



Semi-Annual Progress Report No. 8 – Urban Mobility & Equity Center

Submitted to: U.S. Department of Transportation
Office of the Assistant Secretary for Research and Technology

Grant Number 69A3551747123
Project Title: Urban Mobility & Equity Center

*Morgan State University (Lead Institution)
Virginia Polytechnic Institute and State University
University of Maryland*

Program Director: Dr. Mansoureh Jeihani
443-885-1873

Submitting Official: Same as above

Submission Date: April 30, 2023

DUNS#: 879941318
EIN#: 52-6002033

Recipient Organization: Morgan State University
1700 E. Cold Spring Lane
Baltimore, MD 21251

Recipient Identifying Number
or Account Number, if any: 69A43551747123

Grant Period: 11/30/16 to 9/30/23
Reporting Period End Date: March 31, 2023
Report Term: Semi-annual. This report covers Oct. 1, 2022, March 31, 2023.

Signature:

A handwritten signature in black ink that reads "M. Jeihani". The signature is written in a cursive style with a long, sweeping underline.

1. ACCOMPLISHMENTS.

What was done? What was learned?

1.1 What are the major goals and objectives of the program?

The major goal of UMEC is to improve the mobility of people and goods in urban communities in a safe, environmentally sustainable, and equitable manner and to formulate new technologies, policies, and practices aimed at mobility. An increasingly important facet of UMEC's research is investigating how automated and connected vehicles will contribute to this goal, and how equity concerns will be addressed amid these technological changes.

1.2 What was accomplished under these goals?

Below is a chart listing all 53 UMEC projects.

Thirty two have been completed and are listed in green type. Final reports for these projects are available on our website, www.morgan.edu/umec, and they have been submitted to the appropriate databases.

As we conclude the final year of the grant, we anticipate robust sixth-year projects from our researchers. In the previous five years, these projects have provided students with valuable opportunities for research, helping shape the future transportation workforce. Through this research, students have also gained insight into the changing technologies and challenges endemic to urban transportation, especially with regards to equity.

Project Type/ University	Project Name	PIs
Core-MSU	Advanced Mobility for People with Disability: Autonomous Wheelchair Pilot Deployment at the BWI	Mansoureh Jiehani, Kofi Nyarko, Eazaz Sadeghvaziri, Cynthia Glass
Core-VT	Two-Dimensional Modeling of Bicycle Behavior	Hesham Rakha, Karim Fadhoun
Core-VT	Changes of Bikeshare and Other Non-Automobile Modes of Transportation During The COVID	Jianhe Du, Hesham Rakha
Core-VT	Optimization of Vehicle Trajectories Considering Uncertainty in the Vicinity of Actuated Traffic Signals	Hesham Rakha, Amr Shafik, Seifelddeen Eteifa

Core-VT	Quantifying the Impact of C-V2x on Transportation system Efficiency, Energy and Environment	Hesham Rakha, KyoungHo Ahn
Core-UMD	Development of an Intelligent Tool for Assessing the benefits of Highway Safety Improvement Projects	Gang-Len Chang
Core-UMD	Integrated Mobility Services	Paul Schonfeld
Core-MSU	Investigating Walking and Biking Activities Among Low-Income Americans	Eazaz Sadeghvaziri, Mansoureh Jeihani
Collaborative-UMD, VT	Analysis of Interrelated Network Improvement Alternatives	Paul Schonfeld Hesham Rakha
Collaborative-UMD, VT	Fare Free Public Transportation: A full-scale real-world experiment in Alexandria, Virginia	Cinzia Cirillo, Hesham Rakha
Collaborative-VT, MSU	Optimum Connected Vehicle Speed Control on Signalized Roadways in Mixed Flow	Hao Chen, Hesham Rakha, Mansoureh Jeihani, Eazaz Sadeghvaziri
Collaborative-MSU, UMD	User Preference Analysis for Mobility-as-a-Service (MaaS) and Its Impact in Maryland	Young-Jae Lee, Hyeon-Shic Shin, Paul Schonfeld
Core-MSU	The Typology of Transportation Accessibility: A Qualitative and Quantitative Meta-Analysis	Hyeon-Shic Shin
Core-MSU	Integrated Optimal Transit Network Design with MaaS Implementation	Young-Jae Lee
Core-VT	Impact of COVID-19 on Ridehailing and Other Modes of Transportation	Jianhe Du, Hesham Rakha

