



**USDOT Tier 1 University Transportation Center**

**Semi-Annual Progress Report #1**

Federal Agency: Office of the Assistant Secretary for Research and Technology

Federal Grant ID #: 69A3551747130

Project Title: Maritime Transportation Research and Education Center (MarTREC)

Center Director: Heather Nachtmann, Ph.D., Professor, Department of Industrial Engineering, University of Arkansas, [hln@uark.edu](mailto:hln@uark.edu), 479.575.6021

Submission Date: April 30, 2019

DUNS: 1914297450000

EIN: 71-6003252

Recipient Organization: University of Arkansas

Project/Grant Period: Start Date November 30, 2016  
End Date: September 30, 2022

Reporting Period Start Date: October 1, 2018  
Reporting Period End Date: March 31, 2019

Report Term or Frequency: six months

Signature: 

**Maritime Transportation Research & Education Center (MarTREC)** is a USDOT Tier 1 University Transportation Center funded through the Office of the Assistant Secretary for Research and Technology. Under the FAST Act, MarTREC is *working to preserve the Nation’s transportation system through efficient, resilient, and sustainable maritime and multimodal logistics and infrastructure*. Our vision is to be recognized as the Nation’s premier source for expertise on maritime and multimodal transportation research and education. Made up of renowned maritime transportation researchers dedicated to transferrable research and inclusive education and workforce development, the MarTREC consortium are University of Arkansas (UARK), Fayetteville, AR; Jackson State University (JSU), Jackson, MS; Louisiana State University (LSU), Baton Rouge, LA; University of New Orleans (UNO), New Orleans, LA; Texas A&M University/Texas Transportation Institute (TAMU/TTI), College Station, TX; and Vanderbilt University (VU), Nashville, TN. Maritime and related multimodal transportation research is critical to the future of our transportation system and should be a national priority. Given the link between gross domestic product and international trade, which is expected to double over the next 30 years, efficient and resilient ports are critical to the nation’s overall economy and the ability of intermodal carriers to move freight between ports of entry and inland locations. Proximity to navigable waterways makes this consortium uniquely situated to address our theme.

**1. Accomplishments**

**1.1 Consortium-Level Accomplishments**

**1.1.1 Research**

Goal: MarTREC will conduct research that contributes to preserve the Nation’s transportation system through efficient, resilient, and sustainable maritime and multimodal logistics and infrastructure.

Objectives:

- Conduct research projects related to MarTREC’s research goal
- Engage a diverse set of faculty and students in MarTREC research activities
- Disseminate research findings

Accomplishments:

Research Effectiveness Metrics	Progress
# of peer-reviewed journal articles (published, accepted, submitted)	19
# of conference presentations given	37
# of students participating in transportation research projects funded by UTC	35

**1.1.2 Leadership**

Goal: MarTREC will become the premier source for expertise on maritime transportation research, education, and workforce development.

Objectives:

- Demonstrate academic leadership towards MarTREC’s leadership goal
- Demonstrate industry leadership towards MarTREC’s leadership goal

Accomplishments:

Leadership Effectiveness Metrics	Progress
# of national and regional leadership positions held	28
# of invited talks given	3
# of leadership and research awards received	5

### 1.1.3 Education and Workforce Development

Goal: MarTREC will develop educational resources to elucidate scientific and engineering practices involved in maritime and multimodal transportation systems and practices.

Objectives:

- Conduct education and workforce development (EWD) projects related to the goal
- Educate college students within MarTREC theme
- Conduct workforce development related to MarTREC theme
- Conduct outreach activities related to MarTREC theme

Accomplishments:

Education and Workforce Development Effectiveness Metrics	Progress
# of transportation-related courses offered	61
# of technician certification programs offered	7
# K-12 outreach programs offered	3

### 1.1.4 Technology Transfer

Goal: MarTREC consortium institutions will participate in national, regional, and local education and workforce development outreach to provide state-of-the-art knowledge to private and public transportation organizations and provide a forum where government employees, academic researchers, and private sector can exchange ideas on current issues.

Objectives:

- Transfer MarTREC outcomes into practice
- Develop products in support of MarTREC technology transfer goal

Accomplishments:

Technology Transfer Effectiveness Metrics	Progress
# of project deliverables submitted	2
# of technical briefs	0
# of editorial journal positions held	11

### 1.1.5 Collaboration

Goal: MarTREC will continue our existing partnerships with maritime and multimodal transportation stakeholders and develop new partnerships at the consortium, institution, and project levels to facilitate our planned research, leadership, education, workforce development, and technology transfer activities.

Objectives:

- Develop external partnerships related to MarTREC's collaboration goal
- Develop collaborative products related to MarTREC's collaboration goal
- Engage faculty and students in achieving MarTREC's collaboration goal

Accomplishments:

Collaboration Effectiveness Metrics	Progress
# of existing collaborative partnerships	32
# of new collaborative partnerships formed	9

### **1.1.6 Opportunities for Training and Professional Development**

Nine conference planning positions were held by MarTREC faculty researchers, and six distinguished lectures were delivered by industry professionals. The program sponsored thirteen female students, eight female minority students, and three male minority students. Sixteen students presented at professional conferences. The Center for Training Transportation Professionals (CTTP) certified 401 individuals through twenty-two courses offered during this reporting period. CTTP also created and distributed a total of thirty-four professional training videos in aggregates, concrete, and soils.

### **1.1.7 Dissemination of Results**

Dissemination of results has been in the form of two final reports and the data loaded onto Zenodo repository for the public. In addition, nineteen peer-reviewed journal articles were published, accepted, or submitted and thirty-seven conference presentations were made including three invited talks.

### **1.1.8 Plans to Accomplish Goals and Objectives during Next Reporting Period**

MarTREC has twenty-four active research projects during this reporting period. The faculty researchers will continue to engage with industry experts to ensure that these projects are making transformational contributions. We will continue to emphasize educational and technology transfer activities. MarTREC will be hosting our Annual Professional Advisory Board meeting on November 14-15, 2019. Project-level plans are discussed in 1.2.

## **1.2 Project-Level Accomplishments and Plans for Next Reporting Period**

### **1.2.1 Maritime and Multimodal Logistics Management Projects**

#### **Development and Application of a Methodology for Maritime-Truck Shipments Generation Analysis**

**Mario Monsreal, PhD and Jim Kruse, MS, MBA**

**Texas A&M Transportation Institute**

**December 2017-April 2019**

**Accomplishments:** Truck activity is logically connected to and generated by vessel activity at a port. In turn, vessel activity is generated by truck shipments. Although one might expect a 1 to 1 relationship between the two types of shipments, that is unlikely the case. Terminal capacity is a determinant and a coupling link for vessel and truck flows. Although the current study provided a basic measure of the role that terminal operations play in vessel-truck behavior, a deeper analysis is recommended to identify more precisely the impacts of terminal operations on these multimodal flows. This study found data availability as an important constraint for a more detailed analysis. Therefore, the main recommendation is to explore new data sources, and evaluate data generation techniques to produce a more complete data set for a more thorough analysis.

