page: <https://www.facebook.com/NCATCATM/>
- STI Facebook Page: <https://www.facebook.com/groups/627756624232070/>
- Webpages where STI program information is provided:

<https://www.ncat.edu/cobe/transportation-institute/files/pdfs/stibrochure2020ada.pdf>

<https://www.ncat.edu/cobe/transportation-institute/summer-high-school-transportation-institute.php>

Technologies or techniques

- A computational model for fuel shortage based on SIRS epidemic model - Shared through publications.

Inventions, patent applications, and/or licenses

- Nothing to report

Other products

Software

- Matlab codes of the particle dynamics computational model for hurricane evacuation and fuel shortage

4. OUTCOMES:

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

- Last Mile project: The acquisition, setup, mapping, and training required to make the EasyMile shuttle operational has given the team an understanding of the difficulties in testing autonomous shuttle technologies. These issues with testing are amplified for real-world deployments in more complex environments.
- Emergency project: The students working on this project have gained a better understanding of the importance of transportation systems and the impact a natural disaster can have on transportation systems.
- Non-Driving Mobility Needs project: This project is significantly improving understanding of the transportation barriers that people with disabilities face when they move through the world, as well as opportunities for improvement in the transportation of people with disabilities.
- Dialysis project: The results have demonstrated the need for better scheduling for paratransit services in small and rural counties of North Carolina.
- Pedestrian Willingness project: The findings have provided extensive results on pedestrian's willingness to interact with autonomous vehicles and the factors that predict which type of person is willing to interact with driverless vehicles. Please refer to the final report posted in the Research section of the CATM website for further details.
- Hurricane Evacuation project: The computational model developed as a part of this work demonstrates how crowd-sourced data from the Gas buddy platform can be used for on-the-fly predictions.
- DRONETIM project: The results of this project will provide the framework to apply the resulting model to catastrophic emergency scenarios (e.g., hurricane) where traffic sensors are not working properly and more UAVs assistance is required.
- Student-to-Student initiative: Through this initiative, high school students are made aware of various types of transportation-related issues and the many career opportunities in the transportation field designed to address these issues.

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:

- Last Mile project: The research is expected to identify gaps in ADA current guidance, which did not consider driverless automated vehicles when issued. The research is also

expected to identify new policies which could facilitate testing and deployment of automated shuttle technologies in the future.

- DRONETIM project: This project will result in a new generation of UAV-guided Emergency Response Vehicle (ERV) Routing. This innovative application of UAVs to look ahead for potential routes in which ERVs can pass safely and promptly will likely call for the development of new policies regulating the use of UAVs.

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

- Last Mile project: The project will result in documentation on how hands-on experience with automated technology can impact user attitudes and acceptance and how vulnerable road users prefer to utilize an autonomous shuttle.
- Emergency project: This project is providing decision-making models for road restoration and flight rescheduling for disaster management.
- Pedestrian Willingness project: We have a better understanding of what type of individuals are likely to be willing to interact with driverless vehicles, their preferences between driverless and autonomous vehicles from a pedestrian point of view, and the types of signals they would prefer to receive from a driverless vehicle.
- DRONETIM project: This work has increased knowledge of traffic operation, resource allocation, and non-recurrent congestion mitigation.

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

- Emergency project: The optimization models developed for airline recovery and road restoration can improve the effectiveness and efficiency of response activities in local and regional transportation systems during and after a hurricane.
- Non-Driving Mobility Needs project: The outcome of this project will be used to influence and guide the complementary VRU-MAP project whose team is working to develop a customizable navigation system for people with disabilities.
- DRONETIM project: This research aims to improve efficiency of emergency operations by developing principled methods that determine the most important areas to explore based on the role of the UAVs and ERVs. The role of the UAV in the heterogeneous vehicle-team is to explore unknown traffic conditions, unexpected situations on roads and compensate already known information from loop detectors, automatic vehicle identification detectors, probe vehicle data, and other types of sensors. Once the traffic information center provides such information, the information collected from the UAV will enable ERVs to go through a roadway with reduced obstacles. The role of the ERVs is to coordinate their local decision-making processes to provide a theoretical guarantee on global solution quality under conditions of limited resources.

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

- Research projects: All research projects in which students are engaged are serving as training grounds for future professionals in the transportation domain. The researchers working on these projects have an ongoing commitment to recruit and teach talented undergraduate and graduate students who graduate and transfer their knowledge and lessons learned into the transportation work environment.
- Symposium: This event created a medium whereby CATM research ideas were shared with other researchers, graduate students, and undergraduate students.

- Student-to-Student initiative: The student presentations are designed to inform high school students of the career opportunities in the transportation field and encourage them to seek transportation-related degrees.

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

- Last Mile project: The team’s research may lead to best practices in training and outreach on automated vehicles.
- DRONETIM project: Unmanned aerial and ground vehicle coordination has been developed during this project.

