



Program Progress Performance Report (PPPR) No. 2 – Urban Mobility & Equity Center

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Office of the Assistant Secretary for Research and Technology

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Project Title: Urban Mobility & Equity Center

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

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Signature:

1. ACCOMPLISHMENTS

UMEC now has 15 research projects underway and is finalizing plans for a second year of summer programs designed to increase workforce development.

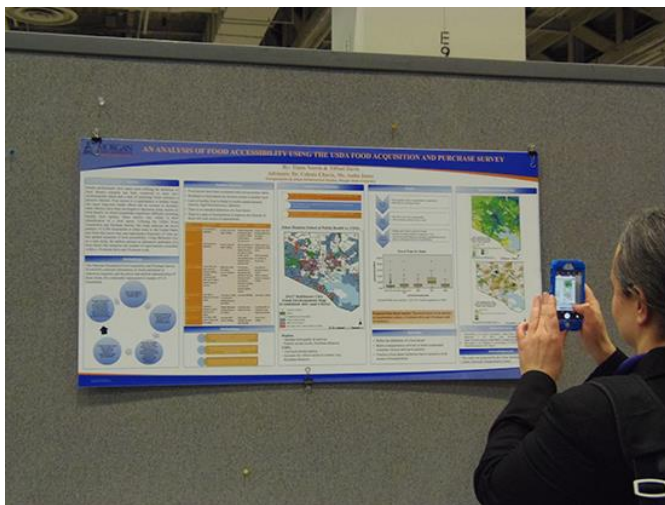
1.1 What are the major goals and objectives?

The Urban Mobility & Equity Center (UMEC) at Morgan State University's National Transportation Center (NTC) focuses its research on the urban mobility of people and goods while also identifying the ways in which mobility affects equity and sustainability. The research, which likely will influence public policy, also develops methods, such as algorithms, that create new efficiencies in transportation systems.

UMEC supports research centered on three themes:

- ◆ Transit, paratransit, and freight planning and operations to improve mobility, access and cost efficiency;
- ◆ Buyer acceptance, affordability and government promotion of connected and automated vehicles;
- ◆ Distribution of transportation costs and benefits, including equity of user fees and taxes that fund infrastructure and services.

UMEC provides utilizable technical assistance and nurtures the next generation of transportation professionals through educational and community outreach projects and programs.



*A poster presentation that was part of the project **Understanding Access to Grocery Stores in Food Deserts in Baltimore City** garnered interest at the Transportation Research Board's annual meeting.*

UMEC's emphasis on public interest research and technical assistance is already having an impact. UMEC-affiliated faculty from two research projects met with a community organization focusing on food deserts. Their research will provide answers to questions the community – and others – have asked, as well as metrics useful to community advocates and stores that might consider locating in a food desert. One project,

Innovative Methods for Delivering Fresh Foods to Underserved Populations, is expected to yield greatly improved methods for developing transportation networks. Applications of the method developed in this project are not limited to transportation, but will advance the state of the art in other disciplines such as project management and engineering economics. The other project, **Understanding Access to Grocery Stores in Food Deserts in Baltimore City**, establishes new metrics for food deserts and determines how people who live in them access grocery stores. A poster presentation at TRB generated quite a bit of interest in the project.

Just as individual researchers are always thinking about their next research project, UMEC is focusing on creating the next generation of researchers and transportation professionals. Internship opportunities, engagement programs with secondary school students and teachers, and connections with regional highway administrative bodies are just some of the ways the next generation is cultivated.

1.2 What was accomplished under these goals?

- Our research projects dovetail with the four priorities cited in the U.S. Department of Transportation Strategic Plan for FY 2018-2022, namely, Safety, Infrastructure, Innovation and Accountability. For example, two projects, **Hands on Wheel, Eyes on Road** and **Optimization of Emergency Traffic Patrols**, contribute knowledge needed to increase safety. Since even a minor crash can quickly cause traffic to snarl, reducing crashes and enhancing incident response improves urban mobility.



