



USDOT Tier 1 University Transportation Center

Semi-Annual Progress Report #3

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

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

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Reporting Period End Date: March 31, 2020

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)	22
# of conference presentations given	16
# of students participating in transportation research projects funded by UTC	33

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	37
# of invited talks given	1
# of leadership and research awards received	7

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	30
# of technician certification programs offered	14
# K-12 outreach programs offered	2

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	17
# of technical briefs	0
# of editorial journal positions held	16

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	28
# of new collaborative partnerships formed	9

1.1.6 Opportunities for Training and Professional Development

- The Center for Training Transportation Professionals (CTTP) certified 569 individuals in 14 transportation disciplines
- Four conference planning positions were held by MarTREC faculty researchers
- 15 distinguished lectures were delivered by industry professionals
- Ten students presented at professional conferences
- 37 leadership positions held by MarTREC faculty researchers

1.1.7 Dissemination of Results (In this reporting period)

- Eight final reports successfully submitted
- Six peer-reviewed journal articles were published

1.1.8 Plans to Accomplish Goals and Objectives during Next 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 5-6, 2020.

1.2 Project-Level Accomplishments and Plans for Next Reporting Period

- 33 total projects
- 14 completed projects

1.2.1 Maritime and Multimodal Logistics Management Projects

Analysis of Blockchain's Impacts on and Applicability to Maritime Industry

Jim Kruse, MBA

Texas A&M Transportation Institute

May 2019-November 2020

Accomplishments: It is unclear how relevant or critical the use of blockchain is for maritime business. A recent survey by Deloitte interviewed U.S.-based executives in the shipping sector and found that 39% of them have little or no knowledge about blockchain. Still 55% of them believe that failure to implement blockchain will put their company at a disadvantage; and 25% of them said that their companies viewed blockchain as a critical top 5 priority. Since it is new to an industry that is international, fragmented, and complex in nature, we explore several research questions arising from the application of blockchain to maritime supply chains and logistics.

Project plans: Team to conduct final literature review. Complete the survey effort. Since most people are working from home it is taking longer than anticipated to follow up with potential respondents. These respondents will be available after the COVID-19 crisis passes. Although the 38 responses were statistically significant for our research objectives, we need to follow up via phone with the survey.

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

Bethany Stich, PhD

University of New Orleans

March 2018-February 2021

Accomplishments: Since the 1969 passage of the National Environmental Protection Act, 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.

Project Plans: Waiting to see if Congress passes the USMCA agreement.

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 GPSData.

Project Plans: Develop fusion approaches and derivation/apply multi-modal freight fluidity measures.

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-March 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. This study found data availability as an important constraint for a more detailed analysis. 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 March 2019. Final project report was submitted and distributed as per grant guidelines.

Development of AIS Model of Texas Gulf Intracoastal Waterway Travel Times

Jim Kruse, MBA

Texas A&M Transportation Institute

October 2019-April 2021

New Project: This work will build on work previously done by the U.S. Army Corps of Engineers Research and Development Center (ERDC) on the Ohio, Illinois, and Upper Mississippi Rivers. That work used Automated Identification Service (AIS) records to develop travel time statistics for the three rivers. The focus of this research project is to perform a similar analysis on the Texas portion of the Gulf Intracoastal Waterway (GIWW). The Texas GIWW presents a level of complexity significantly greater than rivers mentioned above because of the intersections with ship channels and the fact that some barges go into and exit port areas while others pass through.

Interdisciplinary Educational Outreach with Traffic Sensor Build Kits

Sarah Hernandez, PhD, PE

University of Arkansas

May 2019-May 2020

Accomplishments: This project seeks to design and implement freight oriented educational outreach activities centered on traffic sensing technologies for middle, high school, and first-year college students. We've designed a low-cost, easily implementable LiDAR and Bluetooth sensor bundle that was capable of detecting, characterizing, and tracking freight trucks as they traveled to and from inland waterway port areas. We have completed assessment of technologies and design of the build kit.

