Federal Agency	U.S. Department of Transportation
Federal Grant Number	DTRT13-G-UTC33
Project Title	MID-ATLANTIC TRANSPORTATION SUSTAINABILITY UNIVERSITY TRANSPORTATION CENTER (UTC)
Program Director Name, Title, and Contact Information	Brian Smith, Ph.D., P.E. Professor and Chair, Civil and Environmental Engineering MATS UTC Director University of Virginia 351 McCormick Dr. P.O. Box 400742 Charlottesville, VA 22904-4742 Phone: 434-243-8585 Fax: 434-982-2951 Email: briansmith@virginia.edu
Name of Submitting Official, Title, and Contact Information	Robert Merhige Director of Grants and Contracts University of Virginia ospnoa@virginia.edu 434-924-4270
Submission Date	April 2016
DUNS/EIN Numbers	065391526
Recipient Organization (Name and Address)	University of Virginia Office of Sponsored Programs 1001 North Emmet Street P.O. Box 400195 Charlottesville, VA 22904-4195 Phone: 434-924-4270 Fax: 434-982-3096
Recipient Identifying Number, if any	Federal Entity Number 54-6001796
Project/Grant Period (Start Date, End Date)	6/30/14 to 9/30/18
Reporting Period End Date	3/31/16
Report Term or Frequency	Six months
Signature of Submitting Official	

1. Accomplishments

The Mid-Atlantic Transportation Sustainability University Transportation Center (MATS UTC) is a regional consortium of six universities led by the University of Virginia. Our consortium includes Marshall University, Morgan State University, University of Delaware, Old Dominion University, and Virginia Polytechnic and State University. The MATS UTC serves the region through applied research, education, workforce development, and technology transfer focused on environmental sustainability.

1.1 Research

MATS UTC strives to address research problems related to environmental sustainability and transportation.

1.1.1 Research Program Themes

Our research program is organized around five focus areas:

- Sustainable Freight Movement (SF)
- Coastal Infrastructure Resiliency (IR)
- Energy Efficient Urban Transportation (EU)
- Enhanced Water Quality Management (WM)
- Sustainable Land-Use Practices (LU)

We have core projects in all five of these focus areas. We have competitive collaborative projects in most of the focus areas.

1.1.2 Research Program Selection and Management

Our research program has two parts. Each university in the consortium has been allocated a base amount to spend on research, education, and outreach including technical transfer, diversity, and communications. This base money funds the core projects we select collaboratively as a center—guided by our advisory board.

Table 1 lists 16 projects currently funded with base and matching allocations. Many of these include researchers at multiple consortium universities as indicated. Four projects have been completed since the inception of MATS UTC in July 2014. These were highlighted in PPPR #2 in October 2015.

Table 1 Projects Utilizing Base Fund and Matching Fund Allocations

Focus Area	Lead U	PI	Other Investigators	Other U	Title
FR	ODU	Cetin	Ng, Talley, Park, Rakha	ODU, UVA, VT	Multimodal Freight Distribution to Support Increased Port Operations
IR	VT	Murray-Tuite	El-Shawarby, Rakha, Smith	VT, UVA	Infrastructure Resilience and Adaptation for Hurricanes in Coastal Areas
IR	UD	Attoh-Okine	Ivey-Burden	UVA	Multimodal Transportation Facility Resilience Index
IR	UVA	Ozbulut	Harris	UVA	Structural Enhancements to Adapt to Impacts of Climate Change
IR	UVA	Harris	Ozbulut	UVA	Accelerating Use of Sustainable Materials in Transportation Infrastructure
IR	UD	Maresca	Harris	UVA	Microbial Biomarkers for ASR-Damaged Concrete
IR	UD	Meehan	Batra	VT	Implementation of Smart Equipment in Field Construction
EU	MU	Nichols	Park, Rakha, Abbas	UVA, VT, VT	Enhancing Traffic Control Systems to Reduce Emissions and Fuel Consumption
EU	VT	Rakha	Ahn, Cetin, Park	VT, ODU, UVA	Network-wide Impacts of Eco-routes and Route Choice Behavior/Evaluation of AERIS Applications
EU	MSU	Farkas	Shin, Risch, Sowards, Du	MSU, MU,VT	Environmental and Safety Attributes of Electric Vehicle Ownership and Commuting Behavior: Public Policy and Equity Considerations
EU	VT	Rakha	El-Shawarby	VT	Develop and Test Connected Vehicle Freeway Speed Harmonization Systems
WM	MSU	Hunter	Kang, Culver	MSU, UVA	Mitigating Pollutants from Highway Infrastructure for Total Maximum Daily Load (TMDL) Compliance: Monitoring Efficacy of Best Management Practices and Advancing Decision Support
WM	UVA	Goodall	Harris, Smith	UVA	Integrated Data for Improved Asset Management
WM	MSU	Kang	Chirnside, Bundy	UD	Evaluation of Waste Concrete Road Materials for Use in Oyster Aquaculture
LU	UD	Scott	Li, Dayan	UD, MU	Land Use Master Planning for Environmental Sustainability
LU	UVA	Mondschein		UVA	Driver Education for New Street Facilities and Operations: Multimodal and Traffic Management

Appendix A includes progress reports for these base and match funded projects.

The other part of our research program are competitive collaborative projects. Table 2 lists the five projects awarded in Fall 2014. Progress reports for these projects are provided in Appendix B. Table 3 lists the six projects awarded in February 2016. We received 25 proposals with investigators from all six consortium universities. These proposals were evaluated with 75 external reviews, were assessed by our advisory board, and then six were selected by our Executive Team. These projects are expected to start by June 1, 2016.

Table 2 Competitive Collaborative Projects Awarded Fall 2014 (January 1, 2015-August 31, 2016 projects)

Focus Area	Lead U	PI	Other Investigators	Other U	Title
LU	VT	Hankey	Buehler, Mondschein	UVA	Designing a bicycle and pedestrian traffic count program to estimate performance measures on streets and sidewalks in Blacksburg, VA
WM	UD	Chiu	Imhoff, Culver	UVA	Simultaneous Removal of Nitrogen and Phosphorus from Stormwater by Zero-Valent Iron and Biochar in Bioretention Cells
IR	UVA	Goodall	Sridhar	VT	Impact of Climate Change and Sea Level Rise on Stormwater Design and Reoccurring Flooding Problems in the Hampton Roads Region
EU	ODU	Iftekharuddin	Cetin, Rakha	VT	LiDAR for Air Quality Measurement
EU	UD	Prasad	Advani, Shin	MSU	Connected Vehicle Technologies for Energy Efficient Urban Transportation

Table 3 Competitive Collaborative Projects Awarded Spring 2016 (May 1, 2016-October 31, 2017 projects)

Focus Area	Lead U	PI	Other Investigators	Other U	Title
IR	MU	Zatar	Nguyen, Ozbulut	UVA	Fiber-Reinforced Plastic (FRP) Wraps for Next Generation Sustainable and Cost-Effective Rehabilitation of Coastal Transportation Infrastructure in the Mid-Atlantic Region
IR	UVA	Murray-Tuite	Heaslip, Sridhar, Goodall	VT	Transportation Infrastructure Flooding: Sensing Water Levels and Clearing and Rerouting Traffic out of Danger
EU	MU	Nichols	Chou, Cetin, Abbas	ODU, VT	Leveraging Connected Vehicles to Enhance Traffic Responsive Traffic Signal Control
EU	MSU	Rakha	Chen, Jeihani, Chavis	VT	Eco-Speed Control for Hybrid Electric Vehicles and Buses in the Vicinity of Signalized Intersections
EU	ODU	Paleti	Cetin, Rakha	VT	Real-Time System Prediction & Optimal Rebalancing Strategies for Public Bike Sharing Systems
EU	MSU	Chavis	Jeihani, Rakha	VT	Quantifying the Impact of On-Street Parking Information on Congestion Mitigation

1.1.3 Dissemination

No MATS UTC projects were completed during this reporting period. The final research reports of previous projects have been published to the MATS UTC website and results have been further disseminated in multiple ways including website updates and news posts, academic publications, project descriptions in quarterly newsletters, Facebook posts, Twitter tweets, monthly Internal News emails, MATS UTC webinars, and conference presentations.

1.1.4 Plans for Next Reporting Period

Plans for the next reporting period include continuing these projects and starting the new competitive collaborative projects. We anticipate another competitive collaborative solicitation in late Fall 2016. We will continue the dissemination and tech transfer of our research results.