Core-VT	Estimating switching times of Actuated Coordinated Traffic Signals: A deep learning approach	Hesham Rakha, Seifeldeen Eteifa
Core-VT	Developing an Intelligent Connected Vehicle based Traffic State Estimator	Hesham Rakha, Ahmed Abdelrahman, Hossam Abdelghaffar
Collaborative – UMD, MSU	EQUITABLE COMPLETE STREETS: Data and Methods for Optimal Design Implementation	Cinzia Cirillo, Mansoureh Jeihani, Paul Schonfeld
Collaborative – VT, MSU	Integrated Optimization of Vehicle Speed Control and Traffic Signal Timing: System Development and Testing	Hao Chen, Hesham Rakha, Mansoureh Jeihani
Collaborative – VT, MSU	Bicyclist Longitudinal Motion Modeling	Hesham Rakha, Karim Fadhioun, Mansoureh Jeihani
Collaborative – MSU, UMD	A Comparative Study of Pedestrian Crossing Behavior and Safety in Baltimore and Washington, D.C., Using Video Surveillance	Celeste Chavis, Kofi Nyarko, Cinzia Cirillo
Core-UMD	Multi-depot and Multi-school bus Scheduling Problem with School Bell Time Optimization	Ali Haghani
Core-UMD	Adoption and Diffusion of Electric Vehicles in Maryland	Cinzia Cirillo
Core-MSU	The Effect of COVID-19 on Mobility and Equity: A Case Study on Transit Users in Baltimore, MD	Mansoureh Jeihani, Celeste Chavis
Core-VT	Estimating Traffic Stream Density Using Connected Vehicle Data	Hesham A. Rakha, Hossam M. Abdelghaffar
Core-VT	A Study of the Impact of Ridesharing on Public Transit Ridership	Hesham Rakha, Jianhe Du
Core-UMD	Optimized Development of Urban Transportation Networks 2.0	Paul Schonfeld
Core-UMD	How Mobility and Accessibility Affect Crime Rates: Insights from Mobile Device Location Data	Lei Zhang

Collaborative –UMD, MSU	Equity in Accessibility to Opportunities: Insights, Measures, and Solutions based on Mobile Device Location Data	Chenfeng Xiong, Hyeon-Shic Shin
Collaborative – MSU, UMD	Investigating the Effect of Connected Vehicles (CV) Route Guidance on Mobility and Equity	Mansoureh Jeihani, Ali Haghani, Anita Jones
Collaborative – MSU, UMD	E-Bikes Effect on Mode and Route Choice: A Case Study of Richmond, Va., Bikeshare	Celeste Chavis, Vanessa Frias-Martinez
Collaborative – VT, MSU	Developing and Testing an Advanced Hybrid Electric Vehicle Eco-Cooperative Adaptive Cruise Control System at Multiple Signalized Intersections (Short title: EcoCACC for HEVs)	Hao Chen, Hesham Rakha, Mansoureh Jeihani
Core – MSU	Developing Optimal Peer-to-Peer Ridesharing Strategies	Young-Jae Lee, Amirreza Nickkar
Core – VT	Energy Efficient Transportation Modeling	Hesham Rakha
Core – MSU	Optimal Automated Demand Responsive Feeder Transit Operation and Its Impact	Young-Jae Lee, Amirreza Nickkar
Core – UMD	Dynamic (Time Dependent) Green Vehicle Routing Problem	Ali Haghani, Golnush Masghati Amoli, Moschoula Pternea
Core – UMD	Evaluating Equity Issues for Managed Lanes: Methods for Analysis and Empirical Results	Cinzia Cirillo
Core – MSU	Investigating the Impact of Distracted Driving Among Different Socio-Demographic Groups (formerly Hands on Wheel, Eyes on Road)	Mansoureh Jeihani

