Semi-Annual Progress Report No. 7 – Urban Mobility & Equity Center

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

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- VT	Advanced Mobility for People with Disability: Autonomous Wheelchair Pilot Deployment at the BWI	Mansoureh Jeihani, Kofi Nyarko, Eazaz Sadeghvaziri, Cynthia Glass
Core-VT	Two-Dimensional Modeling of Bicycle Behavior	Hesham Rakha, Karim Fadhloun
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, Seifeldeen 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 – VT, MSU	Investigating the Effect of Connected Vehicles (CV) Route Guidance on Mobility and Equity	Mansoureh Jeihani, Ali Haghani, Anita Jones
Collaborative – UMD, MSU	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. Here is the Fall 2021 newsletter from the National Transportation Center, which houses UMEC and includes details about UMEC research and programs. https://issuu.com/morganstateu/docs/fall_ntc_newsletter_pages?fr=sN2EwMjI5MDk3ODE

- **NSTI Program Overview Anecdotes (Youtube):** Several members of the Urban Mobility and Equity Center lent their voices to the National Summer Transportation Institute during a series of interviews outlining the Institutes's Program Overview. UMEC Director Mansoureh Jeihani and former UMEC Education Coordinator Quenia Harley-Burkeen discussed the opportunities that students in the program were given to gain experience working with regional transportation agencies and develop critical skills that would allow them to pursue satisfying careers in the transportation sector.
- **NSTI 25th Annual Award Banquet:** The National Summer Transportation Institute celebrated its 25th anniversary in 2022. The annual banquet provided the opportunity to reflect on the program's successes over the years, featuring speeches from past students and a keynote presentation from Maryland Secretary of Transportation Jim Ports.
- **Maryland Quality Initiative Panel**: UMEC Director Mansoureh Jeihani participated in a panel on the adoption of Connected and Automated Vehicle (CAV) technology hosted by the Maryland Quality Initiative. The panel brought together voices from academia, industry, and the public sector to discuss how these emerging technologies can be

implemented across the state, both in pilot programs and full-scale deployment initiatives.

- **Equity in Transportation Research Funding Webinar:** In June 2022, UMEC Director Mansoureh Jeihani spoke at a webinar hosted by the US Department of Transportation titled, "Equity in Transportation Research and Funding Opportunities." The program focused on implementing principles of equity into the transportation research and funding process by considering how various projects impact underserved communities.
- **Visit from US Transportation Secretary Pete Buttigieg:** US Secretary of Transportation visited Morgan State University as the National Transportation Center celebrated 30 years of innovation in the transportation field. During his stay, secretary Buttigieg viewed a demonstration of the Automated Wheelchair currently being developed by UMEC researchers in partnership with the Baltimore-Washington Thurgood Marshall Airport. The demonstration showcased how wheelchair bound users could use the technology to exercise more autonomy and mobility as they move through the country's busy transit hubs and beyond.
- **Department of Energy Justice Week Panel:** Dr. Mansoureh Jeihani spoke at a roundtable focused on diverse entrepreneurship and the role of minority serving institutions within the energy sector. The discussion explored how stakeholders can more actively engage underserved groups as the country enters a pivotal green energy transition.
- **Occupant Protection Technologies Webinar Series:** UMEC researchers hosted two webinars discussing the latest developments in occupant protection technologies in April and September of 2022, respectively. The first webinar focused on technological innovations and safety features marketed towards the general public, including pedestrian detection systems and collision warnings. The second webinar discussed recent technological developments that aimed to expand accessibility and convenience for disabled travelers using transportation services. These ranged from vehicle modifications and visual displays to smartphone apps connecting disabled travelers to essential services.
- **102nd Transportation Research Board Conference Presentations:** Each of the conference papers referenced in Section 3.3 of this report will be presented at the 102nd Transportation Research Board Conference in January 2023. UMEC Researchers will share the findings elicited from their studies with other transportation research professionals and discuss the implications they have on developments in equity and emerging technologies in the transportation field.

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 with the public and other transportation professionals, with many UMEC researchers 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.

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

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 Publications, conference papers and presentations

- 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

- Jeihani M., & Haghani A. (2022) Investigating the Effects of Connected Vehicles (CV) Route Guidance on Mobility and Equity. *Transportation Research Board.*
- Haghani, A. (2022). Multi-depot and Multi-school bus Scheduling Problem with School Bell Time Optimization. *Transportation Research Board*
- Rakha, H., Abdelrahman, A., Abdelghaffar, H. (2022) Developing an Intelligent Vehicle-based Traffic State Estimator. *Transportation Research Board*
- Chen, H.**,** Rakha H., Jeihani M. (2022) Integrated Optimization of Vehicle Speed Control and Traffic Signal Timing: System Development and Testing
- Rakha H., Abdelrahman A., Abdelghaffar, H. (2022) Impact of COVID-19 on Ridehailing and Other Modes of Transportation

3.3 Conference Papers

- 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.
- 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.
- 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.

3.4 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
We added a LinkedIn page this year and we have 118 followers.
www.twitter.com/NTCMorgan
Our twitter account has about 88 followers
Instagram: ntcumec (https://www.instagram.com/ntcumec/).
We have 65 followers on Instagram.

YouTube: https://www.youtube.com/channel/UCQ4GSAlNdKTKz6qhWqH1hQA
We anticipate focusing more on using videos to promote our research.

3.5 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 principal investigators 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 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.
- **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-experiences transportation professionals' decision-making processes.

3.6 Inventions, patent applications and/or licenses

Integrated Automated Wheelchair and Adapted Automated Vehicle System, M. Jeihani, E. Sadeghvaziri, K. Nyarko, A. Ardeshiri, Walker, N., 08/10/2022

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 **Investigating Walking and Biking Activities Among Low-Income African Americans** has provided valuable insight into the sociodemographic variables affecting non-motorized transportation usage. These findings offer significant

considerations for improving equity in transportation and implementing targeted development strategies designed to benefit those who need it most.

- **Two Dimensional Modeling of Bicycle Behavior** presents a comprehensive investigation of the traffic flow dynamics exhibited by bicycles, drawing on naturalistic cycling data. This research promises to improve further research and development planning with respect to bicycle use by allowing for more accurate modeling of bicycle motion through space and time.
- 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.
- 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.
- Several UMEC projects have made valuable contributions to the transportation field with respect to incorporating principles of equity into transportation research and development practices. **Equitable Complete Streets: Data and Methods for Optimal Design Implementation** provides meaningful conclusions about the practical application of the Complete Street paradigm, an approach to transportation network development which considers the needs of all road users, regardless of income-level, disability, or car-ownership status.
- Moreover, the project, **Investigating the Effect of Connected Vehicles on Mobility and Equity** illustrates the how the consequences of connected vehicle implementation will effect different segments of the population based on their accessibility and degree of market saturation.
- **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 implementation.
- UMEC researchers have made invaluable contributions to technologies now being commercialized by RYG Light LLC. One of which is a work zone safety application used to help both contractors and commercial road users navigate through work zones safely. Another is an automated transit operation methodology used to optimally transport goods and people on a system-wide level, making use of bus, rideshare, and other forms of transportation.

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

- **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 also 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.
- Findings from **Quantifying the Impact of C-V2X on Transportation System Efficiency, Energy and Environment** is 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.

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 January 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.