*An eye-tracking system used in conjunction with a driving simulator determines precisely how long a drivers' eyes are off the road when they text or use an app, part of the **Hands on Wheel, Eyes on Road** research project.*

The **Hands on Wheel, Eyes on Road** project, funded in cooperation with the Maryland Department of Transportation State Highway Administration, will create a Public Service Announcement about distracted driving and an educational video to be shown in Maryland's high schools and colleges. A video promoting the project is on You Tube:

<https://www.youtube.com/watch?v=35Uao14K01k&t=8s>. **Optimization of Emergency Traffic Patrols** will create an important tool to allocate patrol resources in a cost-effective manner during incidents such as crashes, road debris and stalled vehicles.

- With the distribution of second-year funds, 11 core research projects, funded from base funds, are underway as are four collaborative projects that competed for funding. (See chart below.) The process of soliciting and evaluating proposals for the second round of collaborative projects is underway.

| Project Name | Principle Investigator(s) | University | Subject Areas |
|---|--|--|--|
| (Projects in shaded area have been added since the previous PPPR.) | | | |
| Managing the Impacts of Different CV/AV Penetration Rates on Recurrent Freeway Congestion from the Perspective of Traffic Management | Dr. Gang-Len Chang | University of Maryland | Freeway traffic control, autonomous vehicles |
| Sustainable Design of Concrete Bus Pads to Improve Mobility in Baltimore City | Dr. Monique Head Dr. Mehdi Shokouhian | Morgan State University Morgan State University | Concrete bus pads; sustainability; wheel axle loads; reinforcement; transportation; structural concrete design |
| Evaluating Equity Issue for Managed Lanes: Methods for Analysis and Empirical Results | Dr. Cinzia Cirillo | University of Maryland | Road Pricing, Behavioral models for HOT and HOV lanes, Equity Measurements and Appraisal |
| Drivers' | Dr. Mansoureh | Morgan | Autonomous and connected vehicles, |

| | | | |
|--|---|--|--|
| 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 Parameter Estimation | Jeihani | State University | electric vehicles, Complete Streets, multimodal transportation, mobility, safety |
| Hands on Wheel, Eyes on Road | Dr. Mansoureh Jeihani | Morgan State University | Traffic safety, mobility, driver behavior, distracted driving |
| Innovative Methods for Delivering Fresh Foods to Underserved Populations (Collaborative Project) | Dr. Hyeon-Shic Shin Dr Young-Jae Lee Dr. Paul Schonfeld | Morgan State University Morgan State University University of Maryland | Last mile food delivery; Accessibility improvement for underserved population; social justice in transportation; Transportation planning and policy |
| Developing a Connected Vehicle Transit Signal Priority System (Collaborative Project) | Dr. Kyoungho Ahn Dr. Hesham Rakha Dr. Young-Jae Lee | Virginia Tech Virginia Tech Morgan State University | Connected and Automated Vehicle, Connected Traffic Signal Control, Transit Signal Priority, Microscopic Traffic Simulation, Field Testing |
| Developing and Testing an ECO-Cooperative Adaptive Cruise Control System for Buses (Collaborative | Dr. Hesham Rakha Dr. Hao Chen Dr. Mansoureh Jeihani | Virginia Tech Virginia Tech Morgan State University | Connected and Automated Vehicle, Eco-Cooperative Adaptive Cruise Control, Energy Modeling, Hybrid Electric Bus, Diesel Bus, Microscopic Traffic Simulation |

| Project) | | | |
|---|--|--|--|
| Optimization of Emergency Traffic Patrols (ETP) Operations (Collaborative Project) | Dr. Ali Haghani Dr. Mansoureh Jeihani | University of Maryland Morgan State University | Incident response and management |
| Development of Multimodal Traffic Signal Control | Dr. Hesham Rakha Dr. Kyounggho Ahn | Virginia Tech Virginia Tech | Traffic Signal Control |
| Traffic State Prediction: A Traveler Equity and Multi-model Perspective | Dr. Hesham Rakha | Virginia Tech | Multimodal Transportation System, Transit Passenger Demand Prediction, Bike Share System, Travel Time Prediction |
| Optimized Development of Urban Transportation Networks | Dr. Paul Schonfeld | University of Maryland | Transportation Network Evaluation, Traffic In Road Networks, Project Scheduling, Optimization, Economic Analysis |
| Understanding Access to Grocery Stores in Food Deserts in Baltimore City | Dr. Celeste Chavis Anita Jones, M.S. | Morgan State University Morgan State University | Food deserts, Access to Transportation, Public Transportation |
| Optimizing Small-Sized Automated Transit Operations and Its Applications | Dr. Young-Jae Lee | Morgan State University | Automated Vehicles, Transit, Ridesharing |
| Dynamic Vehicle Routing with Route Guidance for Urban Pickup and Delivery | Dr. Ali Haghani | University of Maryland | Freight Mobility, Logistics |