Core – VT	Traffic State Prediction: A Traveler Equity and Multi-model Perspective	Hesham Rakha
Core – VT	Development of Multimodal Traffic Signal Control	Hesham Rakha Kyoungho Ahn
Core – MSU	Understanding Access to Grocery Stores in Food Deserts in Baltimore City	Celeste Chavis, Anita Jones
Core – UMD	Optimized Development of Urban Transportation Networks	Paul Schonfeld
Collaborative – UMD, MSU	Optimization of Emergency Traffic Patrols (ETP) Operations	Ali Haghani, Mansoureh Jeihani
Collaborative – VT, MSU	Developing and Testing an ECO-Cooperative Adaptive Cruise Control System for Buses	Hesham Rakha, Hao Chen, Mansoureh Jeihani
Core – MSU	Driver's Interactions with Advanced Vehicles in Various Traffic Mixes and Flows (autonomous and connected vehicles (ACVs) electric vehicles (EVs), V2X, trucks, bicycles and pedestrians) - Phase I: Driver Behavior Study and Parameters Estimation	Mansoureh Jeihani
Core – VT	Developing a Connected Vehicle Transit Signal Priority System	Kyoungho Ahn, Hesham Rakha, Hossam Abdelghaffar
Collaborative – MSU, UMD	Innovative Methods for Delivering Fresh Foods to Underserved Populations	Hyeon-Shic Shin, Young-Jae Lee, Paul Schonfeld
Collaborative – MSU, UMD	Shared Bus/Bike Lane Safety Analysis: Assessing Multimodal Access and Conflicts	Celeste Chavis, Cinzia Cirillo
Core – MSU	Sustainable Design of Concrete Bus Pads to Improve Mobility in Baltimore City	Mehdi Shokouhian , Kadir Aslan

Core – UMD	Managing the Impacts of Different CV/AV Penetration Rates on Recurrent Freeway Congestion from the Perspective of Traffic Management	Gang-Len Chang
Collaborative – UMD, MSU	E3: Evaluating Equity in Evacuation: A Practical Tool and A Case Study	Cinzia Cirillo, Celeste Chavis
Collaborative – VT, UMD	Developing an Eco-Cooperative Adaptive Cruise Control System for Electric Vehicles	Hao Che Hesham Rakha, Cinzia Cirillo
Collaborative – VT, MSU	Improving Public School Bus Operations: Boston Case Study	Youssef Bichiou, Hesham Rakha, Young-Jae Lee, William Eger

1.3 How have the results been disseminated?

When projects are complete, the reports are submitted to various databases and posted online. We also email a one-page fact sheet summarizing research to our mailing list of 535 people, including researchers, elected officials and journalists. For some projects, we create a brief video and send out the link to the mailing list. We also email an annual newsletter listing all projects. Click here to read [the Spring 2023 newsletter from the National Transportation Center](#).

- MDOT Connected Automated Vehicle Working Group Presentation**
 As part of the MDOT’s Connected and Automated Vehicle Working Group, UMEC Director Mansoureh Jeihani has been deeply involved with ongoing discussions around connected and automated vehicle implementation in Maryland and beyond. These conversations with government and industry leaders have often focused on applications of CAV technology to benefit vulnerable road users like cyclists and pedestrians. She presented Morgan’s progress in this area, gave a demo of the Morgan’s facilities, and served on a panel of experts from industry, government, and academia that discussed CAV technology applications for Vulnerable Road Users.
- Radio Interview with WTOP**
 The Director of UMEC spoke with WTOP news radio to discuss the work being done by the Urban Mobility & Equity Center, the scope of its research, and its partnership with the USDOT, MDOT and other affiliate organizations.
- Interview with Technical.ly**
 UMEC Director Mansoureh Jeihani sat down with reporter Matthew Liptak to discuss our partnership with the USDOT and the implications of Connected and Automated vehicle proliferation. Public sentiment around the topic of automated vehicles has grown rapidly

in recent years as artificial intelligence technology has gone mainstream. Transportation is no different in this respect, and UMEC researchers have been illustrating how these developments can improve safety and reduce fuel consumption through their research and outreach efforts.