Table 6 contains the center-specific performance measures for outcome, 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	0
Outcome #3	Automated vehicle design guidelines based on an increased understanding and awareness of human perceptions of and interactions with automated vehicles	Number of human factors guideline documents published	2	0
Outcome #4	Dissemination of research results through presentations, publications, conference papers, and technical reports	Number of presentations and workshops given	6	18
		Number of peer-reviewed journal papers published	2	4
		Number of newsletter articles, conference papers, and technical reports published	10	10

5. IMPACTS:

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

Emergency project: The optimization models developed for airline recovery and road restoration will improve the effectiveness and efficiency of response activities in local and regional transportation systems during and after a hurricane. Deploying effective response activities to a hurricane can improve the mobility of people and disaster relief efforts during and after a hurricane.

Travelers' Rationality project: Traditional allocation decisions of freeway emergency resources only focus on serving the current emergency and have ignored which future emergency will be occurring. A criterion of no-information about the future input is often too pessimistic. It does not involve full computation of optimal strategies. More importantly, it is not learning the "true model" considering how other decisions would actually influence payoffs. Compared to a scheduling problem, irrevocable decisions need to be made along the way in emergency situations. As a result, previous emergency resource allocation studies have been limited to 1) assuming independency between emergencies; 2) making myopic decisions; 3) only focusing on optimal systems; and 4) neglecting individual traveler's behavior in response to unexpected events. This project overcomes these limitations so that more robust emergency resource allocation decisions can be made.

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 research outcomes of this project are expected to eventually lead to commercialization of technology to better assist vulnerable road users as they navigate through the built environment via a customizable routing application.

Non-Driving Mobility Needs project: The resulting data will support the targeting of features and capabilities of the VRU-MAP application, which will eventually be made publicly available to the community of people with disabilities.

Pedestrian Willingness project: The findings from this series of studies may help manufacturers and government agencies establish policy as they work to integrate driverless vehicles into the current transportation system, with a specific focus on their interaction with pedestrians.

Travelers' Rationality project: Using the look-ahead concept, the online model is likely to have an impact on emergency operators' decision making by flexibly recomputing the solution and basing future decisions on present requests. After having served a designated request, the available and/or remaining vehicles will be relocated to a new base for the next emergency.

Hurricane Evacuation: The refueling model can provide guidance to practitioners regarding apportioning fuel supply to different areas.

What is the impact on the body of scientific knowledge?

VRU-MAP project: The research results, in cooperation with the findings of the complementary disability survey project, will have a positive impact on the base of knowledge of the barriers faced by people with disabilities as they navigate through the world. These results will be primarily in the field of psychology but can and will be applied to the engineering domain as well as through the development of navigational countermeasures to these barriers.

Emergency project: This work will provide quantitative tools for decision-making of road restoration and flight rescheduling in emergency situations.

Non-Driving Mobility Needs project: The findings of this study will make a substantial impact on the base of knowledge of the needs of and opportunities facing the wide community of people with disabilities as they attempt to navigate the environment.

Travelers' Rationality project: This research will impact discrete choice-based routing, choice modeling, and emergency operator dispatching optimization modeling. Additionally, this research focuses on the travelers' behavior perspective based on each dispatching decision. This research will have a significant impact on dispatching decisions related to travelers' decision-making but will assume that the output resulting from travelers' decision-making processes will have no influence on the control action of emergency resources.

Hurricane Evacuation project: A new approach to modeling fuel shortages based on epidemic modeling and control theory is expected to come out of this work.

What is the impact on transportation workforce development?

Emergency project: Four graduate students (2 females, 2 males) and one female undergraduate student have been involved in the project. Working on this project prepares them with a better understanding of the importance of transportation systems and the impact of a natural disaster on transportation systems.

VRU-MAP project: Researchers associated with this project continue to offer hands-on educational experience to undergraduate and graduate students, including many students who are members of gender and/or ethnic minority groups.

Non-Driving Mobility Needs project: This project has provided hands-on opportunities for multiple undergraduate students to conduct surveys and interviews of disadvantaged people to better understand their transportation needs.

Travelers' Rationality project: This research was used in an example of transportation class for following topics: 1. Agent-based modeling, 2. Traffic management, 3. Crash analysis, and 4. Bottleneck analysis.

Student-to-Student initiative: In this program, high school students are given information from current CATM scholars and Supply Chain Management majors. The sessions increase awareness about transportation and supply chain management degree programs and what they entail along with transportation scholarship opportunities. They also are made aware of the many transportation and supply chain management career opportunities. High School teachers at these sessions gain this same knowledge and are able to share with other teachers and other

students. This is also a great recruiting mechanism for the Summer High School Transportation Institute.

Table 7 contains the center-specific performance measures for outcome, 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	1 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	1 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	0

6. CHANGES/PROBLEMS:

Progress for some projects were delayed slightly due to the late distribution of the Year 3 funding. In addition, two- to four- month no-cost extensions were granted for several projects this reporting period due to equipment acquisition issues, student hiring delays, and participant recruitment issues.

7. SPECIAL REPORTING REQUIREMENTS

Nothing to report for this period.