1.2 Education and Workforce Development

The MATS UTC education goal is to foster education and training to contribute to the development of the transportation workforce. Traditional discipline-based education and training is not sufficient for current and future workforce demands; our approach is multi-disciplinary, multimodal, and incorporates both passenger and freight. Under this grant we are developing a series of education activities, from K-12 to PhD and professionals. These programs build on the education and training programs available at all consortium universities.

1.2.1 New Activities Associated with Degree Programs

The MATS UTC Education Steering Committee put a lot of effort into developing a semester long graduate course in Transportation Sustainability that was offered asynchronously at five of the six consortium universities in Fall 2015. We have developed nine one or two week module outlines for this course which are listed along with the instructor and their university in Table 4. The course had good evaluations from participants and instructors. We will offer this course again in Fall 2016.

Table 4 Modules, Length, Instructor and University for the Semester-Long Graduate Course in Transportation Sustainability Offered August 31 – December 15, 2015

Weeks	Topics
1 Aug 31 – Sept 4	**Overview**, Emily Parkany, University of Virginia
2 & 3 Sept 7 – Sept 18	**Energy-Efficient Urban Transportation**, Hesham Rakha & Kyungho Ahn, VA Tech
4 & 5 Sept 21 – Oct 2	**Urban Freight**, Hyeon-Shic Shin, Morgan State University
6 & 7 Oct 6 – Oct 16	**Coastal Infrastructure Resiliency**, Navid Tahvildari, Old Dominion University
8 Oct 19 – Oct 23	**Sustainable Materials**, Wael Zatar, Marshall University
9 & 10 Oct 26 – Nov 6	**Enhanced Water Quality Management**, Jonathan Goodall, University of Virginia
11 Nov 9 – Nov 13	**Land Use**, Andrew Mondschein, University of Virginia
12 & 13 Nov 16 – Dec 1	**Healthy Communities**, Marcia Scott, University of Delaware
14 & 25 Dec 2 – Dec 15	**Finance and Policy**, Troy Mix, University of Delaware

1.2.2 Non-degree Programs

MATS UTC encompasses formal training programs for transportation professionals at the University of Virginia (Transportation Training Academy (TTA), Virginia's Local Technical Assistance Program (LTAP), Marshall University and the University of Delaware (Delaware's LTAP).

MATS UTC offered the TTA workshop:

- Overview of Transportation Sustainability, November 12, Arlington

We plan to offer a new workshop likely related to life cycle cost analysis at our Annual Meeting in August.

1.2.3 Attracting New Entrants to Transportation

MATS UTC has made a conscious effort to attract new entrants to transportation. This includes K-12 efforts and undergraduate efforts focused on transportation in general and specifically addressed to attract diverse audiences including women and underrepresented minorities.

Highlights of our activities in this area include:

- Undergraduate Summer Research Internship Program (USRIP). We received 17 applicants for our Summer 2016 program and we made offers to 15 students to participate in our nine-week program at five consortium universities. We expect at least 12 students in our program across the five universities and for them to participate jointly via web meetings and for all to prepare and present a final report, poster, and oral presentation. 10/12 of these are women and over half are from underrepresented minorities.
- Promoting Careers in Transportation. We held our third webinar in this series on October 16 featuring R.J. Porter from the University of Utah.
- We participated in Career Fairs aimed at getting high schoolers excited about transportation careers and sponsored by the Virginia Department of Transportation in Northern Virginia (October 8) and Hampton Roads (October 21).

1.2.4 Dissemination

We use a variety of methods including email "blasts", website posts, Facebook posts, Twitter tweets, internal news distribution and a quarterly newsletter to disseminate information about our research and education and training activities.

1.2.5 Plans for Next Reporting Period

We are excited about our multi-university version of the Summer Undergraduate Research Internship Program and our second offering of the graduate Transportation Sustainability class.

1.3 Technology Transfer

The goal of the MATS UTC technology transfer program is to broaden our reach and effectively disseminate research results. Appendices A and B include the technology transfer and outreach efforts of researchers affiliated with individual projects. These include seminars and conference poster/podium presentations about specific research projects.

In the section below, we describe our conducted and planned technology transfer and outreach events and media and communications efforts.

1.3.1 Technology Transfer/Outreach Events

MATS UTC Technology Transfer/Outreach Events in this reporting period include:

- A Spring Research Webinar Series from February-June 2016 (5 webinars) featuring 13 researchers and six of our projects.

- All of our webinars are archived on YouTube and we maintain a web page with a link to the archived recording and the presentations and additional information for each one. [YouTube link] List of MATS UTC webinars.
- Each of our research teams maintain a Technology Transfer Implementation Plan for each project. These were completed in July 2015 and updated in March 2016.

1.3.2 Media and Communications

We have developed several outlets for disseminating MATS UTC research, education, diversity, and technology transfer activities. These include the MATS UTC website www.matsutc.org , external email blasts to our list of over 480 (and growing) names, Facebook posts https://www.facebook.com/midatlantictransportationsustainability , a monthly internal news distributed to our advisory board and researchers, and Twitter feeds. Each participating university posts once a week on Facebook and many of the posts are copied as posts to the MATS UTC website and to Twitter.

We have distributed a Quarterly newsletter since April 2015. The E-Newsletter includes a feature article, research spotlights for two projects, faculty and student spotlights, education and training updates, and news from consortium members. The newsletter is distributed to our MATS UTC email list and the articles are available on our website.

1.3.3 Disseminations

Dissemination of research results are achieved through the events, media, and communication channels described in sections 1.3.1 and 1.3.2 and in the Appendices.

Inspired by the tech transfer needs of University Transportation Centers, our Managing Director, Emily Parkany submitted a paper to the 2016 TRB Annual Meeting entitled, “Webinars, Advisory Boards, T2 Implementation Plans and other Examples of University Technical Transfer Best Practices”. The paper has been published by TRB.

1.3.4 Plans for Next Reporting Period

We will continue our communications and outreach efforts and continue to expand our email lists with new addresses of event attendees and other activity participants. We are establishing a MATS UTC Dataverse to include data from our projects. We plan to include the data for six of our projects in summer 2016. Technology transfer related to each individual research project will continue and likely increase as the projects mature.

2. Products

MATS UTC products specific to each of our research projects are provided in the Appendices. Here we describe general products related to our Center.

2.1 Publications

Despite our young Center, several related papers have been submitted to major conferences as shown in the Appendices. This includes 13 presentations at the 2016 TRB Annual Meeting; at least 8 other conference presentations, and at least one journal article (Transportation Research, Part C). Our Center has also issued quarterly newsletters since April 2015.

Individual researchers are encouraged to submit papers related to their work to technical conferences and other avenues.

2.2 Websites

Our MATS UTC website was launched in August 2014: www.matsutc.org Additional project-related websites are provided in the Appendices.

2.3 Technologies

Nothing to report.

2.4 Inventions

Nothing to report.

2.5 Educational Products

We developed a semester-long graduate transportation sustainability course and two one-day professional development workshops as described in section 1.2.1 above.

2.6 Other Products

Here are examples of additional products that have resulted from this grant:

- Webinar archives found on the MATS UTC You Tube site
- Website posts and Facebook posts of Center activities

3. Participants and Collaborating Organizations

MATS UTC is a consortium of six universities. In addition to these universities we collaborate with several match sources including state DOTs and local agencies. We also have an advisory board with 11 members from 11 different agencies and organizations covering multiple modes and our region.

3.1 Participants

MATS UTC participants include researchers, instructors and staff from the six universities; instructors and speakers for our workshops, seminars, and symposia; champions and other partners at our match funding agencies; and our 11 person advisory board.

Appendices A and B and the text in this report provide names of researchers, instructors, and other presenters affiliated with MATS UTC activities.

Table 5 presents the names, titles, affiliations, and location of our 11 advisory board members.

Table 5 MATS UTC Advisory Board Members

Name	Title	Affiliation	Location
Jose Gomez, Chair	Director	Virginia Transportation Research Council	Charlottesville, VA
Damon Fordham	Principal	The Cadmus Group	Crozet, VA
Susan Handy	Director	National Center for Sustainable Transportation, University of California, Davis	Davis, CA
Jason Wang	Senior Transportation Specialist	Appalachian Regional Commission	Washington D.C.
Camelia Ravanbakht	Interim Executive Director	Hampton Roads Transportation Planning Organization	Chesapeake, VA
Holly Rybinski	President	Rybinski Consulting	Wilmington, DE
Domini Scurti	Manager, Market Planning	Maryland Port Administration	Baltimore, MD

Donald Williams	Research and Special Studies	West Virginia DOT	Morgantown, WV
Tim Witten	ITS/Special Projects Manager	Blacksburg Transit	Blacksburg, VA
Hua Xiang	Office of Policy and Research	Maryland State Highway Administration	Hanover, MD
Tigist Zegeye	Executive Director	Wilmington Area Planning Council	Newark, DE

We had 24 external reviewers from academia and organizations provide reviews of our competitive collaborative proposals in December-January 2016. Then our Advisory Board told us which of the better-rated proposals they were more interested in.