**Completed Project:** Conducted by TTI, this project was completed in April 2019. Final project report will be submitted on time and distributed as per grant guidelines.

#### **Changing Trade and Transportation Patterns: NAFTA, Cuba, and the US Gulf Coast**

**Bethany Stich, PhD**

**University of New Orleans**

**March 2018-August 2019**

**Accomplishments:** Since the passage of the National Environmental Protection Act in 1969, transportation planning became a complex, interdisciplinary challenge. The need for meeting environmental legislation coupled with public participation demands have revealed innumerable

problems associated with the use of outdated techniques. In order to satisfy the current regulations and public policies, the transportation planning process can no longer solely rely on the basics of engineering; it is now forced to find the way in a sea of data, values and actors towards a comprehensive and integrated solution. Therefore, not only the variety of data but also the quality and vast amount of data to be processed has become one of the big issues for transportation practitioners.

**Project Plans:** This project is delayed as President Trump's administration is renegotiating several key trade agreements at this time. The research team is keeping up with the situation and continuing to look at how these new agreements may affect trade flows and their supporting infrastructure.

### **Shipping Container Chassis in the US: The Legacy of Ocean Carriers**

**Bethany Stich, PhD**

**University of New Orleans**

**March 2018-May 2019**

**Accomplishments:** Almost half of the chassis date from before 1997 and it is common at marine terminals to find chassis well over 20 years old. Newer chassis are safer, as they are outfitted with radial tires, antilock brakes, and LED lights. Additional technological developments involve the use of GPS systems and data analytics to enhance the efficiency of chassis moves within the supply chain. However, until chassis ownership and management is settled, significant investment in these technologies seems unlikely. The evolution of key safety regulations related to chassis usage has placed the burden of compliance on the marine terminals and trucking companies, rather than the ocean carriers. Cultivating a few large regional pools, a national chassis pool, or possible federal public-private investment in the chassis fleet are some workable answers. The best solution may be encouraging the global model, growing in the US, wherein truckers own their chassis.

**Project Plans:** Final report is in the revision stage.

### **Learning from USACE Open Data for Locks**

**Justin Chimka, PhD**

**University of Arkansas**

**August 2018-August 2020**

**Accomplishments:** Open Data for Locks were originally supposed to be made available via "Socrata," a Connected Government Cloud product sold by Tyler Technologies. USACE was a Socrata customer at some point, but that is no longer the case, according to Socrata Support. Furthermore, "Navigation and Civil Works Decision Support Center (NDC) is not actively pursuing any public data dissemination services at this time. However we are continuously looking for better ways to get data to the public," according to Steven Riley, USACE. Hopefully NDC will field requests for specific data, Corps Locks Queue Archive and Public Lock Unavailability Detailed Report.

**Project Plans:** This project plans to describe stoppages not only in terms of downtime and whether or not it was planned but also in terms of what caused the downtime. That information would be a valuable addition to what has previously been available in the Lock Performance Management System data.

### **Modeling Dynamic Behavior of Navigable Inland Waterways**

**Heather Nachtmann, PhD and Justin Chimka, PhD**

**University of Arkansas**

**August 2018-August 2020**

**Accomplishments:** This project is expanding prior MarTREC research and is utilizing our previously developed Maritime Transportation Simulator (MarTranS), which integrates agent-based modeling, discrete-event simulation, and system dynamics, to further explore the relationship between inland

waterway transportation system components and regional economic impact factors. We collected current data and replicated our past scenario analyses of the McClellan-Kerr Arkansas River Navigation System (MKARNS). MarTranS was modified in order to collect and study more operational data related to lock and dam behavior. In addition, a literature search and review of prior research on and implementation of container-on-barge was completed.

**Project Plans:** We are analyzing the MarTranS results to provide new data analytics and knowledge that can guide future investment, operations, and maintenance decisions. Results will be presented in May 2019 at the Institute of Industrial and Systems Engineers annual conference and submitted to the 2019 American Society for Engineering Management conference. We will analyze the container-on-barge literature review findings to share pertinent information with other researchers and practitioners and identify critical research questions in this area.

### **Combining Truck and Vessel Tracking Data to Estimate Performance and Impacts of Inland Ports**

**Sarah Hernandez, PhD and Chase Rainwater, PhD**

**University of Arkansas**

**January 2019-December 2020**

**Accomplishments:** The purpose of this project is to develop a method to fuse truck and marine vessel tracking data to better estimate performance of multi-modal supply chains that use inland waterway ports. We have reviewed literature and characterization of Marine AIS and Truck GPSTData.

**Project Plans:** We will develop fusion approaches and derivation and apply multi-modal freight fluidity measures.

## **1.2.2 Maritime and Multimodal Infrastructure Preservation Projects**

### **Economic Impact of the Gulf Intracoastal Waterway on the States It Serves**

**Brianne Glover, JD and Jim Kruse, MS, MBA**

**Texas A&M Transportation Institute**

**September 2017-August 2018**

**Accomplishments:** This project reviewed existing literature on the economic value of the Gulf Intracoastal Waterway (GIWW), reviewed the importance of the GIWW to the energy industry, examined the overall economic impact of the GIWW to the states it serves, and estimated the increases in transportation costs resulting from an immediate closure in the GIWW. Overall, this report estimates that the GIWW has an economic impact of \$61.5 billion annually, supports 143,000 jobs, and saves up to \$4.3 billion in transportation cost savings annually.

**Completed Project:** Conducted by TTI, this project was completed in August 2018. Final project report was submitted on time and distributed as per grant guidelines.

### **Engaging the Business and Tourism Industry in Visualizing Sea Level Rise Impacts to Transportation**

**Infrastructure in Waikiki, Hawaii**

**Brian Wolshon, PhD, PE, PTOE**

**Louisiana State University**

**March 2018-September 2019**

**Accomplishments:** The goal of this research is to assess if the use of 3D virtual and augmented reality as a policy deliberation tool for improved coastal planning, engineering and design by deepening the understanding of sea level rise impacts among the business and tourism industries in Waikiki, Hawaii. During this reporting period, the post-surveys for the community meetings were developed.