Project Plans: We are currently working on development of learning modules and guided scripts for instructors. Task 4 was to be implemented this summer during the MarTREC GirlTREC summer camp. We are evaluating alternate opportunities for testing including the MOVITE meeting section.

Learning from USACE Open Data for Locks

Justin Chimka, PhD

University of Arkansas

August 2018-February 2021

Accomplishments: This project plans to describe stoppages that cause downtime. This information would be a valuable addition to what has previously been available in the Lock Performance Management System data. Open Data for Locks were originally supposed to be made available but that was not the case. 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.

Project Plans: Currently our focus is to analyze the NDC Key Lock Report, a monthly summary and year-to-year totals of commodity tonnages and barge traffic for key locks on the inland waterways (Institute for Water Resources Planning Assistance Library).

Modeling Dynamic Behavior of Navigable Inland Waterways

Heather Nachtmann, PhD and Justin Chimka, PhD

University of Arkansas

August 2018-June 2022

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 and we have developed gap research areas and questions to explore. Results were presented in May 2019 at the Institute of Industrial and Systems Engineers annual conference. We provided economic impact data to the Arkansas Waterways Commission in support of their response to the MKARNS flooding event that occurred this fall.

Project Plans: We continue to provide new data analytics and knowledge that can guide future investment, operations, and maintenance decisions on the MKARNS. Results were presented and published at the 2019 American Society for Engineering Management conference. We have completed a global academic and public literature search and review. We have identified the critical research questions in this area and begun associated data collection. We are developing a multi-attribute framework for evaluating the decision whether or not to implement Container-on-Barge within an inland waterway.

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

Bethany Stich, PhD

University of New Orleans

March 2018-December 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. 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. One proposed solution is more competitive pricing among more international chassis lessors.

Completed Project: Conducted by UNO, this project was completed in December 2019. Final project report was submitted and distributed as per grant guidelines.

1.2.2 Maritime and Multimodal Infrastructure Preservation Projects

Dredging Projects Selection when the Random Shoaling Effect is Considered

Bruce Wang, PhD

Texas A&M University

October 2019-March 2021

New Project: Dredging is a constant operation to maintain the waterway shipping capacity. The goal is to achieve a maximum network capacity to support the regional and national economies within a given budget. Shoaling happens after dredging to offset the dredging benefits. Wisely spending the dredging budget for a network capacity by considering the shoaling effect is the objective of this proposed research. Building on earlier models and algorithms developed by the team to propose optimality based stochastic model and algorithms, considering interdependency of project effects on the network.

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 and distributed as per grant guidelines.

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-December 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.

Completed Project: Conducted by JSU, this project was completed in December 2019. Final project report was submitted 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-December 2020

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: Analyze post surveys.

Evaluation of Hydrogel–stabilized Expansive Soils in Mississippi for Sustainable Maritime Infrastructure Design

Yadong Li, PhD

Jackson State University

August 2019-February 2021

Accomplishments: The expansive soil causes a variety maritime transportation infrastructure problem, such as cracks, damage of pipeline, and the differential settlement of foundation. In Mississippi, Yahoo clay, one type of expansive soil, causes significant concern during the maritime design and maintain. This project is proposing feasibility of using innovative hydrogel treatment as alternative expansive soil stabilization. The hydrogel treatment may provide great opportunities as cost-effective and sustainable preserving alternative approach for expansive soil stabilization in maritime infrastructure. Four different sodium alginate contents (0.1%, 0.2%, 0.3% and 0.4% by weight of dry soil) were used in the test. The test results showed that many cracks appeared on the surface of the hydrogel-treated Yazoo clay samples when subjected to moisture, which could be caused by the swelling property of clay in water. Unconfined compressive stress test on the samples showed that the hydrogel improved the strain of the clay significantly but had little improvement on its stress.

Project Plans: We are now optimizing hydrogel treatment recipe based on the stress-strain curve of the hydrogel-treated samples. The focus is on the improvement of the swelling behavior of expansive soil. Also, the weather resistant properties of the samples will be tested with cycles of wet-dry and freeze-thaw conditions.