Representatives from all six consortium universities participate in the MATS UTC Executive Team teleconference held biweekly on Fridays.

3.2 Collaborating Organizations

In addition to the members of our advisory board, MATS UTC has collaborated with several individuals and organizations in conducting our research and other activities. These include research sponsors and presenters at MATS UTC events.

3.2.1 Research Sponsors

Our MATS UTC research sponsors and agency participants include:

- Virginia Transportation Research Council, Virginia Department of Transportation
- Virginia Statewide Bicycle and Pedestrian Committee
- Virginia Beach Department of Public Works
- Maryland State Highway Administration
- Maryland Department of Transportation
- Delaware Department of Transportation
- West Virginia Department of Transportation
- Hampton Roads Transportation Planning Organization; Hampton Roads Planning District Commission
- Maryland Motor Vehicle Administration
- Electric Vehicle Association-DC Chapter
- NASA Langley Research Center
- City of Charlottesville
- Ecosystem Services, LLC, VA;
- ReGenesis Global Solutions, LLC/Infinite Solutions L^3C, PA
- Town of Blacksburg, VA

3.2.2 Presenters at MATS UTC Events

External presenters during this reporting period included:

- R.J. Porter, University of Utah at Careers in Transportation webinar, October 16, 2015

4. Impact

Each of the projects summarized in the Appendices have included impacts in the principal discipline and some include impacts on other disciplines. In the sections below, we provide general impacts and describe how this Center has impacted the principal and other disciplines, human resources, resources

at the University of Virginia and the other consortium universities, technology transfer, and society beyond science and technology.

4.1 Development of the Principal and Other Disciplines

MATS UTC researchers, instructors, and staff represent multiple disciplines including civil engineering (transportation, water resources, structures, and geotechnical engineering), electrical engineering, transportation planning, public policy, and business. Our emphasis on collaboration among universities and disciplines for all of our programs including research, education, and outreach leads to development of students, professionals and faculty in all of these disciplines.

Specific examples include:

- Cross-listing our graduate transportation sustainability course in engineering and public policy schools at University of Delaware; participants in the graduate class are from five of six consortium universities and include civil engineering, urban planning, policy, energy engineering majors
- Researchers from at least six different academic departments involved in MATS UTC projects

4.2 Development of Human Resources

MATS UTC has directly impacted graduate students in terms of Graduate Student Research Assistantships, Fellowships, and our graduate course in transportation sustainability, undergraduate students applying for our summer undergrad research program and attending our Careers in Transportation series, professionals attending our workshop and symposium, and faculty at all six consortium universities involved in research and teaching our semester long graduate course.

4.3 Resources at University and Partner Institutions

MATS UTC resources have expanded the offerings at the University of Virginia, our consortium universities, and our match sources such as the Virginia Department of Transportation. Examples of activities directly enabled by MATS UTC include:

- Environmental sustainability research projects funded by federal funds and match funds that would not be possible without MATS UTC
- Professional development training workshops related to environmental sustainability
- MATS UTC summer undergraduate research program
- Graduate class in transportation sustainability offered at five of six consortium universities

4.4 Technology Transfer

We expect our research results and dissemination to continue after the period funded by the grant has elapsed. In the meantime, we intend to present preliminary and initial results during seminars, webinars, and conferences.

4.5 Society beyond Science and Technology

Sustainability issues will impact all of us. By promoting our activities, disseminating our results, and encouraging our match sources (such as regional DOTs) to spend resources on sustainability, we are increasing awareness of this nascent area.

5. Changes

There are no changes in the scope or objectives of this grant.

Individual projects may have changed a bit since inception as reported in the Appendices.

6. Special Reporting Requirements

No special reporting requirements. Nothing to report.

Appendix A Base-Funded Research Projects

Project: Multimodal Freight Distribution to Support Increased Port Operations

PIs: Mecit Cetin, Old Dominion University, MCetin@odu.edu; Manwo Ng, Old Dominion University, mng@odu.edu; Wayne Talley, Old Dominion University, wktalley@odu.edu; Brian Park, University of Virginia, bpark@virginia.edu; Hesham Rakha, Virginia Tech, HRakha@vtti.vt.edu

Period of Performance: November 1, 2014 – April 30, 2016

Accomplishments:

- The freight optimization model was developed to optimize the haulage and fuel consumptions costs using mixed integer linear programming. The proposed model was designed to fully incorporate the mechanism of economies of scale in freight transportation by assigning different sets of unit cost functions for varying cargo quantity, haulage distance, and freight modes/vehicle sizes.
- A case study was conducted using a hypothetical multimodal network to compare with the existing state-of-the-practice model. The results showed that the total costs were reduced by 5.3% by using the proposed model.
- A large-scale case study for railcar loading is nearing its completion. Preliminary results show that the proposed model can yield significantly higher utilization of rail cars, leading to substantial environmental benefits.
- Received truck data from the University of California, Riverside and developed fuel consumption models for trucks. The research was presented at the TRB Annual Meeting: Wang J. and Rakha H. (2016), "Heavy-Duty Diesel Truck Fuel Consumption Modeling," 95th Transportation Research Board Annual Meeting, Washington DC, January 10-14. [Paper # 16-2147]. The paper was extended and is currently under review at the Journal of Applied Energy.

Products:

- Hong, S., and B. Park, Multi-modal Freight Network Optimization for Environmental Sustainability with Economies of Scale, Virginia Washington Metro Regional Conference in Vienna VA, Apr 4-5, 2015.
- Hong, S., and B. Park, Multi-modal Freight Network Optimization for Environmental Sustainability with Economies of Scale, Civil & Environmental Engineering Graduate Student Research Symposium at University of Virginia, Feb, 2015.
- Makahon, I, Cetin, M, Ng, M.W., Nguyen, D.T., Unloading and premarshalling algorithms with java computer animation for terminal yard operations, To be presented at the TRB Annual Meeting, Jan 2016.
- Wang J. and Rakha H. (2016), "Heavy-Duty Diesel Truck Fuel Consumption Modeling," 95th Transportation Research Board Annual Meeting, Washington DC, January 10-14.

Impact:

- The proposed model representing the economies of scale would provide more accurate and environmentally sustainable strategies for managing the multimodal freight systems.
- The proposed model explicitly considers the environmental costs, thereby the optimal strategies can help practitioners to reflect environmental-related regulations of authorities.
- Developed a new approach to modeling diesel truck fuel consumption levels.

Project: Infrastructure Resilience and Adaptation for Hurricanes in Coastal Areas
PIs: Pamela Murray-Tuite, Virginia Tech, murraytu@vt.edu; Ihab El-Shawarby, Virginia Tech, IEl-Shawarby@vtti.vt.edu; Hesham Rakha, Virginia Tech, hrakha@vtti.vt.edu; Brian Smith, University of Virginia, briansmith@virginia.edu
Period of Performance: October 1, 2014 – June 30, 2016
Other Participants and Collaborating Organizations:

- Willine Richardson – Undergraduate student, Morgan State University. Participant in MATS UTC Summer Research Experience Program (advised by Brian Smith)
- Aphisit Phoowarawutthipanich – Graduate student, Virginia Tech (advised by Pam Murray-Tuite)
- Dr. Jianhe Du – Sr. Research Associate, Virginia Tech
- Mohammed Aljamal – Graduate student, Virginia Tech (advised by Hesham Rakha)

Accomplishments:

- Modeling and running the various evacuation scenarios using INTEGRATION.
- Constructed the MATSIM input files.
- Running the various evacuation scenarios using MATSIM.
- Analyze the simulation results for INTEGRATION and MATSIM.
- Initiate the process of comparing the output results from INTEGRATION and MATSIM.
- Selected 307 data locations for storm surge in the Norfolk / Virginia Beach based on US Army Corps of Engineers data and models.
- Created a GIS boundary layer for use with the data locations and subsequent analyses.
- Gathered more data on time-series water elevation data results, 96 random phase tides, and digital elevation models.
- Designed a methodology for assessing the network vulnerability to sea level rise and storm surge.