**Project Plans:** IRB approval will be requested in the next reporting period.

## **Green Technology Approach for Capturing Pollution Washed from Transportation Infrastructures**

**Danuta Leszczynska, PhD**

**Jackson State University**

**March 2018-July 2019**

**Accomplishments:** The aim of this study is to produce and investigate a carbon-based substance, namely biochar, as a new material for the in-situ adsorption of pollutants carried by the storm water runoff from the roads. Extensive literature review was completed; however, during the course of this research, we are searching for current publications available within the last 6 months. Recently, biochar as off-agricultural material is gaining a lot of interest, but there is a little info about ongoing research for direct transportation applications. Preparation of biochar was completed.

**Project Plans:** We have obtained preliminary results during scheduled time; however, to produce reliable results, larger quantities of biochar are needed (on-going manufacturing). In addition, we have purchased commercial biochar, and leachability tests are currently being analyzed.

## **A Multimodal Network Approach to the Inland and Coastal Waterway System**

**Bruce Wang, PhD**

**Texas A&M University**

**July 2017-January 2019**

**Accomplishments:** The national marine highway initiative intends to position waterways in the context of multimodal transportation system. Maintenance and capacity of each element of the waterway system has implications on the multimodal network. This project has developed a multimodal freight network model that includes both waterway landside components in order to analyze the impact of waterway operations. The goal is to enhance the entire network efficiency. The tests show that the solutions are not sensitive to these parameters. Thus, the model is solved by changing the total amount of available budget into five different scenarios, each having an amount allocated to the locks and dams.

**Completed Project:** Conducted by TAMU, this project was completed in January 2019. Final project report was submitted on time and distributed as per grant guidelines.

## **Large Scale Evaluation of Erosion Resistance of Biocementation against Bridge Scour and Roadway Shoulder Erosion**

**Lin Li, Ph.D., P.E.**

**Jackson State University**

**March 2018-April 2019**

**Accomplishments:** This project is examining the feasibility of using biocementation through MICP as an erosion countermeasure. The results of this study bring an important conclusion that MICP-treated soil was weak to resist long-term erosion of exposing to outdoor environment. However, MICP-treated material was strong to resist rainfall induced erosion and accelerated erosion. Especially the bio-surface treatments could enhance the strength of cement-treated samples significantly and further improve the resistance to accelerated erosion and water absorption. In addition, fiber reinforcement of MICP-treated samples improved the resistance to accelerated erosion, whereas the multiple MICP treatments method could contribute to the improvement of both resistance to accelerated erosion and water absorption.

**Completed Project:** Conducted by JSU, this project was completed in April 2019. Final project report will be submitted on time and distributed as per grant guidelines.

## **Liquefied Natural Gas: Export Competition in a Well Supplied, Flow-Shifting Global Economy**

**Bethany Stich, PhD**

**University of New Orleans**

**March 2018-May 2019**

**Accomplishments:** With trillions of cubic feet of shale reserves, the United States' (US) abundance of natural gas has prompted an increase in production of Liquefied Natural Gas (LNG) as an export commodity. While the Trump administration has taken strides to loosen policy set by the Federal Energy Regulatory Commission (FERC) in order to streamline US LNG export facility permitting, UNOTI has reasoned that policies focused too heavily on LNG as an export is misguided. A more robust energy policy acknowledges the higher value of natural gas to the petrochemical manufacturing industries as well as the development and commercialization of new LNG technologies in the maritime industry, particularly as a marine fuel. Furthermore, US energy independence fueled by shale mining will alter how the US acts in the global market place, thereby destabilizing the system in place since the Bretton Woods Agreement in 1944. However, competing natural gas rich nations like Australia, Qatar, and Russia have similar goals to expand production indicating US LNG export growth will not be without competition. In addition to potential increases in US LNG exports and what this implies for global markets, current transportation developments in LNG powered marine vessel refueling technology allowing for waterside refueling as an alternative to shore side bunkering, as well as an overview of what increased US shale frac'ing and LNG export implies for US roadway infrastructure and how short sea shipping may provide an alternative to trucking and rail movements.

**Project Plans:** Final report is in the revision stage.

## **Effect of Permeability Variation of Expansive Yazoo Clay at the Maritime and Multimodal Transportation Infrastructure in Mississippi**

**Sadik Kahn, PhD, PE**

**Jackson State University**

**September 2018-October 2019**

**Accomplishments:** The existence of Yazoo clay soil in Mississippi frequently causes pavement distress in multimodal transportation infrastructure. Each year, fixing the pavement requires significant maintenance budget of MS DOT. Standard soil tests were conducted on the collected soil samples, which include the moisture content test, particle size analysis. At present, the findings from this study have been presented to the senior officials of MDOT.

**Project Plans:** Investigate hydraulic properties of clay soil, moisture variation at different season, and effect of rainfall and duration on the subgrade moisture variation.

## **Fatigue Crack Control in Waterway Lock Gate Pintle Locations Subjected to Multi Modal Fracture**

**Gary Prinz, PhD, PE**

**University of Arkansas**

**August 2018-August 2020**

**Accomplishments:** This research project will address multi-mode fatigue cracking within critical lock gate pintle locations. The lock gate pintle is a ball-and-socket joint that is crucial for proper gate operation but is subject to frequent fatigue cracking. Fatigue crack repair within pintle locations is particularly challenging due to the complex multi-axial loading conditions. Student has fabricated and started running the multi-axial notched-pipe fatigue experiments for our retrofit development.

**Project Plans:** These experiments will take significant amounts of equipment time and during our early project meetings, we determined it was important to begin them earlier in the project timeline.



### **Trade-Off Analytics for Infrastructure Preservation**

**Greg Parnell, PhD and Ed Pohl, PhD**

**University of Arkansas**

**August 2018-August 2019**

**Accomplishments:** The objective of this project is to develop a course that can be taught to civil engineers, industrial engineers, and the maritime and multimodal infrastructure community on the use of trade-off analytics as a tool to assist them in their infrastructure preservation efforts. This course will be packaged into a webinar that could be delivered on-line for practicing professionals. This course will build on existing best practices defined by the International Council on Systems Engineering. We are on track with our course development.

**Project Plans:** We plan to offer in Fall 2019, 2<sup>nd</sup> 8 Week Session. We are working with ERDC to have the course available for U.S. Army Engineer Research and Development Center employees.

### **Using CSA Cement for Novel Waterway Repair Materials**

**Cameron Murray, PhD and Michelle Bernhardt-Barry, PhD, PE**

**University of Arkansas**

**August 2018-August 2020**

**Accomplishments:** The objective of this research is to investigate the properties and behavior of Calcium Sulfoaluminate-Belite (CSA) cement mixtures for waterway repair applications. Student on the project has found that the ideal water/cement ratio for an underwater BCSA cement grout appears to be 0.4. At this w/c, the early age strengths are excellent (>4,000psi at roughly 2 hours of age), even when the mortar is placed under standing water. At w/c lower or higher than 0.4, the early age strength is reduced.