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

Gary Prinz, PhD, PE

University of Arkansas

August 2018-February 2021

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. Detailed Sub-Modeling of the Pintle Ball and Socket during Gate Operation has been completed.

Project Plans: Parametric FEA Investigation to Develop Effective Multi-Mode Retrofit Strategies, task is currently under way and we are investigating several CFRP orientations and geometries for mitigating the crack-tip stresses. Experimental Verification task is also under way and we have been running several fatigue tests on un-retrofitted cracked plates to develop our base-line fatigue performance for later retrofit improvement comparisons.

Green Technology Approach for Capturing Pollution Washed from Transportation Infrastructures

Danuta Leszczynska, PhD

Jackson State University

March 2018-December 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.

Completed Project: Conducted by JSU, this project was completed in December 2019. Final project report was submitted and distributed as per grant guidelines.

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 and distributed as per grant guidelines.

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

Lin Li, PhD., P.E.

Jackson State University

March 2018-April 2019

Accomplishments: This project examined 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.

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

Liquefied Natural Gas Phase II: The Future of LNG for the US and Gulf Coast Economies

Bethany Stich, PhD

University of New Orleans

November 2017-December 2019

Accomplishments: The continued growth of Liquefied Natural Gas (LNG) production and long-distance trade has traditionally been taken as a given by global energy analysts, who have premised their positive estimates on gas being both relatively scarce and demand for it virtually unquenchable

Despite Louisiana experiencing a new cargo export potential with LNG and the subsequent construction and pending permitting of LNG Export Terminals in diverse locations along Louisiana's shorelines, the

primary finding of this report, based on the state of the current energy market, precludes the utility of a focus on LNG as an export commodity. Regarding the acceleration of LNG as an industrial feedstock, as supported by the American Chemistry Council's growth projection data for the use of LNG in the petrochemical industry, our fieldwork revealed a petrochemical manufacturing boom in the parishes between New Orleans and Baton Rouge.

Completed Project: Conducted by UNO, this project was completed in December 2019. Final project report was submitted and distributed as per grant guidelines.

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

Bethany Stich, PhD

University of New Orleans

March 2018-December 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. UNOTI continues to urge that U.S. natural gas energy policy best practice is not to focus on export and export alone, but rather adopt a diversified and climate responsible energy policy that focuses on the Ports of South Louisiana, the Gulf Coast, and the U.S. remaining globally competitive by investing in necessary LNG fueling infrastructure, as well as continued investment in the existing petrochemical sector of Coastal Louisiana and the Gulf Coast.

Completed Project: Conducted by UNO, this project was completed in December 2019. Final project report was submitted and distributed as per grant guidelines.

Trade-Off Analytics for Infrastructure Preservation

Greg Parnell, PhD and Ed Pohl, PhD

University of Arkansas

August 2018-December 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.

Completed Project: Conducted by UA, this project was completed in December 2019. Final project report was submitted and distributed as per grant guidelines.

Using CSA Cement for Novel Waterway Repair Materials

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

University of Arkansas

August 2018-February 2021

Accomplishments: Calcium Sulfoaluminate-Belite (CSA) cement is a rapid setting hydraulic cement. Due to its rapid hardening characteristics and lower shrinkage and creep compared to typical portland cement, it is an ideal candidate as a repair material. The goal of this work is to develop new mixtures utilizing CSA cement that can be applied to waterway repairs.

Project Plans: A grout mixture capable of setting up rapidly underwater and a soil-cement mixture that can rapidly stabilize slopes and waterway structures will be developed. We have found the ideal water/cement ratio for an underwater BCSA cement grout. Soil cement mixtures is being developed to test the soil cement under moving water and determine its resistance to erosion.

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

Assessment of Evacuation Network Performance under Different Evacuation Scenarios

Brian Wolshon, PhD., P.E., PTOE

Louisiana State University

July 2019-December 2020

Accomplishments: Several major disasters have occurred in the United States and impacted coastal and river valley communities. The economic and societal impact of such disasters have demonstrated a need for better emergency planning, response, recovery, and adaptation. Through the understanding of the behavior, characteristics of past events, much informed decisions can be made. This study will utilize data from Hurricane Irma (2017).