Impact:

- This project will account for the total influences of sea level rise, storm surge and high tides.
- The conceptual framework can be transferred to other coastal areas.

Changes/Problems:

- There is missing water elevation data for some points since the validation of STWAVE model for those points is being performed. Not all the data needed for the project is not available on the Coastal Hazard System website, but should be available in the next few weeks, according to the US Army Corps of Engineers.

Project: Multimodal Transportation Facility Resilience Index
PIs: Nii Attoh-Okine (UD) – email: okine@udel.edu; Lindsay Ivey-Burden (UVa) – email: lindsay.ivey@virginia.edu
Period of Performance: October 1, 2014 – December 31, 2016
Accomplishments:

- Attended a training of how to use Big Data paradigm in Resilience Engineering

Products:

- Presented a Seminar at UVA
- Abstract submission to Big Data Conference – New York ' Big Data and Resilience Engineering

Impact:

- Working with Dr. Ivey-Burden to advise a Master's Thesis at UVA

Project: Structural Enhancements to Adapt to Impacts of Climate Change
PIs: Osman Ozbulut, University of Virginia, ozbulut@virginia.edu; Devin Harris, University of Virginia, dharris@virginia.edu
Period of Performance: October 1, 2014 – May 31, 2016
Accomplishments:

- This project focuses on reducing the vulnerability of civil infrastructure systems by developing and integrating advanced composite materials into sustainable structural design. In this reporting period, following activities were conducted:

Shape memory alloy fiber reinforced polymers:

- The roughened superelastic NiTi wires with a diameter of 0.495 mm were used as fibers. SMA coupons with different reinforcement ratios were fabricated using the vacuum assisted hand lay-up technique. In particular, the test matrix included five types of specimens with fiber volume ratios of 0%, 1.9%, 3.0%, 4.2%, and 4.9%. At least, five specimens were prepared and tested for each test set.
- The uniaxial tensile tests were conducted under monotonic loading. The carbon FRP tabs were glued on both sides of the gripping area in each specimen to prevent crushing of this area by the machine grips and enhance gripping during the test.
- The results of the tests were assessed in terms of ultimate strength, ultimate strain, and failure modes of the composites.
- Additional specimens with fiber volume ratios with 3% and 4.9% will be prepared soon for cyclic testing.

Shape memory alloy fiber reinforced concrete:

- The experimental results obtained from testing in the previous reporting period was analyzed and a journal paper was written.

Ultra high performance concrete (UHPC):

- The original experimental program for the UHPC component has shifted to include a primary emphasis on constitutive modeling of ultra-high and high performance concrete (relevant to other fiber reinforced concretes). Recent work has included the development of algorithms for randomizing and modeling discrete distributed fibers within the FEA software package ABAQUS. In addition, these modeling efforts have progressed to include techniques for model updating. In the coming period the project team is collaborating with VTRC to cast a series of high performance fiber reinforced concrete specimens that will be used for model validation and updating. The specimens will primarily be ASTM standard geometries (cylinders, beams, etc.), but will provide the necessary experimental data for model validation.

Products:

- Following conference papers prepared in the previous reporting period:
  → Khakimova, E., Sherif, M.M., Ozbulut, O.E., Harris, D.K., Ozyildirim, H.C. (2015). "Experimental investigations on shape memory alloy fiber reinforced concrete." Proceedings of The Joint 6th International Conference on Advances in Experimental Structural Engineering (6AESE) and 11th International Workshop on Advanced Smart Materials and Smart Structures Technology (11ANCRiSST), Urbana-Champaign, IL.
  → Khakimova, E., Sherif, M., Tanks, J. D., Ozbulut, O. E., Harris, D. K., Ozyildirim, H. C. (2016). "Feasibility of using shape memory alloys as fiber reinforcement in concrete." Proceedings of TRB Annual Meeting 2016, Washington, D.C., January 2016.
- A poster was presented in the First Annual MATC UTC Meeting in Delaware.
  → Khakimova, E., Sherif, M., Ozbulut, O. E., Harris, D. K., Ozyildirim, H. C. (2015). "Structural enhancements to adapt to impacts of climate change." Poster Presentation, MATS UTC Annual Meeting 2015, Wilmington, DL, August 6-7, 2015.
- In this reporting period, the journal paper below was prepared and submitted.
  → Sherif, M., Khakimova, E., Ozbulut, O. E., Harris, D. K., Ozyildirim, H. C. (2016). "Behavior of mortar and concrete beams with randomly distributed superelastic SMA fibers." Smart Materials and Structures, Under Review, Submitted, April 2016.
- Also, the following abstract was accepted for the presentation in Engineering Mechanics Institute (EMI) --
  → Conference and will be presented in May 2016.
  Daghash, S.M., and Ozbulut, O.E. (2016). "Development of fiber-reinforced polymer composites with superelastic shape memory alloys." Engineering Mechanics Institute Conference 2016, Nashville, TN, May 2016.

Impact:

- Engaged one undergraduate student (from underrepresented groups) for summer research.
- Three graduate students involved in the study.

Changes/Problems:

- The project team initiated discussions with researchers at the Federal Highway Administration (FHWA) to create UHPC specimens for the model validation phase; however, recent changes within the administration structure did not allow for FHWA to cast the specimens. The project team has developed an alternative path for collaborating the VTRC on casting.

Project: Accelerating Use of Sustainable Materials in Transportation Infrastructure
PIs: Devin Harris, University of Virginia, dharris@virginia.edu; Osman Ozbulut, University of Virginia, ozbulut@virginia.edu
Period of Performance: August 1, 2015 – May 24, 2016
Accomplishments:

- The self-sensing capabilities of GNP-reinforced hydraulic Portland cement composites were investigated.
- In particular, the effects of GNP content on the electrical properties and piezoresistive characteristics of mortar specimens were explored.
- In addition, a simple fabrication method that does not require special treating procedures such as ultrasonication and chemical (covalent) treatments for the dispersion of GNPs was pursued.
- The GNPs used in this study had an average thickness of 8 nanometers and a diameter of 25 microns.
- Standard prismatic mortar specimens containing different GNP concentrations (0%, 0.1%, 0.5%, 1%, 2.5%, 5%, 7.5%) were prepared using three different mixing procedures.
- The resistivity of the specimens was measured using a four-point probe method at different curing periods (1-day, 7-day, 14-day, and 28-day).

Products:

- Pavgi, R., Jiang, Z., Ramniceanu, A., Ozbulut, O. E., Harris, D. K. (2016). "Self-sensing cementitious composites with graphene nanoplatelets." International Concrete Sustainability Conference 2016, Washington, D.C., To be presented in May 15-18.

Impact:

- Engaged one undergraduate student (from underrepresented groups) for summer research.
- One graduate student involved in the study.

Project: Microbial Biomarkers for ASR-Damaged Concrete
PIs: Julia Maresca, University of Delaware, jmaresca@udel.edu; Devin Harris, University of Virginia, dharris@virginia.edu
Period of Performance: June 1, 2015 – May 31, 2017
Accomplishments:

- DNA has been extracted from concrete
- Microbial populations in initial test cylinders have been characterized
- The amount of sequencing performed is more than enough to completely sample the microbial population

Products:

- Manuscript has been submitted (2/23/16) and is in review at Materials & Structures
- Research has been presented at a Gordon Research Conference (July 2015) and the American Concrete Institute meeting (November 2015)
- Research has been presented at invited seminars at Villanova University (October 2015), Wentworth Institute of Technology (November 2015), Michigan State University (November 2015), and Towson University (April 2016)

Impact:

- 3 undergraduates have worked on this project
- 1 graduate student has been trained
- experiments have provided preliminary data for one pending NSF proposal (Environmental Engineering program) and one NSF proposal in preparation (CMMI)

Changes/Problems:

- Graduate student working on this project has left UD
- A postdoctoral researcher will be joining the lab in mid-April and will perform the necessary work this spring
- Anticipate hiring a new graduate student in the fall

Project: Implementation of "Smart Equipment" in Field Construction
PIs: Christopher Meehan, University of Delaware, cmeehan@udel.edu
Other Participants and Collaborating Organizations: Dhruv Batra, Virginia Tech, Blacksburg, VA; Jim Pappas and Javier Torrijos, Delaware Department of Transporation, Dover, DE
Period of Performance: June 1, 2015 – May 31, 2017
Accomplishments:

- A retrofit equipment kit for continuous compaction control (CCC) soil compactors has been approved for procurement by DelDOT for utilization with future field studies. This retrofit kit will be installed on an existing soil compaction roller in order to collect real time data about compaction effectiveness during future field studies. The purchase of this equipment will allow the University of Delaware research team to perform CCC for soil compaction on an active project site. Along with this retrofit kit, several other essential pieces of equipment including in situ testing equipment (i.e., a dynamic cone penetrometer) and a DAQ/accelerometer system from National Instruments have been proposed to DelDOT for possible procurement; these sensors and other tools are planned for use with our future field studies.
- The University of Delaware research team has also been in contact with SITECH (a local equipment vendor) for scheduling training for the proper use of this retrofit kit, to better understand how to utilize this equipment in the field. The planned training will take place prior to our first field study.
- The University of Delaware research team has also made continuous progress in their Literature Review and current state of the art analyses for Intelligent Compaction applications (i.e. geospatial analyses, kriging and other spatial interpolation analyses). The University of Delaware research team is also looking into more advanced state of the art machine learning techniques and their potential usefulness for application to analysis of CCC/IC data sets.