**Project Plans:** Current work involves investigating later age strengths (up to 28 days). Another aspect of the work is improving the mortar flow. Improved flow facilitates easy placement of the material and should result in a better consolidated, stronger finished product. The mortar needs to be easy to place to reduce the amount of labor needed for repairs. Currently, the 0.4 w/c appears to provide the best flow using the current amounts of admixture (high range water reducer and viscosity modifying admixture). Current work also involves using different sand/cement ratios at the ideal w/c (0.4) to further improve mortar flow and strength. This work is expected to continue through summer.

### **1.2.3 Disaster Response and Transportation Planning for Coastal and River Valley Communities Projects**

#### **Development and Implementation of Sustainable Transportation Resilience Indicators**

**Mark Abkowitz, PhD**

**Vanderbilt University**

**June 2017-March 2019**

**Accomplishments:** The intent of this project is to establish a protocol and method for evaluating a community's level of sustainable transportation resilience, such that if deficiencies exist, attention can be focused on mitigating those concerns. The protocol and method are being subsequently applied to a river valley community to demonstrate proof-of-concept.

**Project Plans:** Next steps in this project are to: 1) develop a list of sustainable transportation resilience indicators applicable to communities at risk from natural disaster events, 2) identify a case study area that is representative of flood risk (e.g., downstream community with high population density on the inland waterway system that is protected by an earthen levee that is frequently threatened by overtopping), and 3) measure the level of sustainable transportation resilience in the case study area using the developed indicators.

### **Interdependency of Port Clusters during Regional Disasters**

**Brian Wolshon, PhD, PE, PTOE**

**Louisiana State University**

**January 2018-August 2019**

**Accomplishments:** The research seeks to build upon the prior knowledge and expand the scientific understanding of regional disruptions to port clusters, areas of the country with multiple ports servicing the same region. The contribution of this research is to empirically show how port clusters rely upon each other during disruptive events to increase the overall resiliency of water bourn commerce during disruptive events. During this reporting period, the identification of port clusters for analysis was completed. A timeline of disruption events has also been completed.

**Project Plans:** The team is currently working on time-dependent resilience plots for each port.

### **Utilizing Graceful Failure as an Opportunity for Flood Mitigation Downstream to Protect Communities and Infrastructure**

**Janey Camp, PhD, PE, GISP, CFM**

**Vanderbilt University**

**May 2018-October 2019**

**Accomplishments:** In 2011, we observed how “graceful failure” through planned damages to the Birds Point Levee by the US Army Corps of Engineers was enacted to alleviate extreme flooding on the Mississippi River. This action, while flooding croplands as planned in the past, actually reduced flooding and damage to waterway infrastructure and communities downstream. We completed the initial criteria selection and the screening analysis to identify sites along the inland waterway system where levees may be intentionally broken to allow for flood mitigation. We have begun doing the localized feasibility analysis of selected sites that have potential for controlled diversion and water storage during flooding events. We have tried a couple of approaches to estimating the volume and extent of storage and are trying another that may work now that we have a better understanding of the challenges.

**Project Plans:** Complete analysis and feasibility study of select sites. Estimate volume of floodwaters that could be contained/diverted as well as investigate the extent of flooding in the event of a breach to ensure minimal impacts to people and infrastructure at the select locations.

### **Visualizing Sea Level Rise Impacts in Transportation Planning**

**Brian Wolshon, PhD, PE, PTOE**

**Louisiana State University**

**January 2018-June 2019**

**Accomplishments:** The goal of this research is to test and compare new technologies in community-meeting settings in South Florida to assess the effectiveness of 3D visualization technology on improving residents’ understanding of the impacts of sea level rise on their communities and the transportation infrastructure. During this reporting period, the research team completed the content for the community meetings including the 2D and 3D media, and post-surveys were tested.

**Project Plans:** Pre-test will be completed, and community meetings are currently being scheduled.

### **Exposure to STEM: Diversity in Maritime Transportation**

**Rick Coffman, PhD, PE**

**University of Arkansas**

**August 2018-August 2019**

**Accomplishments:** The goal of this education and workforce development project is to develop an educational/mentoring/advising model to open doors to all students, regardless of socio-economic background, who want to pursue careers in fields related to maritime and multimodal transportation.

We have identified underrepresented groups in AP classes at LRCHS. Recruited and retained students from underrepresented groups through K-12 outreach. Developed mentoring, interaction, and personal development. Demonstrated increased enrollment of underrepresented students in STEM.

**Project Plans:** Little Rock Arkansas Trip will be completed on April 2, 2019. Another trip is scheduled for April 20, 2019. During the first trip, a lecture will be provided on the importance of Locks and Dams to members of the LRCHS STEM Club. The students will then tour the Murray Lock and Dam. The second visit will be similar for a different audience. During the second trip, students from the AVID program and from PSC will be shown the lock and dam presentation and taken to the Murray Lock and Dam.

**Informing Post Disaster Restoration through Modeling Interdependent Agriculture and Transportation Networks**

**Sarah Nurre, PhD, Kelly Sullivan, PhD, and Ben Runkle, PhD**  
**University of Arkansas**  
**August 2018-August 2020**

**Accomplishments:** Agriculture supply chains are of utmost importance for the function of society. Agriculture supply chains are inherently complex due to their interdependency with critical infrastructure systems including energy, water, and maritime and multimodal transportation. Our overall aim is to develop the necessary methodology to describe ag-sector and transportation-sector interdependence. Mathematically characterize interdependencies arising between interdependent agriculture and transportation infrastructure. We created a mathematical model to characterize the movement of goods through a multi-modal transportation network with different agriculture commodities that represent agriculture inputs and outputs. We are currently in the process of modeling further interdependencies between transportation and agriculture.

**Project Plans:** We plan to build a geospatial dataset of interdependent agriculture and transportation infrastructure.

**Towards Integrating Resilience into Everyday Transportation Practices of Coastal and River Valley Communities**

**Brian Wolshon, PhD, PE, PTOE and Nelida Herrera**  
**Louisiana State University**  
**August 2018-June 2019**

**Accomplishments:** Coastal and river valley communities have become increasingly vulnerable to sea level rise, hurricanes and other natural disasters. In many cases, these events force the communities to evacuate in a relatively unpredictable way. Emergency evacuations require safe and effective mobilization of the public from hazardous areas while facing uncertainty. During this reporting period, the literature review was completed and initial simulations were tested.