- **NTC simulator test used to evaluate cannabis-impaired driving in Frederick MD**
National Transportation Center researchers have worked closely with law enforcement agencies in Frederick Maryland to develop simulator tools that can safely assess how travelers under the influence of cannabis drive in a simulated environment. These tests are especially relevant with recreational cannabis becoming legal in Maryland later this year. Using the simulator, investigators found that cannabis users experienced a significant decline in motor skills despite their perceptions of increased awareness among participants.
- **UMEC Research referenced in WI Shared Bus/Bike Lane Report**
Transportation Research published by UMEC researchers have informed recent efforts by analysts and policymakers in Milwaukee, WI to adopt shared bus/bike lanes in their downtown area. The cited paper, “Shared Bus-Bike Lane Safety Analysis: Assessing Multimodal Access and Conflicts,” finds that proper bus/bike lane implementation in major urban centers can improve the safety and mobility of travelers by diversifying transit options.
- **Gas Prices Features in the New York Times and NBC News**
NTC Director Mansoureh Jiehani spoke with reporters at NBC News and the New York Times to discuss the unique psychological impact that gas prices have on American consumers in the context of public transit, highlighting the specific limitations of the US transportation system. With few alternatives to cars for medium- and long-distance trips, traveling invariably becomes more expensive when gas prices go up. Gas prices also act as a signal for future inflation across most sectors of the economy, as rising transit costs for various goods and services are passed on to consumers.
- **CBS News Baltimore Segment**
CBS News Baltimore visited the National Transportation Center this month to discuss the Center’s ongoing research and the challenges women in STEM fields experience with Director Mansoureh Jiehani. Dr. Jiehani has led the NTC since 2020 and is the first woman to serve as Director. [The interview](#) was held at the NTC’s Safety and Behavioral Analysis Lab, where students and researchers have been using the facility’s state-of-the-art testing equipment to evaluate work zone practices, distracted driving behavior, and other topics in transportation safety.
- **Presentations at the Transportation Research Board Annual Meeting**
UMEC researchers have been recognized for their high-quality scholarship at the Transportation Research Board (TRB) Annual Meeting, where scientists in the field have the opportunity to share their findings with industry, the public, and each other. This year, one UMEC researcher won the Outstanding Graduate Poster Presentation award, and another was selected to present at the TRB Bike Committee meeting. UMEC hosts two TRB minority fellows.
- **WBAL News Segment**
A recent [news segment](#) on WBAL TV highlighted the Center’s ongoing research activities regarding LIDAR systems that are being installed on Morgan State University’s campus and shuttle systems. The report followed recent news of a \$15 million grant

given to the National Transportation Center and featured interviews with UMEC staff and PhD candidates.

- **GRC Virtual Funding Summit, “How Campuses Can Engage with the DOT”**
UMEC researchers have discussed the University Transportation Center organizational model with other researchers and universities to discuss how they can navigate the research, education, grant application and technology transfer processes. The discussion focused on the recent Infrastructure Investment and Jobs Act and how programs within the law can be leveraged to promote transportation research.
- **Interest from Maryland Transit Caucus Regarding Public Transit Accessibility**
Legislators in the Maryland Transit Caucus have expressed interest in forthcoming results from **Fare Free Public Transportation: A full-scale real-world experiment in Alexandria (VA)**. Lawmakers may be willing to implement similar state-backed programs pending successful implementation of the program in Virginia.
- **FMCSA Administrator Forum**
Researchers at UMEC participated in a closed 1-hour discussion with Robin Hutchinson, Administrator of the Federal Motor Carrier Safety Administration, covering the latest developments in motor carrier transit research, including recent scholarship designed to evaluate highway work zone practices. Researchers discussed findings from two ongoing UMEC research projects conducted in partnership with the FMCSA: “A Comprehensive Study on CMV Safety Using ITS in-Work Zones on Freeways and Arterials,” and “CMV Safety Countermeasures using Telematics and Driving Simulator Data.”

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

Most of the ongoing UMEC projects will be completed. Their final reports will be submitted to the appropriate journals and research databases. Projects developing innovative technologies will also file for patents. Finally, this information will be shared with both the public and other transportation professionals, and UMEC researchers will continue sharing their findings at conferences and webinars.

2. PARTICIPANTS AND COLLABORATING ORGANIZATIONS. Who has been involved?

2.1 What organizations have been involved as partners?

The Maryland Aviation administration has collaborated with UMEC to implement the Autonomous Wheelchair being developed by researchers at Morgan State University at the Baltimore-Washington Thurgood Marshall Airport.

Cube Root, Inc. provided consulting services and video data to train pedestrian detection algorithms being developed by UMEC Researchers.

The Maryland Department of Transportation’s Highway Safety Office has collaborated with UMEC to develop technologies and best practices that can improve traffic safety along the state’s highways.

UMEC has partnered with Cambridge Systematics to craft proposals for the USDOT's National Cooperative Highway Research Program and Transit Cooperative Research Program.

The Center has worked closely with the Federal Motor Carrier Safety Administration to improve safety for travelers, particularly with respect to advanced collision warning systems and work zone practices.

UMEC is working with several firms to implement its Mixed Traffic CAV Testbed. Ouster is working with our research team to install LIDAR units at intersections around campus while Iteris is installing on-board units inside of Morgan State University's shuttles.

2.2 Have other collaborators or contacts been involved?

Dr. Young-Jae Lee is an Associate Editor for the KSCE Journal of Civil Engineering as well as for Urban Rail Transit. He was a guest editor for a special issue in July of the Journal of Advanced Transportation; the issue is Advanced Data Intelligence Theory and Practice in Transport. He also serves on the TRB Standing Committee on Automated Transit Systems (AP040) and is a member of the SAE International Shared and Digital Mobility Committee as well as being a member of the Maryland Strategic Highway Safety Plan and the Maryland CAV working group.