Products:

- One Presentation regarding the current findings from this project has been presented:
  Baker, W. J. and Meehan, C. L. (2016). "Utilizing Continuous Compaction Control to Improve Soil Compaction." Delaware Valley Geo-Institute Meeting, Villanova University, Villanova, PA, 2/9/16, (poster presentation).
- Two additional poster presentations are planned for the next period of performance.

Changes/Problems:

- To date, the major challenge for the project has been the logistics of procuring the necessary equipment in order to conduct the proposed field studies. The process has been moving in the right direction with the approval to procure but the timeline on when the equipment will be procured and ready for field implementation is still an unknown or not clearly defined.

Project: Enhancing Traffic Control Systems to Reduce Emissions and Fuel Consumption
PIs: Andrew Nichols, Marshall University, andrew.nichols@marshall.edu; Brian Park, University of Virginia, brianpark@virginia.edu; Hesham Rakha, Virginia Tech, hrakha@vtti.vt.edu; Montasir Abbas, Virginia Tech, abbas@vt.edu
Period of Performance: October 1, 2014 – March 31, 2016
Accomplishments:

- Work has commenced on the final report for the project. The majority of the research has been completed at this point.

Products:

- Three papers from this project were submitted and presented at TRB in January 2016. At least one of those papers was accepted for publication by the Journal of the Transportation Research Board. Versions of the other two papers are being submitted for publication with other journals.

Impact:

- This will be better summarized after the final report is compiled and all information is obtained from the co-PIs.

Project: Network-wide Impacts of Eco-routes and Route Choice Behavior/Evaluation of AERIS Applications
PIs: Hesham Rakha, Virginia Tech, hrakha@vtti.vt.edu; Kyoungho Ahn, Virginia Tech, kahn@vtti.vt.edu; Mecit Cetin, Old Dominion University, mcetin@odu.edu; Brian Park, University of Virginia, bpark@virginia.edu

Period of Performance: November 1, 2014 – April 30, 2016
Accomplishments:

- VT researchers made 3 conference presentations and published 2 refereed conference publications and 1 journal publication.
- An Eco-CACC system developed in an earlier study was implemented in the INTEGRATION traffic simulation software. A simulation sensitivity analysis demonstrated that as the CACC-equipped vehicle market penetrate rate increases the energy and environmental benefits also increase, and that the overall savings in fuel consumption are as high as 19% when the market penetration rate is 100%. On multi-lane roads, the algorithm may produce network-wide increases in the fuel consumption level when the market penetrate rate is less than 30%. The analysis also demonstrates that the length of control segments, the Signal Phasing and Timing (SPaT) plan, and the traffic demand levels significantly affect the algorithm performance. The study further demonstrates that the algorithm may produce increases in fuel consumption levels when the network is over-saturated and thus further work is needed to enhance the algorithm for these conditions.
- New algorithms were developed for the prediction of future states. These models could be integrated within the Eco-routing system.
- The research team from ODU has developed methods to predict traffic volumes based on trajectory data from probe vehicles. The preliminary results were presented at the 18th International IEEE Conference on Intelligent Transportation Systems. New methods for estimating volumes are developed based on the shockwave theory. Results from these new methods are going to be presented at the EURO Working Group on Transportation Meeting in September 2016.

Products:
The following papers were presented:

- Venkat Ala M., Yang H., and Rakha H. (2016), "A Modeling Evaluation of Eco-Cooperative Adaptive Cruise Control in the Vicinity of Signalized Intersections," 95th Transportation Research Board Annual Meeting, Washington DC, January 10-14. [Paper # 16-2891]
- Elhenawy M. and Rakha H. (2016), "Expected Travel Time and Reliability Prediction using Mixture Linear Regression," 95th Transportation Research Board Annual Meeting, Washington DC, January 10-14. [Paper # 16-2813]
- Elhenawy M. and Rakha H. (2016), "Traffic Stream Speed Short-term Prediction using Machine Learning Techniques: I-66 Case Study," 95th Transportation Research Board Annual Meeting, Washington DC, January 10-14. [Paper # 16-3805]
- K. A. Anuar and M. Cetin, “Estimating Freeway Traffic Volume Using Shockwaves and Probe Vehicle Trajectory Data”, Accepted for presentation at the 19th EURO Working Group on Transportation Meeting (EWGT2016), Istanbul, Turkey, September 5-7, 2016. (to be presented)

The following papers were published in a journal:

- Venkat Ala M., Yang H., and Rakha H. (2016), "A Modeling Evaluation of Eco-Cooperative Adaptive Cruise Control in the Vicinity of Signalized Intersections," *Transportation Research Record: Journal of the Transportation Research Board*. DOI:10.3141/2559-13.

Impact:

- The research conducted as part of this project was included as a two-week module in the joint Transportation Sustainability course that was offered as part of MATS UTC.
- A webinar was presented on the project on March 23, 2016.

Project: Environmental and Safety Attributes of Electric Vehicle Ownership and Commuting Behavior: Public Policy and Equity Considerations
PIs: Z. Andrew Farkas, Morgan State University, andrew.farkas@morgan.edu; Hyeon-Shic Shin, Morgan State University, hyeonshic.shin@morgan.edu; Christine Risch, Marshall University, christine.risch@marshall.edu
Period of Performance: October 1, 2014 – September 30, 2016
Collaborating Organizations: Maryland Motor Vehicle Administration, Glen Burnie, MD; Electric Vehicle Association-DC Chapter, Rockville, MD; Maryland Electric Vehicle.org
Accomplishments:

- Planned steps with MVA of deriving two large samples of registered vehicle owners in Maryland (MVA finally determined that there were no data privacy issues).
- Conducted extensive survey distribution to various EV and conventional vehicle owners' forums.
- Collected survey responses and analyzed data preliminarily.

Products:

- Poster presentation at Morgan Innovation Day at State Legislature, March 15, 2016

Impact:

- Topics of electric vehicles and owner attitudes and commuting behaviors have been discussed in various transportation and planning classes.
- Maryland Electric Vehicle Infrastructure Council has been informed of preliminary survey results and strategies for public charger locations have been influenced as a result

Changes/problems:

- Because MVA was concerned about data privacy, planned distribution of surveys to registered vehicle owners was greatly delayed. Team distributed surveys to various forums (see above).
- Scope of project has been enlarged to include national level survey data. National data will be used for stand-alone analyses and for comparisons with state level data.
- Project is now in two phases: (1) national survey of interest groups and (2) survey of registered vehicle owners in Maryland. A project final report of first phase will be developed in next reporting period.
- Estimated completion of phase 1 is September 2016.

Project: Mitigating Pollutants from Highway Infrastructure for Total Maximum Daily Load (TMDL) Compliance: Monitoring Efficacy of Best Management Practices and Advancing Decision Support

PIs: James Hunter, Morgan State University, james.hunter@morgan.edu; Dong Hee Kang, Morgan State University, donghee.kang@morgan.edu; Teresa Culver, University of Virginia, tculver@virginia.edu

Period of Performance: October 1, 2014 – May 31, 2016

Accomplishments:

- Leveraging this research effort for a project with the Maryland State Highway Administration to focus on characterization of pollutants from inlet cleaning activities. Awarded March 2016, this project will start April 1, 2016.