**Project Plans:** The research team is currently working on extracting the resilience metrics from the test simulations to later conduct the analyses.

**2. Participants & Collaborating Organizations**

<b>Organization Name</b>	<b>Location</b>	<b>Collaboration</b>
US Army Corps of Engineers	Vicksburg, MS	research collaborator
Dr. John Renne, Florida Atlantic University	Boca Raton, FL	research collaborator
Port of New Orleans International Freight Forwarders & Customs Brokers Assn. of New Orleans	New Orleans, LA	Industry networks

World Trade Center Transportation Committee Ports Assn. of Louisiana GNO Port Safety Council Propeller Club of New Orleans New Orleans Regional Planning Commission MS Valley Trade & Transport Port of South LA Port of Plaquemines Coastal Cargo Triple G. Express Jefferson Transit Regional Innovation Alliance		
TN Department of Transportation TN Department of Economic and Community Development American Bureau of Shipping	TN	research collaborator
ISL, Germany	Germany	software
National Marine Transportation Center	Wuhan, China	resource
Dr. Scott Parr, Embry-Riddle Aeronautical University	Florida	research collaborator
Christine Lozano/ERDC - Information Technology Laboratory Dr. Guillermo A. Riveros, P.E./ERDC Dr. Kenneth Mitchell/ERDC - Coastal and Hydraulics Laboratory Dr. Simon R. Goerger/ERDC - Institute for Systems Engineering Research Dr. Stanley Woodson/ERDC Graduate Institute	Vicksburg MS	research collaborator
Deidre Smith, Executive Director, AR Waterways Commission, Little Rock, AR	AR	research collaborator
Dr. Jingjing Tong, Assistant Professor, Southeast Missouri State University, Cape Girardeau, MO	MO	research collaborator
Chad Johnston, United States Department of Homeland Security, Office of Infrastructure Protection, Protective Security Advisor – Arkansas District	AR	research collaborator
Glenn Moore, United States Department of Homeland Security, Office of Infrastructure Protection, Protective Security Advisor – Oklahoma District	OK	research collaborator
Dr. Furkan Oztanriseven, Assistant Professor of Data Analysis, LeMoyne College	NY	research collaborator
Dr. Mohammad Barik, a researcher in University Space Research Association (USRA)	AL	research collaborator
Professor Ming Zhong, Wuhan University of Technology in China, Director of Intelligent Transportation System Center	China	research collaborator
YouthForce NOLA	New Orleans, LA	Outreach Activity
Supply Chain Transportation Council	Baton Rouge, LA	Industry networks

University of Memphis, Tennessee Department of Economic and Community Development, Federal Emergency Management Agency	TN	research collaborator
Dr. Marek Jozwiak	Poland	research collaborator
Dr. Shahadat Hossain, Professor, Department of Civil Engineering, UT Arlington	TX	research collaborator
Henry Liu, Professor at Civil Engineering, University of Michigan, Ann Arbor	MI	research collaborator
National Waterway Foundation	DC	resource

### 3. Outputs

#### 3.1 Publications

##### *Peer Reviewed Journal Articles*

1. Delgado-Hidalgo, Liliana, and Heather Nachtmann "A Heuristic Approach to Managing Inland Waterway Disruption Response," *Engineering Management Journal* (under review)
2. Delgado-Hidalgo, Liliana, Chase Rainwater, and Heather Nachtmann, "A Computational Comparison of Cargo Prioritization and Terminal Allocation Problem Models," *Computers & Operations Research* (under review)
3. Tong, Jingjing, and Heather Nachtmann, "A Tabu Search Approach to the Cargo Prioritization and Terminal Allocation Problem," *International Journal of Shipping and Transport Logistics*, (accepted September 2018)
4. Gedik, Ridvan, Gokhan Egilmez, Chase Rainwater, Kenneth Ned Mitchell, and Heather Nachtmann, "A Constraint Programming Approach for Scheduling Maintenance Dredging Activities of the U.S. Marine Transportation System Expert Systems With Applications," *Expert Systems With Applications* (under review)
5. Oztanriseven, Furkan, and Heather Nachtmann, "Modeling Dynamic Behavior of Navigable Inland Waterways," (under review)
6. Mahmoudzadeh, Ahmadreza, Ma Chaolun, Khodakarami Adel, Xiubin Wang, Yunlong Zhang, and Ming Zhong. (students) "A Multimodal Network Approach to the Inland and Coastal Waterway System," *Transportation System and Information* (under review)
7. Khan, M. S., M. Nobahar, J. Ivoke, and F. Amini "Rainfall Variation Effect on Slope made of Expansive Yazoo Clay soil," *Transportation Infrastructure Geotechnology* (under review)
8. Khan M. S., J. Ivoke, and M. Nobahar, "Coupled Effect of Wet-Dry Cycles and Rainfall on Highway Slope made of Yazoo Clay," *Geoscience* (under review)
9. Khan, M.S., D. Thornton, J. Ivoke, and M. Nobahar, "Numerical Investigation of Slope Stabilization using Recycled Plastic Pin on Yazoo Clay," *ASCE Journal of Materials in Civil Engineering* (under review)
10. Zhanga, Ying, Ruimei Fanb, Qinku Zhanga, Ying Chena, Omaid Sharifia, Danuta Leszczynska, Rong Zhanga, and Qilin Dai, "Synthesis of CaWO<sub>4</sub>-biochar Nanocomposites" *Organic Dye Removal Journal: Materials Research Bulletin*, 110, 169-173, 2019
11. Nelson, K., L. Gillespie-Marthaler, H. Baroud, D. Kosson and M. Abkowitz, "An Integrated and Dynamic Framework for Assessing Sustainable Resilience in Complex Adaptive Systems," *Sustainable and Resilient Infrastructure*, doi.org/10.1080/23789689.2019.1578165
12. Gillespie-Marthaler, L., K. Nelson, H. Baroud, and M. Abkowitz, "Selecting Indicators for Assessing Community Sustainable Resilience," *Risk Analysis* (in review)