Dr. Celeste Chavis is a:

Member, Transit Research Analysis Committee (TRAC), Transportation Research Board, 2018 – Present (national)

Member, Federal Highway Administration (FHWA) Transportation Innovation Education Stakeholders (TIES), 2020 – Present (national)

A member of three Transportation Research Board committees, (Bicycle, Equity in Transportation, Innovative Public Transportation Services & Technologies) (national)

Board Member, Central Maryland Transportation Alliance, 2018 – Present (regional)

Member, Complete Streets Equity Workgroup, Baltimore City Department of Transportation, 2017-2019 (regional)

Board Member, Public Advisory Committee (PAC) of the Baltimore Regional Transportation Board (BRTB), 2017 – Present (regional)

Dr. Mansoureh Jeihani is:

Chair of Strategy 3 for the Highway Safety Strategic Plan.

Member, Maryland Connected and Autonomous Vehicle Working Group (CAV-WG)

Co-Chair, CAV-WG technical group

Member, Maryland Quality Initiative

Member of the Transportation Research Board committee on Artificial Intelligence and Advanced Computing Applications

Member, editorial board of the Journal of Traffic and Logistics Engineering.

Member, National Cooperative Highway Research Program (NCHRP) Panel - Transportation Research Board, 2019-Present

Member, Behavioral Traffic Safety Cooperative Research Program (BTSCR) Panel – Transportation Research Board, 2023-Present

Dr. Eazaz Sadeghvaziri, Postdoctoral Research Associate, is a new member of the Standing Committee on Rural, Intercity Bus, and Specialized Transportation

Ramina Javid, PhD student is a new member of the Standing Committee on Rural, Intercity Bus, and Specialized Transportation

3 OUTPUTS: What new research, technology or process has the program produced?

- The ongoing development of the **Integrated Automated Wheelchair and Adapted Automated Vehicle System** has yielded promising results for wheelchair-bound individuals and their caretakers. In partnership with Baltimore-Washington International Thurgood Marshall Airport, the research team at Morgan State University has launched a pilot program aimed at improving the mobility and independence of travelers using these devices. This technology was further demonstrated during Transportation Secretary Buttigieg’s visit to the MSU campus in April of 2022.

3.1 Conference papers and presentations

- Javid, R., “Identifying Transit Deserts in Baltimore City: Equity Analysis Using GIS,” *2023 GIS For Transportation Symposium*, Oklahoma City, OK, April 2023. **Winner of Student Paper Contest.**
- Ansaryar, A., Ardeshiri, A., Vaziri, E., Jeihani, M., “Investigating the Traffic Behavior of Bicyclists in Interaction with Car Users on Shared Bike Lanes Without Physical Barriers”, *102nd Transportation Research Board Annual Meeting*, Washington, D.C., January 2023.
- Javid, R., Vaziri, E., Jeihani, M., “A Bayesian Network Model to Prevent Distracted Driving”, *102nd Transportation Research Board Annual Meeting*, Washington, D.C., January 2023.
- Khadem, N., Kabir, M., Jeihani, M., Anderson, N., and Ardeshiri, A., “Identifying Safest Complete Street Design: A Driving Simulator”, *102nd Transportation Research Board Annual Meeting*, Washington, D.C., January 2023.
- Taylor, E., Chavis, C., and Jeihani, M., “Bicycle and Pedestrian Traffic Around Baltimore City Parks During COVID-19”, *102nd Transportation Research Board Annual Meeting*, Washington, D.C., January 2023. **Winner of Graduate Poster Presentation**

- Javid, R., Vaziri, E., Jeihani, M., “Active Transportation for Underrepresented Populations: A Systematic Review of the Literature”, *102nd Transportation Research Board Annual Meeting*, Washington, D.C., January 2023.
- Vaziri, E., Javid, R., Jeihani, M., “Exploring the Socio-demographic Characteristics of Bicycle Trip Makers,” *102nd Transportation Research Board Annual Meeting*, Washington, D.C., January 2023.
- Findings from the ongoing UMEC Project, “**A Comparative Study of Pedestrian Crossing Behavior and Safety in Baltimore and Washington, DC Using Video Surveillance**” were presented at the 2022 ITE International Annual Meeting and Exhibition in New Orleans, Louisiana
- Dr. Young-Jae Lee presented findings from **Integrated Optimal Transit Network Design with MaaS Design** as the keynote speaker for the 2022 International Conference for Road Engineers hosted by the Korean Society of Road Engineers