Project Plans: Focusing on the evacuation process of the coastal communities in the Florida Keys.

Development and Implementation of Sustainable Transportation Resilience Indicators

Mark Abkowitz, PhD

Vanderbilt University

June 2017-March 2019

Accomplishments: This project worked 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 were applied to a river valley community to demonstrate proof-of-concept.

Completed Project: Conducted by Vanderbilt, this project was completed in March 2019. Final project report was submitted and distributed as per grant guidelines.

Development of Freeway Corridor Capacity Measure to Improve Transportation Resilience

Brian Wolshon, PhD., P.E., PTOE

Louisiana State University

July 2019-December 2020

Accomplishments: Natural disasters like hurricanes and floods occur throughout the world. However, coastal areas tend to be the most vulnerable to these disasters. During imminent life and death conditions, such as those posed by hurricanes, evacuations are used as a protective action. And although evacuations have a long track record of success, they can be complex, costly, and at times even risky. Capacity is one of the most important characteristics of a freeway facility which quantifies its traffic carrying capability and is a critical component to the resilience of transportation systems .

Project Plans: A case study has been conducted in this research to estimate the capacity of a freeway corridor consisting of multiple bottleneck sections using traffic data from a coastal area.

Exposure to STEM: Diversity in Maritime Transportation

Rick Coffman, PhD, PE

University of Arkansas

August 2018-September 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.

Completed Project: Conducted by UA, this project was completed in September 2019. Final project report was submitted and distributed as per grant guidelines.

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-February 2021

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. 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.

Informing Post-Disaster Restoration through Modeling Interdependent Agriculture and Transportation Networks - Phase II VU

Janey Camp, PhD, PE, GISP, CFM
Vanderbilt University

October 2018-February 2021

Accomplishments: Agriculture is a critical part of the U.S. economy both domestically and in terms of exports. While disruptions due to weather, etc. can affect any sector, agriculture is unique in its time sensitivity for planting, harvesting, etc. Additionally, agriculture is interdependent on other sectors, particularly transportation to get seed and fertilizers to fields at appropriate times and in getting products that may spoil to market efficiently. At present, available tools and models do not appropriately address the interdependencies and interactions that occur between agriculture and transportation infrastructure systems during times of disruption and restoration of these systems post event. This project will develop models that determine how to effectively use transportation and coordinate restoration efforts to make ag supply chains more resilient.

Project Plans: Progress has been made on the GIS to feed into the model that our colleagues at U of Arkansas is building. Next steps are resolving issues with coordinate systems and the transportation networks across the three modes, as well as identifying potential disruption scenarios.

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.

Completed Project: Conducted by LSU, this project was completed in August 2019. Final project report was submitted and distributed as per grant guidelines.

Planning for Managed Retreat: Decision Making in the Face of Climate Uncertainty

Leah A. Dundon, JD, PhD

Vanderbilt University

December 2019-May 2022

New Project: Sea level rise, increased frequency and intensity of flooding, and other extreme weather events have sparked a growing recognition that managed retreat must be among the solutions considered. This project will examine the need for managed retreat, case studies, and the significant challenges to implementing managed retreat as an adaptation strategy (e.g., resources, policy, law, role of insurance, cultural acceptance, and ability of relocated area to absorb increased population), with a particular focus on transportation and its interdependencies with other critical infrastructure systems. The project will also develop a decision-making framework that can be used by transportation planners attempting to evaluate managed retreat as a potential adaptation strategy.

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-December 2020

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. We have completed identifying performance measurements and developed simulation scenarios.

Project Plans: Working on the impact of different strategies and analyze simulation outputs.

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-March 2020

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.

Completed Project: Conducted by VU, this project was completed in March 2020. Final project report was submitted and distributed as per grant guidelines.