13. Gillespie-Marthaler, L., H. Baroud, and M. Abkowitz, "Sustainable Resilience of Flood Protection Infrastructure in the U.S.: Failure Mode and Implications Analysis," *Safety Science* (in review)
14. Chimka, Justin, Fernandez De Luis and A. McGee, "Statistical effects of waterway lock unavailability on commodity flow," *Quality Technology & Quantitative Management* (accepted)
15. Kruse, James C., Kenneth N. Mitchell, Patricia K. DiJoseph, Dong Hun Kang, David L. Schrank, and William L. Eisele, "Developing and Implementing a Port Fluidity Performance Measurement Methodology using Automatic Identification System Data," *Transportation Research Record Journal of the Transportation Research Board*, Volume: 2672 issue: 11, pages 30-40, December 2018.
16. Stich, Bethany and Peter Webb, "Disconnects in Megaregional Freight Planning Are Holding Back the Louisiana Gulf Coast," *Public Works Management & Policy*, Accepted, Online October 2018, in print April 2019 (student)
17. Asborn, M. and S. Hernandez, "Using Data from a State Travel Demand Model to Develop a Multicriteria Framework for Transload Facility Location Planning," *Transportation Research Record: Journal of the Transportation Research Board*, pp. 1-12, 2018 (students)
18. Smith, S., A. Braham, S. Hernandez, and J. Kent, "Development of a Cost-Estimation Framework for Potential Transload Facilities," *Transportation Research Record: Journal of the Transportation Research Board*, pp. 1-11, 2018 (students)
19. Asborn, M., C. Burris, and S. Hernandez, "Truck Body Type Classification Using Single Beam Lidar Sensors," *Transportation Research Record: Journal of the Transportation Research Board*, 2019; OnlineFirst (students)

#### *Conference Papers*

1. Asborn, M., Burris, C., and Hernandez, S., "Truck Body Type Classification Using Single-Beam LiDAR Sensors", *TRB*, Washington D.C., January 2019 (accepted)
2. Khan M. S., J. Ivoke, M. Nobahar, and G. Kibria, "Effect of Wet-Dry Cycle on the Void Ratio of Expansive Yazoo Clay Soil", *Geo-Congress*, 2019 (accepted)
3. Khan M. S., J. Ivoke, M. Nobahar, and G. Kibria, "Progressive Change in Shear Strength of Yazoo Clay Soil", *Geo-Congress*, 2019 (accepted)

#### *Books/Other One-Time Publications*

1. Nachtmann, Heather, "Contributions of Women to Multimodal Transportation Systems," *Women in Industrial and Systems Engineering* (book chapter, 1st Edition; Switzerland: Springer, TBD - accepted)
2. Renne, J., Wolshon, B., Murray-Tuite, P., Pande, A., Kim, K. *Creating a Resilient Transportation System: Policy, Planning and Implementation* (in progress)
3. Stich, Bethany, "The US Chassis Experiment" *A Sustainable Transportation Infrastructure for Long-Term Economic Growth*, IGI Global Publishing, February, 2019 (accepted)
4. Webb, Peter, "New Orleans, a Living Laboratory: Dueling Narratives- Tourism vs Freight," *University of New Orleans*, December 2018, dissertation (accepted)

#### *Editorial Journal Positions*

1. Advisory board member, *Transportation research Part E: Logistics Review*
2. Area Editor, *The Engineering Economist*
3. Area Editor, *Transportation Research D, Journal of Transportation Safety System Security*
4. Associate Editor, *IEEE Transaction on Reliability*
5. Associate Editor, *Journal of Military Operations Research*
6. Associate Editor, *Journal of Risk and Reliability*

7. Associate Editor, Operations Research Letters
8. Editorial Board, Stochastics and Quality Control
9. Editorial Board, Systems and the IEEE Transaction on Engineering Management
10. Co-Editor-in-Chief, Engineering Management Journal
11. Co-Editor-in-Chief, Engineering Management Journal

### 3.2 Websites

Website Title	Web Address
MarTREC	<a href="http://martrec.uark.edu/">http://martrec.uark.edu/</a>
Institute for Multimodal Transportation	<a href="http://www.jsums.edu/imtrans/">http://www.jsums.edu/imtrans/</a>
Gulf Coast Center for Evacuation and Transportation Resiliency	<a href="http://www.evaccenter.lsu.edu/">http://www.evaccenter.lsu.edu/</a>
Merritt C. Becker Jr. UNO Transportation Institute	<a href="http://transportation.uno.edu/">http://transportation.uno.edu/</a>
Texas A&M Transportation Institute	<a href="https://tti.tamu.edu/">https://tti.tamu.edu/</a>
Vanderbilt Center for Transportation and Operational Resiliency (VECTOR)	<a href="http://www.vanderbilt.edu/vector/">http://www.vanderbilt.edu/vector/</a>

### 3.3 New Methodologies, technologies, or techniques

Nothing to report

### 3.4 Inventions, patents, and/or licenses

Nothing to report

### 3.5 Other products

Nothing to report

## 4. Outcomes

### 4.1 Increased understanding and awareness of transportation issues

#### *Distinguished Lectures*

1. Brian Wolshon, "Analysis of Police Manual Traffic Control at the Deep South", Institute of Transportation Engineers Meeting, October 25, 2018, Baton Rouge, 50 attendees
2. Mary Kincaid, "Designing for Resilience," March 14, 2019, 15 attendees
3. Matt Hahne, "The Intertwined Transportation Infrastructure, as Magnified during an Outage or Stoppage," October 19, 2018, UNO, 20 attendees
4. Randy Guillot, "An Insight into the Role of Trucking in the New Orleans Economy and Its National Implications," October 19, 2018, UNO, 20 attendees
5. Sam Briuglio, Senior Vice President Federal Master Planning and Geospatial services for DoD, March 14, 2019, 15 attendees
6. Tianjia Tang, Chief of Travel Monitoring and Surveys Division, Federal Highway Administration, U.S. Department of Transportation, "Challenges & Opportunities in Surface Transportation", University of Arkansas November 15, 2018, 100 attendees

#### *K-12 Programs*

- K-12 Target outreach – 1515 students total, 638 female, 716 underrepresented
- Classroom visits – 1472 students total, 513 female, 386 underrepresented
- Campus visits – 896 students total, 384 female, 271 underrepresented