3.2 Journal publications

- A. K. Shafik, S. Eteifa and H. A. Rakha, "Optimization of Vehicle Trajectories Considering Uncertainty in Actuated Traffic Signal Timings," in *IEEE Transactions on Intelligent Transportation Systems*, doi: 10.1109/TITS.2023.3253424.
- Du, J.; Ahn, K.; Farag, M.; Rakha, H. Impacts of Vehicle-to-Everything Enabled Applications: Literature Review of Existing Studies. *Computer Networks and Communications* 2023, 1(1), 116–146.
- Farag, M.M.G.; Rakha, H.A. Development and Evaluation of a Cellular Vehicle-to-Everything Enabled Energy-Efficient Dynamic Routing Application. *Sensors* 2023, 23, 2314. <https://doi.org/10.3390/s23042314>
- Chavis, Celeste; Bhuyan, Istiak; Cirillo, Cinzia, “Shared Bus-Bike Lane Safety Analysis: Assessing Multimodal Access and Conflicts,” *Urban Mobility & Equity Center, Repository & Open Access Science Portal*, July 1, 2022.
- Sadeghvaziri, Eazaz; Javid, Ramina; Jeihani, Mansoureh, “Investigating Walking and Biking Activities Among Low Income African Americans,” *Urban Mobility & Equity Center, Repository & Open Access Science Portal*, March 3, 2023
- Shafik, Amr; Eteifa, Seifeldeen; Rakha, Hesham, “Optimal Trajectory Planning Algorithm for Connected and Autonomous Vehicles Towards Uncertainty of Actuated Traffic Signals,” *Urban Mobility & Equity Center, Repository & Open Access Science Portal*, April 2023
- Rakha, Hesham; Fadhloun, Karim, “Two-Dimensional Modeling of Bicycle Behavior,” *Urban Mobility & Equity Center, Repository & Open Access Science Portal*, January 2023

3.3 Websites or other Internet sites

- www.morgan.edu/umec. The Urban Mobility and Equity Center’s website hosts all of the institution’s completed and ongoing research projects, complete with one-page fact sheets and detailed descriptions related to the relevant investigators’ aims and findings. The site also contains an wide array of information about the Center’s staff, facilities, and workforce development initiatives.

- [LinkedIn](#) 150 (followers)
- [Twitter](#) (91 followers)
- [Facebook](#)
- [YouTube](#)

3.4 Technologies or techniques

- Researchers at Morgan State University developed autonomous wheelchair technology as part of **Advanced Mobility for People with Disabilities: Autonomous Wheelchair Pilot Deployment at the BWI**. The research team retrofitted a traditional powered wheelchair with sensors, cameras, and Arduino interactive electronics software to make it move and navigate its environment autonomously. It is worth noting that the wheelchair made use of technologies that were previously developed for use in connected autonomous vehicles, demonstrating the broad applications these tools may have in the future. The device will allow users to traverse crowded complex environments without the need of an attendant.
- UMEC has established a **Mixed Traffic Connected and Automated Vehicles (CAV) Testbed** at Morgan State to develop innovations related to CAVs in an urban environment. Two intersections have been equipped with Roadside Units, CCTVs, and LiDARs to record the movement of every object passing through the intersections, generating a substantial amount of data. The research team has been working with contractors to install on-board units inside several of the university's campus shuttles. The testbed received the **I-Start Technology Award** from Morgan State's Office of Technology transfer in 2023.
- UMEC Researchers at Morgan State University have developed a methodology for selecting intersections with which to analyze pedestrian behavior using multivariate clustering techniques on **A Comparative Study of Pedestrian Crossing Behavior and Safety in Baltimore and Washington, D.C., Using Video Surveillance**. Researchers also found a novel method of implementing perspective transformation from OpenCV library to project points from the image plane into GPS coordinate space.
- The CAV applications being developed in **Optimum Connected Vehicle Speed Control on Signalized Roadways in Mixed Flow** partially consist of a manual mode controller which enables human drivers to follow simple driving instructions to pass signalized intersections with less energy consumption and delay. Moreover, the automated mode controller being developed can help CAVs achieve even more savings by following energy-optimized trajectories more precisely.
- A model developed in **Optimization of Vehicle Trajectories Considering Uncertainty in the Vicinity of Actuated Traffic Signals** applies innovations in CAV technologies to optimize vehicle trajectories near actuated traffic signal controllers for greater fuel efficiency. The algorithm being used shows great promise in balancing the needs of traffic mobility and sustainability, particularly in high-traffic environments. These technologies can also be applied to traditional vehicles in the form of prompts, as discussed in section 5.
- **Development of an Intelligent Tool for Assessing the benefits of Highway Safety Improvement Projects** will see the development of an AI-based system designed to

assist transportation engineers in selecting the most effective measures to improve intersection safety. The tool applies knowledge of the key factors contributing to intersection accidents and make use of the best practices used by senior engineers to guide less-experienced transportation professionals' decision-making processes.