Products:

- Oral Presentation: Hunter, J.G. and Kang, D.H.. Using the Long-Term Hydrologic Impact Assessment Method as a tool for Stormwater Compliance. World Environmental and Water Resources Congress 2016. ASCE. (abstract accepted)

Impact:

- This research will help highway agencies determine appropriate crediting of practices for TMDL compliance and to collect information that could support enhancements to the existing credit allowed.

Project: Integrated Data for Improved Asset Management

PIs: Jonathan Goodall, University of Virginia, goodall@virginia.edu; Devin Harris, University of Virginia, dharris@virginia.edu; Brian Smith, University of Virginia, bls2z@virginia.edu

Period of Performance: August 1, 2015 – May 24, 2016

Other Participants and Collaborating Organizations: Drew Scott, District Hydraulic Engineer, VDOT, Hampton Roads District, VA; Greg Johnson, Stormwater Technical Services Engineer, Virginia Beach, Department of Public Works

Accomplishments:

- We have obtained bridge datasets from VDOT and are combining these data with digital terrain data and hydrologic data and models to estimate the river stage at bridge locations during extreme (100, 200, and potentially 500 yr) storm events. The goal is to determine which, if any, bridges will be overtopped by these large storm events by using only available data. The data being used in the analysis is an integration of information from VDOT and other data federal, state, and local providers. It includes bridge spatial locations and attributes, high-resolution digital terrain datasets, river centerlines from the National Hydrography Dataset, and flood model outputs from FEMA.

Impact:

- We are working closely with Drew Scott, VDOT's District Hydraulic Engineer for the Hampton Roads District.

Project: Evaluation of Waste Concrete Road Materials for Use in Oyster Aquaculture
PIs: Dong Hee Kang, Morgan State University, donghee.kang@morgan.edu; Anastasia E. M. Chirnside, University of Delaware, aemc@udel.edu; Mark Bundy, Michigan State University PEARL, mark.budy@morgan.edu
Period of Performance: August 1, 2015-December 31, 2016
Collaborating Organization: Maryland State Highway Administration, Baltimore
Accomplishments:

- All results of organic chemical concentration in RCA were BDL (Below Detection Limit) for both extraction methods of Flanigan & Sons, Inc. Four organic chemicals for EPA 3570 extraction procedure were detected at the samples collected from Machado Construction Co., Inc. and The Recycling Center. However, the concentrations were at least 100 times lower than COMAR 26.08.02.03-2. The result concluded that RCA should give no concern for hydrocarbon components releasing into Chesapeake Bay waster shed, if RCA is used as a bottom conditioning material for oyster aquaculture.

Products:

- Submit the final report as draft to SHA

Impact:

- Undergraduate students are involved in the process. Students are learning sample collection, preparation, and extraction methods. They also learned GC-MS operating skill.

Changes/Problems:

- Additional chemicals leaching test using collected RCA samples will be carried out.

Project: Land Use Master Planning for Environmental Sustainability
PIs: Marcia Scott, University of Delaware, msscott@udel.edu; Mingxin Li, University of Delaware, lmx@udel.edu; Sinaya Dayan, Marshall University, dayans@njrati.org
Period of Performance: September 1, 2014 – August 31, 2016
Accomplishments:

- Developed total of 6 ArcGIS Story Maps (in various formats) to harness the power of maps with multi-media content to engage stakeholders in planning for transportation sustainability, foster technology transfer, and disseminate research outcomes
- Created UD IPA Implementing Complete Communities in Delaware GIS Story Map Gallery: http://udel.maps.arcgis.com/apps/MapAndAppGallery/index.html?appid=c72d06880390498b9193b12617943592
- Produced 3 YouTube presentations to use the a popular online video-sharing website for both scholarly and non-scholarly communication
- Both seasoned ArcGIS practitioners and non-skilled graduate students learned the ability to develop ArcGIS Story Maps as an effective and engaging strategy to both disseminate outcomes of research and
- Learned the effectiveness of YouTube as a scholarly/non-scholarly resource and graduate-level course module delivery method
- Learned the value of Infographics as a creative graduate-level assignment, a medium to provide visual representation of data, and visualization tool to disseminate information on transportation sustainability

Products:
Produced 6 ArcGIS Story Maps:
Marshall University Rahall Transportation Institute (RTI) - Moving Towards Sustainability in Extraction Economies of
Appalachia: http://marshalluniv.maps.arcgis.com/apps/MapJournal/index.html?appid=bc38294006b242608fdbc65682ae74d4
University of Delaware, Institute for Public Administration (IPA) - Implementing Complete Communities in Delaware

- Complete Streets: Context-Sensitive Solutions
  - http://www.arcgis.com/apps/MapSeries/index.html?appid=6cb7a5e0fe6d47cbbad8e4b3816c458c

- Healthy and Livable: Planning for Aging-Friendly Communities - http://www.arcgis.com/apps/MapSeries/index.html?appid=a5ff645c56534cb599352500180ea127
- Efficient Land Use: Mixed-Use Development - http://www.arcgis.com/apps/StorytellingSwipe/index.html?appid=8c9eb040ec3346b3a0e3032ba17bc40c#
- Inclusive and Active: Historic Preservation – http://www.arcgis.com/apps/MapSeries/index.html?appid=dbc4cd68813945368caa7bd726384c4c
- University of Delaware IPA – Downtown Development Districts in Delaware: http://www.arcgis.com/apps/MapJournal/index.html?appid=c9fcb8233bab4dc99c4618283fadb6ae

2 Articles in Delaware Center for Transportation's (DCT) TranSearch Newsletter (Winter 2016):

- IPA Policy Scientists Instruct MATS UTC Sustainability Course Modules (Mix/Scott, p. 3)
- Using GIS Story Maps to Engage Citizens (Edwards, Scott, p. 4)

http://sites.udel.edu/dct/files/2013/12/DCT-UTC-2016-Winter-Newsletter-Final-2g2pqrv.pdf

UD IPA Graduate Student Acceptance of Abstract for April 2016 DELMARVA GIS Conference – The abstract, "Utilizing GIS Story Maps to Engage Citizens in Planning for Complete Communities in Delaware," was selected for a presentation and poster

- Savannah Edwards, IPA Public Administration Fellow is preparing a PowerPoint and a 24 H" X 36 W" poster entitled, " for the 2016 DELMARVA GIS Conference on April 14, 2016

UD IPA YouTube Presentations – Produced and narrated 3 presentations for MATS UTC Transportation Sustainability Course Module and uploaded to IPA's online *Delaware Complete Communities Planning Toolbox's* YouTube Channel (www.youtube.com/user/CompleteCommunities):

- **Moving from Smart Growth to Sustainable and Complete Communities** (40.11 minutes, 28 views)
- The Built Environment and Healthy Communities (22.12 minutes, 253 views)
- Benefits and Economic Implications of Complete Streets (26.53 minutes, 93 views)

MATS UTC Website Post:

Example Infographics from Graduate Course in Transportation Sustainability (December 11, 2015)

Impact:

Transportation Education –

- YouTube offers an opportunity to instructors to expand their educational audiences by providing course online content and increasing the public's awareness of the course module topic.
- Presentations on Smart Growth, Built Environment and Health, and Complete Streets are easily accessible online to both graduate students and faculty from other institutions
- Platform provides additional opportunities to engage students visually in the educational learning process

Research –

- Production of 6 GIS Story Maps that can be accessed online
- Drafting white paper to describe value of GIS Story Map technology in visually conveying and communicating outcomes of smart growth plans, policies, and practices

Technology Transfer –

- **Winter 2016 DCT TranSearch Newsletter articles**
- **2016 Delmarva GIS conference presentation** – April 14 presentation/poster will showcase outcomes of research on smart growth, support goals of regional GIS community, and improve the coordination of the use of GIS tools and spatial data in the Delmarva area.