- UMEC faculty member Dr. Celeste Chavis is serving on the Equitable Access Leadership Task Force for the Greater Washington Partnership, which focuses on regional mobility from Richmond to Baltimore.
- Faculty and NTC staff continue to assist Morgan State and the Maryland Transit Administration as they plan what will be a permanent route for the BaltimoreLink Silver Line, a bus line that links Morgan State and nearby residential communities with downtown and other educational institutions. Last year, they helped create a temporary route that served until some necessary construction could take place.
- UMEC director Dr. Andrew Farkas continues to serve on Maryland's Electric Vehicle Infrastructure Council, established by the state legislature.
- Jeremy Weiss, a master's degree student in City & Regional Planning at Morgan State University, was chosen as a University Transportation Center Outstanding Student of the Year for 2017. He recently earned an Excellence in Community Planning Certificate for his entry in the Sustainable Growth Challenge, a collegiate competition hosted by the Maryland Sustainable Growth Commission that engages students in planning, sustainability and reinvestment issues.
- UMEC planned to sponsor an event, the Second Annual Transportation Summit, which will take place in the next reporting period on April 18, 2018; panelists will include a city councilman and a state delegate as well as a representative from Lyft to address the role of private industry.
- UMEC decided to help sponsor Transportation Camp Baltimore 2018, which will take place May 12 at the University of Baltimore. It's an unconference, a format in which attendees program and lead the sessions.

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

- Morgan State University offers transportation-related degrees at the bachelor's, master's and doctoral levels, as well as a post-baccalaureate transportation certificate in three schools – the School of Engineering, School of Architecture and Planning, and the School of Graduate Studies. In 2016-2017, Morgan awarded 16 Bachelor of Science transportation-related degrees and two Master of Science transportation-related degrees.
- The University of Maryland awarded one transportation-related master's degree in 2016-2017. All three schools in UMEC also offer civil engineering degrees.
- UMEC inaugurated an innovative educational program for middle school students, the **Middle School Summer Transportation Initiative (MSSTI)**, which sparked their interest in transportation. Created with support from the Maryland Department of Transportation State Highway Administration, the program's first class introduced 17 students to bridges and bridge engineering through field trips and hands-on activities. Plans are underway for the second MSSTI, which will have 15 students.



Middle school students test their bridge designs.

MSSTI is an outgrowth of an existing, highly successful workforce development program, the **Summer Transportation Institute (STI)**. STI is a month-long pre-collegiate program that gives 20 high school students unprecedented levels of experience with transportation planning professionals, technology, and preparation for entering university. Additionally, the two-week **Teacher Transportation Institute (TTI)** exposes teachers and administrators such as guidance counselors to transportation concepts that they can use in STEM-based lessons. They earn continuing education credits for their participation. Both STI and TTI were established under previous grants, and UMEC funds enable them to continue their mission in the future.

VTTI AND VDOT SCHOOL DAY
April 19, 2018

Take a Tour of VTTI
See the Smart Road Control Room, look into instrumented research vehicles, and ride on the Virginia Smart Road, as rain is produced right on the road.

Smart Road Basics
The Smart Road is a full-scale, closed research facility managed by VTTI and owned and maintained by VDOT. Over 16 years of operation, the 2.5-mile Smart Road has seen over 26,000 hours of research by VTTI, automakers, suppliers, and government entities. The Smart Road features weather-making capabilities, a variable lighting test bed, pavement markings, road weather information systems, differential GPS, and a signalized intersection. The test bed also serves as a Federal Aviation Administration test site for unmanned aircraft systems. Recent and ongoing expansions to the Smart Road will facilitate the evaluation of automated vehicles in a full range of customizable environments, including urban, residential, and rural roadways.