- Models being developed in **Integrated Mobility Services** are designed to analyze, evaluate, and coordinate public transportation services in a simulated environment in order to optimize them for greater connectivity, thereby improving mobility for transit users.

3.6 Inventions, patent applications and/or licenses

- US Patent # 17885080, [Autonomous Mobility System](#)
- US Patent # 11565711, [System and Method for Generating Vehicle Speed Alerts](#)

4 OUTCOMES. What outcomes has the program produced? How are the research outputs described in section 3 above being used to create outcomes?

- Findings from **Integrated Optimal Transit Network Design with MaaS Design** have provided a blueprint for developers and policymakers to implement the emerging Mobility-as-a-service concept to increase the efficiency and equity of public transit systems by integrating different public transit modes in a convenient, cost-effective way.
- Research conducted in **Changes in Bikeshare and Other Non-Automobile Modes of Transportation During Covid-19** has investigated the evolving role of non-motorized modes of transportation during and after Covid-induced lockdowns. The findings from the study suggest the critical role these modes, particularly bikeshare, can play in improving the sustainability and efficiency of public transit networks. This is especially relevant in first- and last- mile travels, where bicycles have a significant ability to complement public bus and rail networks.

5. IMPACTS. What is the impact of the programs/ How has it contributed to improve the transportation system: safety, reliability, durability, etc.; transportation education; and the workforce?

- Nearly all UMEC projects have enlisted the contributions of graduate students to conduct high-quality research, training a new generation of transportation scholars and practitioners with the knowledge and experience needed to implement technologies that are rapidly changing the field, such as autonomous vehicles and advanced driving simulators.
- The UMEC Project, **Advanced Mobility for People with Disabilities: Autonomous Wheelchair Pilot Deployment at the BWI**, has provided students from diverse academic backgrounds to collaborate on a novel technology with practical benefits for disabled travelers. Researchers are now developing the fourth iteration of the autonomous wheelchair, expanding the machine's capabilities in preparation for the launch of the pilot

program at BWI airport in the coming months. UMEC was awarded **the Innovation Award in Physical Science** by the Morgan State University Office of Technology Transfer for the development of the Autonomous Wheelchair in 2022.

- The **Mixed-Traffic CAV Testbed** will serve as the foundation of an innovation center that aims to attract public and private sector researchers and test advanced driving system applications in real-world conditions. The high-resolution transportation data generated from this testbed will not only benefit the campus but also Baltimore City and the Maryland Department of Transportation (MDOT). The applications of such a testbed will enhance safety and mobility on campus and within the Morgan Community Mile.
- Connected and Autonomous vehicles have the potential to significantly reduce fuel consumption by calibrating vehicle speeds with traffic infrastructure. Researchers working on **Optimum Connected Vehicle Speed Control on Signalized Roadways in Mixed Flow** are actively exploring how CAVs can communicate with traffic signals and surrounding vehicles to optimize their movement for sustainability and throughput. The similar technologies are also being applied to traditional vehicles, wherein drivers are prompted to change their speed in accordance with the timing of traffic signals to improve efficiency.
- Systems being developed in **Analysis of Interrelated Network Improvement Alternatives** are being used to identify, optimize, and simulate improvements to regional transportation networks in order to improve efficiency and sustainability. These improvements include transportation projects like additional road and rail links, widened transit links, and the implementation of exclusive bus lanes. Moreover, these systems will consider other variables when making recommendations, such as future demand and budgetary constraints. Graduate students have played integral roles in shaping the optimization and simulation models used in this program.
- **Development of an Intelligent Tool for Assessing the benefits of Highway Safety Improvement Projects** has the potential to dramatically improve roadway engineering practices, and in turn, safety, by providing engineers with a tool to identify hazards in their design. This will be an excellent tool for students as they become acquainted with best practices with respect to safety and will save lives by avoiding collisions with the environment or other vehicles.
- **The Effect of Covid-19 on Mobility and Equity: A Case Study of Transit Users in Baltimore, MD** similarly evaluated how different regions and socio-demographic groups changed their transportation practices in response to the pandemic by comparing public transit ridership data. Early findings suggest that ridership patterns could permanently change as a result of the mass adoption of telework, and that changes in ridership over time vary considerably between those of different professions.