MATS UTC Website Post on Use of Infographics in Graduate Course Module

Changes/Problems:

- Phase I report editing/publication delay (Ph.D. student assigned to project dropped out of program). Editing now underway of final report: *The Use of Smart Growth Scorecards/Assessment Tools to Advance Sustainable Land-Use Practices*

Project: Driver Education for New Street Facilities and Operations: Multimodal and Traffic Management
PIs: Andrew Mondschein, University of Virginia, mondschein@virginia.edu
Period of Performance: August 1, 2015 – August 24, 2016
Other Participants and Collaborating Organizations:

- Amy O'Leary, John Miller, Peter Ohlms, Virginia Center for Transportation Innovation and Research (VCTIR)
- Virginia Statewide Bicycle and Pedestrian Committee

Accomplishments:

- Assembled review of literature on driver education practices for new multimodal infrastructure
- Assembled database of driver education materials
- Conducted and transcribed in-depth interviews with professional regardless the implementation and effectiveness of current driver education practices
- Currently compiling synthesis of research and practice as a part of best practices guidebook.
- Key findings: Relationship of education and outreach to multimodal planning and design practice, categorization of driver education practices by type of infrastructure, geographic scale, medium, content, actors, financial commitment, and other factors, barriers to implementation of driver education

Products:

- Technical report and best practices guidebook for Virginia DOT (to be submitted May 2016)
- Qualitative data can be made available on MATS UTC Dataverse

Impact:

- Engaged 2 graduate planning students and one undergraduate in the research
- Will supply findings to VDOT to contribute to driver education best practices
- Will continue to disseminate results at TRB and through submission of paper for journal publication

Project: Develop and Test Connected Vehicle Freeway Speed Harmonization Systems
PIs: Hesham Rakha, Virginia Tech, hrakha@vtti.vt.edu; Ihab El-Shawarby, Virginia Tech, shawarby@vtti.vt.edu
Period of Performance: July 1, 2015 – June 30, 2017
Accomplishments:

- Developed speed harmonization algorithm using reinforcement learning and conducted preliminary simulation testing on a section of I-66.
- Developed speed harmonization algorithm using bang-bang control and conducted preliminary simulation testing of the algorithm on a section of I-66.

Products:

- We have written two papers and one of the papers is under review in the IEEE Transactions on ITS.

Project: Exploring the use of LIDAR data from Autonomous Cars for Estimating Traffic Flow Parameters and Vehicle Trajectories
PIs: Mecit Cetin, Old Dominion University, MCetin@odu.edu
Period of Performance: October 1, 2015 – September 30, 2017
Accomplishments:

- Field data collected with Velodyne VLP-16 mounted on a sedan vehicle driven on arterial and freeway segments for about 30 minutes
- Collected LIDAR data processed in Matlab. Preliminary methods implemented in Matlab for segmenting and classifying point cloud data so that vehicles can be identified and tracked.

Products:

- C. Sazara, R. V. Nefazat, and M. Cetin, "Multiple target tracking using LIDAR detection", Accepted for presentation at the 19th EURO Working Group on Transportation Meeting (EWGT2016), Istanbul, Turkey, September 5-7, 2016.

Project: Alternative Fuels Usage in Maritime Transportation System
PIs: Jennifer Shand, Marshall University, shandj@cbermu.org; James Corbett, University of Delaware, jcorbett@udel.edu
Period of Performance: January 1, 2015 – July 31, 2015
Accomplishments:
Research was completed. Market analysis indicated that while the supply of natural gas is abundant within the region due to the Marcellus shale activities, existing LNG supplies may be insufficient to support long term growth. In addition to competing uses for natural gas, which serves chemical manufacturing and energy industries, a critical condition for the use of LNG as an alternative fuel is complementary refueling infrastructure, which is largely absent at current.
Further analysis of technological conversion for inland fleet indicate that switching to LNG would reduce emissions from GHGs except CO. High capital costs of conversion and age of current fleet suggest gradual phase in of technology may be preferred among operators. Within Region 3, West Virginia merits additional study as an option for investing in LNG infrastructure based on vessel age, activity and emissions.
Products:
A combined report consisting of two papers – the market analysis (supply considerations) and the vessel technology analysis (demand) has been submitted to UVA.
Paper/presentation submission to TRB for technology analysis is anticipated.
Impact: The research highlights economic issues and considerations associated with large scale fleet conversions for using LNG as an alternative fuel in inland maritime for Region 3. While conversion may produce some emission reductions, critical issues include capital costs of retrofitting or new vessels as well as the lack of complementary refueling infrastructure within Region 3. While natural gas supply is currently abundant due to Marcellus shale activities, this supply is used in several industries such as power generation and chemical manufacturing, in addition to transportation.
Changes/Problems: Communication challenges and unique expertise between project partners necessitated separately pursuing scopes of work, producing two separate papers which constituted the final report. Potential for future integration of work exists.

Appendix B Competitive Collaborative Projects (Awarded in 2015)

Project: Designing Bicycle and Pedestrian Traffic Count Program to Estimate Performance Measures on Streets and Sidewalks in Blacksburg, VA
PIs: Steve Hankey, Virginia Tech, hankey@vt.edu; Ralph Buehler, Virginia Tech, ralphbu@vt.edu; Andrew Mondschein, University of Virginia, mondschein@virginia.edu
Period of Performance: January 1, 2015 – May 31, 2016
Collaborating Organization: Town of Blacksburg – town staff provides crews to divert traffic during installations. Town planning staff has helped with assessing count location feasibility.
Accomplishments:

- Completed collection of traffic counts at continuous reference sites (4 locations; 1 year of traffic counts).
- Completed short-duration traffic counts (96 locations; 1-week of traffic counts per location).
- Adjusted all count data using correction equations; QA/QC of suspect data for entire count campaign.
- Developed negative binomial regression models to impute missing count days at reference sites.
- Developed day-of-year scaling factors based on the 4 continuous reference sites.
- Estimated annual-average daily traffic (AADT) for all 101 count sites.
- Completed aggregation of land use variables at all count sites.
- Developed preliminary facility-demand (spatial) models of bicycle and pedestrian traffic in Blacksburg, VA.

Products:

- A Masters Thesis (Tianjun Lu) based on the analysis described in the analysis section.
- Regular meetings and reports with Town of Blacksburg staff on progress.

- AADT estimate for 10% of the transportation network in Blacksburg, VA.
- A cleaned non-motorized traffic count dataset that includes ~42,000 hours of traffic counts.
- Preliminary working papers to be developed into journal articles to publish our findings.
- Preliminary findings for a literature review of direct-demand modeling.
- Two accepted conference presentations at NATMEC (Miami, FL).

Impact:

- To date, this project has involved 3 students in the process of data collection, data analysis, and write ups.
- We have worked to ensure our results are shared with members of the Town of Blacksburg Planning Staff. We will continue to develop a final report and presentation to staff.
- Count equipment has been used in class exercises (taught by S Hankey) to allow students to deploy counters and work with count data.

Project: Simultaneous Removal of Nitrogen and Phosphorus from Stormwater by Zero-Valent Iron and Biochar in Bioretention Cells

PIs: Pei Chiu, University of Delaware, pei@udel.edu; Paul Imhoff, University of Delaware, imhoff@udel.edu; Teresa Culver, University of Virginia, tculver@virginia.edu

Period of Performance: January 1, 2015 – May 31, 2016

Other Participants and Collaborating Organizations: Dan Sweet and Kristel Riddervold, City of Charlottesville, VA; Kip Mumaw, Ecosystem Services, LLC, VA; Charles Hegberg, ReGenesis Global Solutions, LLC/Infinite Solutions L^3C, PA

Accomplishments:

- Post-retrofit sampling completed for four storms, between August 2015 to March 2016.
- Comparison data collected for 3 storms at a nearby non-retrofitted facility.
- Experimental design for biochar electron storage capacity measurement completed.
- Three column experiments completed to measure phosphate removal by ZVI.
- A manuscript published on the mechanism of biochar-promoted nitrate removal.
- A visit to Venable site, and a project meeting at UVa, were conducted on Feb. 19, 2016.

Products:

- Peer-Reviewed Journal Papers:
  Saquing, J., Yu, Y.-H. and Chiu*, P. C. (2016) "Wood-Derived Black Carbon (Biochar) as a Microbial Electron Donor and Acceptor" *Environmental Science & Technology Letters*, 3(2), 62-66.
  Tian, J., Miller, V., Chiu, P. C., Maresca, J. A., Guo, M. and Imhoff*, P. T. (2016) "Nutrient Release and Ammonium Sorption by Poultry Litter and Wood Biochars in Stormwater Treatment" *Science of the Total Environment*, 553, 596-606.
- Conference Presentations:
  02/16 The 3rd Microbial Systems Symposium, Newark, DE. Oral presentation. "Black Carbon as a Microbial Electron Donor and Acceptor."
  02/16 The 3rd Microbial Systems Symposium, Newark, DE. Poster presentation. "Wood-Derived Biochar as a Microbial Electron Donor and Acceptor."
  12/15 American Geophysical Union (AGU) 2015 Fall Meeting, San Francisco, CA. Oral presentation. "Biochar Addition to Stormwater Treatment Media for Enhanced Removal of Nitrogen."
- In addition to the above, a MATS UTC Research Webinar, entitled "Simultaneous Removal of Nitrogen and Phosphorus from Stormwater by Zero-Valent Iron and Biochar in Bioretention Cells", is scheduled for April 27, 2016, to be presented by the investigators.