Kid-friendly Stats

- The Smart Road Bridge is 175 feet above the ground, making it one of the tallest bridges in Virginia. It would take 36 10-year-olds standing on each other's shoulders to be able to touch the top of the bridge from the ground. (Average height of a 10-year-old: 58 inches)
- It would take 584,558 10-year-olds to create the same weight as the bridge. (Average weight of a 10-year-old: 68 lbs.)
- Since the inside of the bridge is hollow, there is enough space to fit 14 houses! (Average home size: 2,600 sq. ft.)
- If a 10-year-old wanted to buy a bridge like this, he or she would have to save \$1.00 a day for 48,000 years!

If you are interested in having your school visit to observe VTTI, please register at: <http://bit.ly/schoolday2018>

For any questions, please email: tours@vtti.vt.edu
For more about events/tours at VTTI: <https://www.vtti.vt.edu/about/tours.html>

VT VIRGINIA TECH TRANSPORTATION INSTITUTE **VDOT**

- Virginia Tech Transportation Institute and the Virginia Department of Transportation planned to host an event in the next reporting period, a **School Day** scheduled for April 25, 2017; it is based on a successful event last year in which students in first through 12th grade toured the Smart Road and learned about the science behind transportation research. They saw demonstrations of rain-making, instrumented vehicles and other research gadgets.
- The NTC and UMEC have a relationship with the Maryland Department of Transportation (MDOT) to continue two **internship programs**: undergraduate-level summer internships with the State Highway Administration and full-year, graduate-level internships at the administrative subdivisions of MDOT.
 - ◆ The selection process is underway for the 2018 MDOT SHA Summer Interns. The 2017 interns were: Destiny Copeland, Venita Russell, Ayomiposi Akinyemi, Amirah Fields, Wayne Johnson, Adrianna Rhoden, and Anthony Lovelace.
 - ◆ Final selection of the 2017-2018 MDOT/MSU Graduate School interns will be completed by the end of June; orientation is in July 2018. The previous interns were Zohreh Rashidi Moghaddam, Kelechi Uradu, Nnanna Ekedebe, Christopher Tokpah, Steve Charles, Eseose Kadiri, Sha'von Terrell, Chinedu Okeke, Ibrahim Aka, Tu Hguyen, Rawaa Altameemi, and Blessing Esimobi.

1.4 How have the results been disseminated? If so, in what ways?

Researchers receiving UMEC funding are encouraged to publish their results in journals, present at conferences and create webinars; professional editing services are available to them.

- **Understanding Access to Grocery Stores in Food Deserts in Baltimore City** was presented in a poster format at the Transportation Research Board's annual meeting in 2018.

- **Optimized Development of Urban Transportation Networks** was presented at the January 2018 annual Transportation Review Board meeting (Jovanovic, U., Shayanfar, E. and Schonfeld, P. “Selecting and Scheduling Link and Intersection Improvements in Urban Networks,” Annual TRB Meeting, Jan. 2018 (18-05088)), and it was published in the peer-reviewed Transportation Research Record in October 2017.
- Samira Ahangari, a Ph.D. student at Morgan, will present **Developing and Testing an ECO-Cooperative Adaptive Cruise Control System for Buses** (Collaborative Project) at the 2018 ITE Mid-Colonial District Annual Conference in April.
- From Oct. 1, 2017, to March 26, 2018, the UMEC website, www.morgan.edu/umec, had 3,371 page views and 615 unique visitors.
- UMEC’s Facebook page now has 55 followers. On average posts appear on 27 people’s pages daily and an average of 4 people engage with the post, liking, commenting or sharing. The most successful post recently appeared on 563 people’s walls and was shared twice. Posts are often shared on the National Transportation Center’s Facebook, page, which has 116 followers, and the NTC Twitter feed, which has 57 followers. UMEC’s Twitter feed, which has just 20 followers, still had 700 tweet impressions in February and 646 impressions in March. A video promoting a UMEC project is on You Tube: <https://www.youtube.com/watch?v=35Uao14K01k&t=8s>
- A newsletter, *The UMEC Report*, was distributed via email to 400 transportation professionals, researchers, community organizations and government officials. It’s available on the UMEC website.
- Press releases will be developed for appropriate media when research and/or results are newsworthy, and fact sheets will be developed to facilitate technology transfer.