5.1 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?

- The project **A Comparative Study of Pedestrian Crossing Behavior and Safety in Baltimore and Washington, D.C., Using Video Surveillance** adopted two different CV algorithms for better accuracy for object detection and tracking and used Region of Interest (ROI) to determine the pedestrian crossing for jaywalking a.

- A startup tech company has expressed interest in developing a work zone safety app based on UMEC designs. The app will provide motor carrier drivers with advanced warning and re-routing information as they approach work zones.

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

- **Integrated Optimal Transit Network Design with MaaS Implementation** is exploring how the emerging Mobility-as-a-Service transportation paradigm can improve mobility, accessibility, and sustainability while working within existing transit frameworks. By facilitating tighter connections between mass transit platforms like buses and rail, new micro-mobility options like scooters and bikeshare can provide efficient travel alternatives to cars, especially in urban areas.
- **Impact of COVID-19 on Ridehailing and other Modes of Transportation** has identified significant increases in the use of bikeshare during and after the pandemic, with important data collected on typical bikeshare routes and duration of usage. This data can inform developers and policymakers who wish to promote bikeshare as a connecting mode between public transit hubs.
- **Fare-Free Public Transportation: A Full-Scale Real-World Experiment in Alexandria, VA** is applying advanced survey methods to determine if free public transportation can increase ridership and facilitate greater access to jobs and other opportunities, particularly for low-income riders. This data can inform policymakers' cost-benefit analyses when implementing public transportation programs.
- Researchers on **Quantifying the Impact of C-V2X on Transportation System Efficiency, Energy and Environment** are currently evaluating the role that Connected Vehicle Technology can play in improving air quality and fuel consumption on a system-wide level.

5.3 What is the impact on transportation workforce development?

Beyond UMEC's ongoing train and provide valuable experience for graduate students in the transportation field, the Center continues to develop the professional development of the transportation workforce through its robust internship and transportation programs. UMEC's parent institution, the National Transportation Center, boasts a 30-year internship program with the Maryland Department of Transportation as well as a longstanding commitment to educating young people through the National Summer Transportation Institute.

- **A Comparative Study of Pedestrian Crossing Behavior and Safety in Baltimore and Washington, DC Using Video Surveillance** was included in the 2021 Smart City Research Experience for Undergraduates and Teachers training program at Morgan State University funded by the National Science Foundation.
- Students from Electrical Engineering and Transportation programs at MSU have been learning hands on how to build a robotic/autonomous vehicle in **Advanced Mobility for People with Disabilities: Autonomous Wheelchair Pilot Deployment at the BWI**

6 CHANGES/PROBLEMS.

6.1 Changes in approach and reasons for change.

Nothing to report.

6.2 Actual or anticipated problems or delays and actions or plans to resolve them.

The project **A Comparative Study of Pedestrian Crossing Behavior and Safety in Baltimore and Washington, D.C., Using Video Surveillance** has experienced delays on account of trouble with duplicate IDs for the GPS tracking algorithm. Researchers are in turn updating the algorithm to YOLO v.7, with the intention of completing the project by June 2023.

6.3 Changes that have a significant impact on expenditures.

Nothing to report.

6.4 Significant changes in use or care of human subjects, vertebrate animals, and/or biohazards.

Nothing to report.

6.5 Change of primary performance site location from that originally proposed

Collaboration with Cube Root, Inc. has allowed researchers to add more survey locations with a greater focus on data collection efforts in Baltimore, MD in **A Comparative Study of Pedestrian Crossing Behavior and Safety in Baltimore and Washington, D.C., Using Video Surveillance**.

7. SPECIAL REPORTING REQUIREMENTS

All of our completed research projects – indicated in green in the table at the beginning of this report – have been submitted to the following databases: research.hub@dot.gov, NTLDigitalSubmissions@dot.gov, TRIS-TRB@nas.edu, and the Transportation Library at Northwestern University, The Volpe National Transportation Systems Center, the Federal Highway Administration Research Library and the National Technical Information Service.

Research projects conducted in Maryland are also submitted to MD-SOAR, a statewide repository.