#### **4.2 Passage of new policies, regulation, rulemaking, or legislation**

Nothing to report

#### **4.3 Increases in body of knowledge**

##### *Conference Presentations*

1. Whalin, Robert W., "Summer Research Experiences and Minority Serving Institution Research Teams", 4th Annual Meeting, Coastal Resilience Center, University of North Carolina, Chapel Hill, North Carolina (invited) March 2019
2. Whalin, Robert W., "PhD in Engineering (Coastal Engineering and Computational Engineering Concentrations) at an HBCU", 4th Annual Meeting, Coastal Resilience Center, University of North Carolina, Chapel Hill, North Carolina (invited) March 2019
3. Peter Webb, "New Orleans, a Living Laboratory: Dueling Narratives- Tourism vs Freight," Innovate UNO (invited) November 2018, speaker was a PhD. student
4. Gillespie-Marthaler, Leslie, "Failure Mode Analysis and Implications for Sustainable Resilience of Flood Protection Infrastructure in the U.S.," INFORMS 2018, Phoenix, AZ, November 2018
5. Loshelder, Julia, MarTREC Poster Session, "Exposure to STEM: Diversity in Maritime Transportation", November 2018, speaker was a student
6. John Doerpinghaus (student), Classification of the Interdependencies in the Food and Agriculture Critical Infrastructure Sector in Arkansas, INFORMS Annual Meeting, November 2018
7. Anielia Garay Sianca (student), "Informing Post-Disaster Restoration through Modeling Interdependent Agriculture and Transportation Networks", MBTC Poster, November 2018
8. Gallarno, George (student), "Trade-off Analytics to Optimize USACE Civil Works Budget Allocations", IISE, May 2019
9. Johnson, Ashley, Trade-Off Analytics to Preserve Maritime Infrastructure in Arkansas, IISE, May 2019, (student)
10. J. Camp and J. Williams, "Utilizing GIS to Prioritize Locations for Flood Mitigation through Graceful Failure", The 17th Annual Middle TNGIC GIS Forum, Murfreesboro, TN, November 2018, (student co-presented)
11. Doerpinghaus, J. (student), A. Garay, S. Nurre, K. Sullivan, B. Runkle, J. Camp. "Informing Post-Disaster Restoration through Modeling Interdependent Agriculture and Transportation Networks." Poster presentation, MBTC Board Meeting, University of Arkansas, November 2018
12. Maryam Izaldi, (student) "Assessing Costs and Benefits of an Urban Trail: Lafitte Greenway, Poster Presentation, Active Living Research Conference, New Orleans, LA" February 2019
13. Maryam Izaldi, (student) "Inside the Bikeshare System: A space-Time Hot Spot Analysis of Divvy," poster presentation, LA Remote Sensing and GIS Workshop, Chicago, IL March 2019
14. Maryam Izaldi, (student) "Built Environment and Active Commuting of University Students", ACSP, October 2018
15. Asborn, M., Burris, C., and Hernandez, S., "Understanding Commodity Flow Truck Body Type Classification with Data from a Non-intrusive Lidar Sensor", Presented at the MOVITE Fall Meeting, Lexana, KS, October 2018 (students)
16. Asborn, M., Burris, C., and Hernandez, S., "Truck Body Type Classification Using Single-Beam LiDAR Sensors", Presented at the 2019 Annual Meeting of the Transportation Research Board, Washington D.C., January 2019 (students)
17. Asborn, M. and Hernandez, S., "Identification of Distance Thresholds for Freight Mode Choice Using Commodity Flow Survey Public Use Microdata and Machine Learning Tools", 2019 Annual Meeting of the Transportation Research Board, Washington D.C., January 2019 (student)



18. Khan M. S., Nobahar M., Ivoke J., and Amini F., "Progressive change in stability of a highway slope made of Yazoo clay" Lectern Presentation at 98th TRB, Washington DC. January 2019
19. Khan M. S., Ivoke J., Nobahar M., and Amini F., "Impact of Wet Dry Cycles on the Stability of Highway Slope Made of Yazoo Clay" Poster Presentation, TRB, Washington DC. January 2019
20. Khan M. S., Ivoke J., Nobahar M. and Thornton, D., "Numerical Investigation of Slope Stabilization using Recycled Plastic Pin on Yazoo Clay" Poster Presentation at 98th TRB Washington DC. , January 2019
21. Khan M. S., Ivoke J., and Nobahar M., Kibria, G., "Effect of Wet-dry Cycle on the Void Ratio of Expansive Yazoo Clay Soil", Poster Presentation, Geo-Congress, Philadelphia, PA, March 2019
22. Khan M. S., Ivoke J., and Nobahar M., Kibria, G., "Progressive Change in Shear Strength of Yazoo Clay Soil", Poster Presentation at Geo-Congress 2019, Philadelphia, PA, March 2019
23. Abkowitz, Mark, "Securing the Freight Flow Supply Chain", Transportation Resilience Innovations Summit and Exchange, Denver, CO, October 2018
24. Abkowitz, Mark, "Fostering Researcher/Practitioner Partnerships", Transportation Resilience Innovations Summit and Exchange, Denver, CO, October 2018
25. Abkowitz, Mark, "The Agriculture-Transportation Climate Change Resilience Nexus: The Case of Developing Nations, Annual Meeting of the Transportation Research Board, January 2019
26. Abkowitz, Mark, "Should I Stay or Should I Go - When to Stop Shielding Assets and Relocate Them", Annual Meeting of the Transportation Research Board, January 2019
27. Renne, John, Koleini Hoermann, and Chakravarti Hajek, 3-D Virtual Reality sea-level rise exploration in Ft. Lauderdale, Transforming a wetter Florida into a better Florida: Sea-level rise resilience collaborations, Congressman Ted Deutch, Florida Sea Grant, Citizens Climate Lobby, and American Flood Coalition, October 2018
28. J. Camp and J. Williams, "Utilizing Graceful Failure As An Opportunity for Flood Mitigation Downstream to Protect Communities and Infrastructure", Annual Advisory Board Meeting, MarTREC University Transportation Center, University of Arkansas, November 2018
29. Stich, Bethany, "Transportation Policy and Changing Trade Patterns," American Society for Public Administration, Washington, D.C., March 2019
30. Stich, Bethany, Peter Webb, and James Amdal. "Chassis: The Linchpin of International Trade," Transportation Research Board, Washington, D.C., January 2019
31. Stich, Bethany, James Amdal, Ian Butler-Severson and Dennis Thornton, "Liquefied Natural Gas: Export vs. Domestic Commodity Value", Transportation Research Board, Washington, D.C., January 2019
32. Stich, Bethany, "Response and Recovery Efforts Post Hurricane Katrina: A 13 Year Analysis," Journée d'étude internationale du Centre, Orléans, France, November 2018
33. Tian, Guang, "What do we know about bike share systems in the United States? Findings from four US regions", 58th Association of Collegiate Schools of Planning (ACSP) Annual Conference, Buffalo, NY, November 2018
34. Nachtmann, Heather, "Commerce & Transportation from 19th Century – Today: McClellan-Kerr Arkansas River Navigation System (MKARNS)," Fusion: Arkansas Arts & Humanities Symposium, Clinton Presidential Center, Little Rock, Arkansas, February 2019
35. Nachtmann, Heather, "Modeling Dynamic Behavior of the McClellan-Kerr Arkansas River Navigation System (MKARNS)," Arkansas Waterways Association Annual Conference, Hot Springs, Arkansas, November 2018
36. Nachtmann, Heather, and Edward A. Pohl, "Publishing in EMJ," American Society for Engineering Management International Annual Conference, Coeur d'Alene, Idaho, October 2018