1.5 What do you plan to do during the next reporting period to accomplish the goals and objectives?

- UMEC will evaluate the second-year funding round of competitive proposals and choose several for collaborative research.
- UMEC will increase its social media presence by using video to showcase its research and continuing to build more followers.
- All of our research projects will continue toward their stated objectives in a timely fashion.
- The project **Developing a Connected Vehicle Transit Signal Priority System** will develop an advanced CV-enabled TSP algorithm and a connected TSP simulation model which utilizes communication software.
- The algorithms developed for **Optimizing Small-Sized Automated Transit Operations and Its Applications** will be completed. These algorithms, developed for ridesharing and flexible feeder routes, can be applied to hypothetical networks to compare travel times and costs by two different travel options.

- **Development of Multimodal Traffic Signal Control** will develop an integrated CV simulation platform and also develop an I-SIG algorithm which will be implemented on the CV simulation platform.
- The project **Traffic State Prediction: A Traveler Equity and Multi-modal Perspective** will use machine learning or statistics methods to develop bus prediction models.
- The project **Developing and Testing an ECO-Cooperative Adaptive Cruise Control System for Buses** will develop energy consumption models for diesel and hybrid electric buses, calibrate bus energy models by real data, and develop a bus ECO-CACC system using the calibrated energy models.

2. PRODUCTS

2.1 Publications, Conference papers, presentations

- **Understanding Access to Grocery Stores in Food Deserts in Baltimore City** was presented in a poster format at the Transportation Research Board's annual meeting in 2018.
- Samira Ahangari, a Ph.D. student at Morgan, will present **Developing and Testing an ECO-Cooperative Adaptive Cruise Control System for Buses** (Collaborative Project) at the 2018 ITE Mid-Colonial District Annual Conference in April.
- The **Hands on Wheel, Eyes on Road** project will produce an educational video about distracted driving that will be shown in high school and college classrooms in Maryland.
- Dr. Andrew Farkas authored an op-ed piece for the Baltimore Sun on autonomous vehicles that was published on April 2, 2018.
<http://www.baltimoresun.com/news/opinion/oped/bs-ed-op-0402-driverless-cars-20180330-story.html>
- **Optimized Development of Urban Transportation Networks** was presented at the January 2018 annual Transportation Review Board meeting (Jovanovic, U., Shayanfar, E. and Schonfeld, P. "Selecting and Scheduling Link and Intersection Improvements in Urban Networks," Annual TRB Meeting, Jan. 2018 (18-05088)), and it was published in the peer-reviewed Transportation Research Record in October 2017.

2.2 Websites or other internet sites

www.morgan.edu/umec

www.facebook.com/urbanmobilityandequitycenter

www.twitter.com/UMECresearch

As part of its mission to be a community resource, UMEC posts guests blogs on its website. The bloggers represent a variety of voices interested in transportation, and they explore topics ranging from complete streets to bike advocacy to autonomous vehicles. The blogs can be found under the News & Events section.

2.3 Technologies or techniques

UMEC's research projects reflect the priorities of the U.S. Department of Transportation Strategic Plan for FY 2018-2022 with their emphasis on innovation and accountability.

- The project **Developing and Testing an ECO-Cooperative Adaptive Cruise Control System for Buses** develops energy consumption models for diesel and hybrid-electric buses, calibrates bus energy models by real data and develops an adaptive cruise control system for heavy-duty vehicles. This project and the following one are examples of the innovation targeted in the strategic plan.
- The project **Traffic State Prediction: A Traveler Equity and Multimodal Perspective** will develop and implement prediction models for transit passengers that can be used in commercial software for transit agencies to manage bus schedules.
- **Developing a Connected Vehicle Transit Signal Priority System** will develop a connected vehicle transit priority system that provides equitable priority for buses with minimum disruption to surrounding traffic for near-side, far-side and mid-block bus stops.
- **Development of Multimodal Traffic Signal Control** will develop an integrated CV simulation platform and an I-SIG algorithm which will be implemented on a CV simulation platform.
- **Sustainable Design of Concrete Bus Pads to Improve Mobility in Baltimore City** will formulate a newly proposed design for sustainable concrete bus pads that can withstand various loading scenarios to minimize cracking, an important advancement in infrastructure.

2.4 Inventions, patent applications or licenses

Nothing to report.

2.5 Other products such as databases, physical collections, audio or video products, software or NetWare, model education aids, curricula, instructions, equipment

Nothing to report.