Impact:

- 13 undergraduates and 1 graduate student engaged in the study at UVa.
- 3 undergraduates, 2 graduate students, and 1 postdoc involved in the study at U of DE.
- Laboratory experiments confirmed a hypothesized mechanism for biochar-promoted microbial reduction of nitrate. In addition, we determined the electron capacity of the biochar used in this and other field applications. Both the mechanistic understanding and the measured capacity of biochar can yield strategies that will improve then design and performance of bioretention systems for stormwater treatment.

- PI Imhoff participated in the Chesapeake Bay Day on Capitol Hill (March 2016). Imhoff presented a poster to congressional staff on research to reduce the cost of stormwater BMPs treating nutrient runoff from transportation systems.

Changes/Problems:

- At the field site in the City of Charlottesville, VA, the bioretention medium was modified by mixing in biochar and zero valent iron (ZVI). Because this freshly-prepared medium also includes an organic compost and fine particles, initial stormwater effluent samples in 2015 indicated nitrogen leaching from the organic compost and release of particulate matter, complicating the assessment of biochar/ZVI for reducing nitrogen concentrations. This problem will be addressed by focusing our field sampling in 2016, after the medium has aged.

Project: Impact of Climate Change and Sea Level Rise on Stormwater Design and Reoccurring Flooding Problems in the Hampton Roads Region

PIs: Jonathon Goodall, University of Virginia, goodall@virginia.edu; Venkat Sridhar, Virginia Tech, vsri@vt.edu
Period of Performance: January 1, 2015 – May 31, 2016
Collaborating Organization: Hampton Roads Planning District Commission
Accomplishments:

- Historic analysis of climate extremes using National Climatic Data Center (NCDC) is done for the period between 1950 and 2015. The stations for our analysis include Williamsburg, Elizabeth City, Norfolk, Richmond and Wakefield and these are located in the vicinity of Coastal Virginia. This step is verified with the downscaled CMIP5 General Circulation Model (GCM) scenarios. The locations for GCM verification are selected in such a way that each NCDC station remains within the corresponding grid cell of the downscaled (1/16th of a degree) data. The fifteen climate models are: bcc-csm1-1, bcc-csm1-1-1, BNU-ESM, CanESM2, CCSM4, CNRM-CM5, CSIRO-Mk3-6-0, GFDL-ESM2G, GFDL-ESM2M, inmcm4, IPSL-CM5A-LR, IPSL-CM5A-MR, IPSL-CM5B-LR, MIROC5, and MIROC-ESM.
- We have completed the simulations with Weather Research and Forecasting (WRF) model to dynamically downscale North American Regional Reanalysis (NARR) data from 32 km to 4 km resolution for the period of 1985 – 2010 and the results will be available in May.
- What we have learned so far is that station-based observed precipitation data for Intensity, Frequency, and Duration analysis trends show that there is an increase in IDF in the past 30 years and in the future as well.
- We have gathered all gauged rainfall data from the City of Virginia Beach, HRSD, and Weather Underground. We have analyzed the 20 days with the highest rainfall amounts to determine spatial variability within the data for 1 day, 1 hour, and 15 minute time steps. This analysis aims to determine the required spatial density of rainfall stations to capture rainfall patterns for large events.
- We have collected and analyzed the LIDAR DEM for the region to identify watersheds for the region and to assess the vulnerability of transportation infrastructure to higher sea levels and storm surge. Undergraduate students have participated in this research effort as part of a CE 4990 capstone course.

Products:

- A conference presentation at the National Capital Region American Water Resources Association in Washington D.C was made in April 2015 [Valayamkunnath, P., M. Billah and V. Sridhar (2015) Design storm and climate change analysis in Eastern Virginia)
- Contributed to the poster presentation made by Dr. Goodall and his graduate student at the MATS UTC Annual Meeting in Wilmington, DE , Aug 2015
- A conference presentation at the National Capital Region American Water Resources Association in Washington D.C was made in April 2016 [M. Billah, Valayamkunnath, P., and V. Sridhar (2016) Impacts of Extreme Precipitation on Flood Frequency in Southeastern Virginia)
- A presentation has been accepted for the upcoming ASCE EWRI conference in May, 2016.

Impact:

- Conducted workshop on sea level rise and infrastructure vulnerability held in May 2015 at Virginia Beach, VA
- Two to three manuscripts for publication in a peer-reviewed journal are in preparation.

Project: LiDAR for Air Quality Measurement

PIs: Khan Iftekharuddin, Old Dominion University, iftekhar@odu.edu; Mecit Cetin, Old Dominion University, MCetin@odu.edu; Hesham Rakha, Virginia Tech, hrakha@vtti.vt.edu

Period of Performance: January 1, 2015 – November 30, 2016

Collaborating Organization: NASA Langley, Hampton VA

Accomplishments:

- Restored the operation of the Lidar by collaboration with Dr. Russell Deyoung from NASA Langley
- Procured new polarizer for channel 532 LiDAR to obtain depolarization ratio of aerosol
- Installed the new polarizer on the Lidar and currently working to obtain depolarization ratio measurements
- Hosting Dr. Jasper Lewis from NASA Goddard Space Flight Center and U of Maryland BC for collaborative research discussion in atmospheric particulate material (PM) detection and tracking
- Working on algorithms to obtain the PM measurement in the atmosphere
- Wrote and submitted a paper on identifying the source of a pollutant based on LiDAR measurements.

Products:

- Submitted an abstract of conference paper to Optics and Photonics for Information Processing X, part of SPIE Optical Engineering + Applications, August 2016
- Submitted a paper to the SAE Journal. We received comments and are working on addressing the reviewer comments.

Impact:

- The end goal of the project is to improve the LiDAR capability in profiling the aerosol in Hampton Roads area. The new capability for the instrument to measure the depolarization ratio, in addition to the color ratio, such that the new acquired measurements will be excellent source for analyzing the air quality and the identifying the sources of the aerosol in the area of study.

Changes/Problems:

- The current end date for this project been extended until December 2016

Project: Connected Vehicle Technologies for Energy Efficient Urban Transportation

PIs: Ajay Prasad, University of Delaware, prasad@udel.edu; Suresh Advani, University of Delaware, advani@udel.edu; Hyeon-Shic Shin, Morgan State University, hyeonshic.shin@morgan.edu

Period of Performance: January 1, 2015 – May 31, 2016

Accomplishments:

- A sizing study of a fuel cell/battery hybrid vehicle was conducted to optimize fuel economy and fuel cell stack durability. It was shown that the combination of smaller battery and larger fuel cell stack gives better fuel economy with the penalty of higher capital cost associated with the larger fuel cell stack. The optimization study is aimed at achieving the desired balance between fuel consumption and capital cost.
- A radial basis function (RBF) neural network was trained using our simulation model of our fuel cell hybrid bus to predict end state-of-charge (SOC) of the battery. The inputs to the neural network include the initial SOC, 60 seconds of velocity profile, and fuel cell power. The purpose of the neural network is to reduce the computational load by eliminating realtime execution of the dynamic programming optimization of the physical model of the vehicle and enable realtime onboard implementation of the optimal power management system. Performance validation by field implementation will be conducted next.

Products:

Newsletter Articles –

- DCT Newsletter: Exploring Connected Vehicle Technologies with the UD Fuel Cell Hybrid Bus, Yongqiang Wang, Suresh Advani and Ajay Prasad, Center for Fuel Cell Research, Department of Mechanical Engineering, University of Delaware, https://sites.udel.edu/dct/files/2013/12/DCT-UTC-Newsletter-Summer-2015-279n2wk.pdf

Webinar –

- Connected Vehicle Technologies for Energy Efficient Urban Transportation" Ajay Prasad, Yongqiang Wang, and Suresh Advani, University of Delaware, http://www.matsutc.org/2016/02/please-join-us-on-our-mats-utc-research-webinar-series/

Journal articles –

- Wang Y, Advani SG, and Prasad AK, "A real-time optimal power management system for fuel cell hybrid vehicles based on dynamic programming and neural networks," (in preparation for Applied Energy).
- Wang Y, Advani SG, and Prasad AK, "Optimization-based sizing study of fuel cell hybrid vehicles with durability considerations," (in preparation for Energy).

  *Data from this project can be made available to anyone on a Dataverse site.