37. Nachtmann, Heather, Frances Alston, Suzanna Long, and Elizabeth Schott, "Women in Engineering Management Panel," American Society for Engineering Management International Annual Conference, Coeur d'Alene, Idaho, October 2018

#### *Conference Planning Positions*

1. Chair, 15th International Symposium on Recent Advances in Environmental Health Research
2. Chair, Marine Operations and Management Track, World Transport Convention, 2018, 2019
3. Organizer, Summer Meeting for select TRB Freight and Marine committees
4. Organizing Committee, SE Symposium on Contemporary Engineering Topics, Entergy Corp.
5. Planning committee, American Geophysical Union Fall Meeting
6. Planning Committee, Transportation Resilience 2019
7. Session Organizer, 2018 Transportation Resilience Innovations and Exchange (RISE) conference
8. Sub-committee chair, ABG20- Transportation Training and Education, Workshop Leader
9. Track Chair, Security Engineering at the Industrial and Systems Engineering Research Conference

#### **4.4 Improved processes, technologies, techniques, and skills in addressing transportation issues**

##### *Leadership Positions*

1. Advisory Council for Transportation Research Member, ARDOT
2. Chair, AISC Methods of Design Committee
3. Chair, Freight Modeling Subcommittee, AT015 TRB
4. Chair, TRB Special Task Force on Climate Change
5. Co-advisor, Institute of Transportation Engineers Student Chapter at LSU
6. Committee Member, ASCE Infrastructure Resilience Division
7. Faculty advisor, U of A chapter of the Institute of Industrial and Systems Engineers
8. Group Chair, Marine Transportation Research Board
9. Member, Advisory Council for Transportation Research, ARDOT
10. Member, AISC Fatigue and Fracture Committee
11. Member, ASCE Committee for American's Infrastructure
12. Member, Lt. Gov.'s Port Advisory Board
13. Member, Marine Transportation System National Advisory Committee
14. Member, Supply Chain Transportation Council, Baton Rouge LA
15. Member, Transportation Research Board, Technical Advisory Council
16. Member, TRB Intermodal Freight Committee
17. Member, TRB Logistics of Disaster Committee
18. Membership Coordinator, TRB Inland Waterway Committee
19. Past President, American Society for Engineering Management
20. President, Society for Reliability Engineers
21. Representative, INFORMS Subdivisions Council
22. Sub-committee Chair, ABG20- Transportation Training and Education
23. Technical Member, TRB AFP 30 Soil and Rock Properties Committee
24. Treasurer, Ocean and Marine Division, American Society for Engineering Education
25. US representative, World Association for Waterborne Transport Infrastructure (PIANC) Task 193
26. Vice Chair, Engineering Infrastructure Specialty Group, Society for Risk Analysis
27. Vice Chair, Geo-Institute Soil Properties and Modeling Technical committee
28. Vice President, Geo-Institute Geophysics Committee

### Leadership Awards

1. Janey Camp, 2019 Outstanding Young Alumnus Award, Executive Board of the Tennessee Tech Alumni Association, 2019
2. Kelly Sullivan, John L. Imhoff Chair, Industrial Engineering Department, 2019
3. Magdalena Asborno, 2018 Jan Kibbe Student Scholarship Award from MOVITE, MOVITE Fall Meeting, Lexana, KS, October 2018
4. Sadik Kahn, Engineer of the Year, ASCE MS Section, 2019
5. Sarah Hernandez, Private Sector Applicability Award, TRB Standing Committee on Intermodal Freight Transportation

### 4.5 Enlargement of the pool of trained transportation professions

Certification Courses	# Attending
Basic Aggregates	18
Basic Aggregates Testing	17
Basic Aggregates Testing	19
Basic Aggregates Testing	20
Concrete Field Testing	17
Concrete Field Testing	19
Concrete Field Testing	14
Concrete Field Testing	23
Concrete Field Testing	19
Concrete Strength Testing	13
Concrete Strength Testing	14
Hot Mix Asphalt	20
Hot Mix Asphalt	10
Hot Mix Asphalt	14
Hot Mix Asphalt	17
National Pollutant Discharge Elimination System	29
National Pollutant Discharge Elimination System	29
Soils Testing	20
Soils Testing	18
Soils Testing	18
Soils Testing	18
Soils Testing	15
7 programs	401

### 4.6 Adoption of new technologies, techniques or practices

Nothing to report

## 5. Impacts

### 5.1 Effectiveness of the Transportation System

#### Stakeholder Citations

<https://www.ecnmag.com/news/2019/02/lidar-sensors-keep-tabs-whereabouts-tractor-trailers>

<https://phys.org/news/2019-02-planners-prioritize-highway.html>

<https://news.uark.edu/articles/46156/system-will-help-planners-identify-prioritize-highway-projects>

## **5.2 Technology Transfer**

- Louisiana State University, video highlighting the research funded by MarTREC: Visualizing Sea Level Rise Impacts for Transportation Planning, <http://cues.fau.edu/slr/>
- Final Report - [A Multimodal Network Approach to the Inland and Coastal Waterway System](#)
- Final Report - [Economic Impact of the Gulf Intracoastal Waterway on the States It Serves](#)

## **5.3 Increase in the Body of Scientific Knowledge**

- Delivered 37 presentations
- Published three papers
- Submitted two final reports

## **5.4 Transfer of Results to Government/Industry Entities**

- Vanderbilt University, influencing the development of resilience programs within state DOT

## **5.5 Commercialization of Technology/Process or Adoption of New Practices**

Nothing to report

## **5.6 Improved Performance, Skills, or Aptitudes of Underrepresented Groups**

### *Diversity*

- 36% of our research projects are led by female researchers
- 33% of our student research participation is from underrepresented populations:
  - 8 female minority students
  - 3 male minority students
- At the University of Arkansas, 35% of our k-12 participants are from underrepresented groups
  - We are continuously working toward growing our outreach summer camps to show STEM careers as an option for underrepresented groups. Below is a video highlighting k-12 outreach <https://www.facebook.com/UofAEngr/posts/10156440025588337>

## **5.7 Development and Dissemination of New Educational Materials**

- GirlTREC learning modules available at [sites.uark.edu/sarahvh](http://sites.uark.edu/sarahvh)

## **6. Changes/Problems**

Nothing to report

## **7. Special Reporting Requirements**

Nothing to report