3. PARTICIPANTS & COLLABORATING ORGANIZATIONS

3.1 What organizations have been involved as partners?

Morgan State University (lead)

- Financial Support
- In-Kind support
- Facilities
- Collaborative Research
- Personnel exchanges

Virginia Tech, Blacksburg, Virginia

- Financial Support
- In-Kind support
- Facilities

- Collaborative Research
 - Personnel exchanges
- University of Maryland
- Financial Support
 - In-Kind support
 - Facilities
 - Collaborative Research
 - Personnel exchanges

3.2 Have other collaborators or contacts been involved?

Maryland Department of Transportation State Highway Administration, Virginia Department of Transportation, Appalachian Regional Council, North Carolina State University

4. IMPACT

4.1 What is the impact on the development of the principle disciplines of the program?

UMEC's research already has contributed to the body of knowledge and offered such tools as predictive methods and algorithms, and that will continue in the second year.

- The methods developed as part of **Innovative Methods for Delivering Fresh Foods to Underserved Populations** will help improve the effectiveness, safety, sustainability and affordability of transportation systems. By specifying appropriate constraints when using the proposed methods, equity will also be achievable.
- The developed algorithm and software for the project **Developing a Connected Vehicle Transit Signal Priority System** can be used as teaching material in transportation engineering courses.
- **Developing and Testing an ECO-Cooperative Adaptive Cruise Control System for Buses** focuses on developing ECO-CACC systems for heavy-duty vehicles (diesel and hybrid buses); previous similar work focused only on light-duty vehicles. Both non-automated and automated vehicles will be considered to equip the developed systems, and simulation tests will demonstrate the benefits.
- There is a shortage of studies on autonomous and connected vehicle (ACV) behavior in a roadway network. No study has developed a fully multimodal traffic simulation that includes ACV and V2Xs and EVs. **Drivers' Interactions with Advanced Vehicles in Various Traffic Mixes and Flows – Phase 1: Driver Behavior Study and Parameter Estimation** will help fill that gap in knowledge.
- The project **Managing the Impacts of Different CV/AV Penetration Rates on Recurrent Freeway Congestion from the Perspective of Traffic Management** proposes to develop a set of operational guidelines for responsible highway agencies to manage the impacts of different CV/AV penetration rates on traffic conditions.

4.2 What is the impact on other disciplines?

UMEC's research projects incorporate a multidisciplinary approach that may include

computer science, operational research, urban planning, economic impacts and environmental engineering. The results may influence equally diverse fields.

- Applications of the method developed in **Innovative Methods for Delivering Fresh Foods to Underserved Populations** will advance practices in other disciplines such as project management and engineering economics.
- The methods developed in **Optimized Development of Urban Transportation Networks** are applicable to fields such as operations research, business administration and industrial engineering.

4.3 What is the impact on the development of transportation workforce development?

- Students interested in transportation infrastructure development can gain valuable insight into the movement of goods from the project **Innovative Methods for Delivering Fresh Foods to Underserved Populations**.
- The project **Developing a Connected Vehicle Transit Signal Priority System** provides opportunities for research to graduate students and helps develop and disseminate their educational materials and provide assistantships.
- A growing understanding of how critical it is to introduce students to STEM concepts and career options earlier spurred the development of the **Middle School Summer Transportation Initiative**. In a blog “The Economic Impact of Early Exposure to STEM Education,” Sidharth Oberoi writes, “One of the most important factors that limits the United States’ ability to stay ahead of the STEM curve is the lack of introduction to these educational areas at an early age.” He notes that providing laptops and iPads is not enough. “Students use technology as consumers, but not as innovative developers through their formal education experience.”
- Like its new middle school counterpart, the **Summer Transportation Institute** has been introducing students to careers in transportation for more than 20 years. Jawiyambe Thomas-James went through STI in 2012 and now is majoring in civil engineering at Morgan. “The most memorable thing was definitely the trip to Virginia Tech and visiting their Smart Road,” he recalls. “STI influenced my decision to attend Morgan for engineering by exposing me to the staff and the environment in the engineering department. The program also gave me an insight on whether I wanted to focus on transportation engineering or civil engineering, and how I could possibly work in both focuses in the future.”
- UMEC continues to support **two internship programs** in partnership with the Maryland Department of Transportation (MDOT) and the MDOT State Highway Administration. Undergraduates have an opportunity to do summer internships in the various divisions of the MDOT SHA, while graduate students work full time in the summer and part time during the school year for MDOT in an internship that gives them significant responsibility and real-world experience.

4.4 What is the impact on physical, institutional and information resources at the university and/or other partner institutions?

Nothing to report.

4.5 What is the impact on technology transfer?

- We have created a preliminary technology transfer plan, which is available on our website. We will have a finalized plan submitted and posted by the July 31, 2018, deadline.
- Ray Dizon, Technology Transfer Manager for Morgan, gave a presentation to researchers about technology transfer, educating them about tools such as provisional patents, licenses and trademark and copyright. He detailed the support UMEC and the Morgan Office of Technology Transfer can provide. Researchers were encouraged to think of wider applications for their research.
- Project proposals are reviewed with the possibility of technology transfer in mind.
- The project **Developing and Testing an ECO-Cooperative Adaptive Cruise Control System for Buses** develops a cruise control system for buses; automotive companies may consider implementing the system into different types of vehicles.
- The project **Innovative Methods for Delivering Fresh Foods to Underserved Populations** is expected to yield greatly improved methods for developing transportation networks. The methods will include appropriately integrated components for evaluating candidate projects, selecting them and scheduling their implementation, while satisfying constraints regarding budgets and construction times.
- The algorithms developed for **Optimizing Small-Sized Automated Transit Operations and Its Applications** can be used to compare travel times and costs in hypothetical networks.
- **Traffic State Prediction: A Traveler Equity and Multi-modal Perspective** will develop a prediction model that can be used in commercial software for transit agencies to manage bus schedules.
- The project **Optimization of Emergency Traffic Patrols (ETP) Operations** extends an earlier mathematical model developed by researchers to design the network for patrol programs. This piece will determine the most efficient patrol coverage area, given an underlying transportation network. This will help incident management officials determine where patrol units are required and where other strategies such as dispatch response are desired. Determining the patrol coverage area will significantly save on operation costs.

4.6 What is the impact on society beyond science and technology?

While researching algorithms and traffic models, it's important to remember the stories behind them: Someone is standing in the bitter cold, waiting for a bus that doesn't come, or a commuter is stuck in traffic that will make them late for work – again. Successful transportation can be as simple as a special birthday gift that arrives on time, thanks to an efficient delivery system.

- The project **Developing a Connected Vehicle Transit Signal Priority System** will help buses move through intersections and bus stops in ways that minimize congestion. Although buses are the workhorses of moving city commuters, their cumbersome acceleration causes traffic delays, and alleviating those delays will improve urban mobility.

- The project **Develop an ECO-Corporative Adaptive Cruise Control System for Buses** proposes to develop a system that will improve transit operation by reducing vehicular delay while at the same time increasing fuel/energy savings and reducing emissions.
- The prediction model developed for **Traffic State Prediction: A Traveler Equity and Multi-modal Perspective** can be used as an example for other transit agencies to solve similar issues.
- As road pricing is used to alleviate congestion, it raises serious equity issues, especially for low-income commuters who already spend a disproportionate amount of their income on transportation. The project **Evaluating Equity Issue for Managed Lanes: Methods for Analysis and Empirical Results** is expected to produce methods and results that will help design better congestion-pricing projects.
- One of the most basic measures of urban mobility is the ability to get to the grocery store – and not just a corner store with nothing but packaged food, but a store that offers fresh produce and healthy options. **Understanding Access to Grocery Stores in Food Deserts in Baltimore City** establishes how people actually shop and how they access stores, information that is needed to address the problem of food deserts.

5. CHANGES/PROBLEMS

5.1. Changes in approach and reason for change?

Nothing to report.

5.2 Actual or anticipated problems or delays and actions or plans to resolve them

Nothing to report.

5.3 Changes that have a significant impact on expenditures

Nothing to report.

5.4 Significant changes in use or care of animals, human subjects and/or biohazards

Nothing to report.

5.5 Change of primary performance site location form that originally proposed

Nothing to report.

5.6 Additional information regarding products or impacts

Nothing to report.

6. SPECIAL REPORTING REQUIREMENTS

There are no special reporting requirements at this time.