Visualizing Sea Level Rise Impacts in Transportation Planning

Brian Wolshon, PhD, PE, PTOE

Louisiana State University

January 2018-December 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.

Completed Project: Conducted by LSU, this project was completed in December 2019. Final project report was submitted and distributed as per grant guidelines.

2. Participants & Collaborating Organizations

Organization Name	Location	Collaboration
US Army Corps of Engineers	Vicksburg, MS	research
Dr. John Renne, Florida Atlantic University	Boca Raton, FL	research
Port of New Orleans International Freight Forwarders & Customs Brokers Assn. 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	New Orleans, LA	Industry networks
TN Department of Transportation TN Department of Economic and Community Development American Bureau of Shipping	TN	research collaborator
Dr. Scott Parr, Embry-Riddle Aeronautical University	FL	research
Dr. Kenneth Mitchell/ERDC - Coastal and Hydraulics Laboratory	Vicksburg MS	research
Deidre Smith, Executive Director, AR Waterways Commission,	AR	research
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, LeMoyne College	NY	research
Dr. Mohammad Barik, a researcher in University Space Research Association (USRA)	AL	research collaborator
Supply Chain Transportation Council, Baton Rouge	LA	Industry
University of Memphis, Tennessee Department of Economic and Community Development	TN	research collaborator
Dr. Shahadat Hossain, Professor, Department of Civil Engineering, UT Arlington	TX	research collaborator
Travis Black, Office of Ports & Waterways Planning, MARAD	DC	stakeholder
Matthew Chambers, Bureau of Transportation Statistics, USDOT; Raquel Wright, Federal Railway Administration, USDOT; Kirk Claussen, Loan Specialist, Maritime Administration, USDOT; Wade Morefield, Office of Ports & Waterways Planning US Dept. of Transportation, Maritime Administration; Bruce Lambert, MARAD, USDOT	DC	stakeholders

3. Outputs

3.1 Publications

Peer Reviewed Journal Articles

1. Ahmadsreza, Mahmoudzadeh, Chaolun Ma (students), Mohammadadel Khodakarami, Kenneth Mitchell, Bruce Wang and Yunlong Zhang, "Waterway Maintenance Budget Allocation in A Multimodal Network," *Transportation Research Part E*, (under review).
2. Ahmed, A., Khan, M.S., Hossain, M.S., Sadigov, T. and Bhandari, P., "Safety Prediction Model for Reinforced Highway Slope Using Machine Learning Method," *Journal of Transportation Research Board: Transportation research record*, (under review 2019).
3. Allen, M., L. Gillespie-Marthaler, M. Abkowitz, J. Camp, "Evaluating Flood Resilience in Rural Communities: A Case-Based Assessment of Dyer County, Tennessee," *Natural Hazards*, (accepted for publication 2020).
4. Asborn, M., Taslima Akter, (students) and Sarah Hernandez, "Multicommodity Port Throughput from Truck GPS and Lock Performance Data Fusion," *Maritime Economics and Logistics*, 2020, <https://doi.org/10.1057/s41278-020-00154-7>
5. Chimka, J., Fernandez, and McGee (students) (2019), "Statistical effects of waterway lock unavailability on commodity flow," *Quality Technology & Quantitative Management* 16(6): 736-742.
6. Delgado-Hidalgo, Liliana, and Heather Nachtmann, "A Heuristic Approach to Managing Inland Waterway Disruption," *Engineering Management Journal* (accepted 2020).
7. Delgado-Hidalgo, Liliana, Chase Rainwater, and Heather Nachtmann, "A Computational Comparison of Cargo Prioritization and Terminal Allocation Problem Models," *Computers & Industrial Engineering*, Vol. 144 (accepted 2020).
8. Fong B, Reba ML, Teague TG, Runkle BRK, Suvočarev K, "Eddy covariance measurements of carbon dioxide and water fluxes in US mid-south cotton production," *Agriculture, Ecosystems and Environment*, Volume 292, 106813, April 2020.
9. 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 revision).
10. Gillespie-Marthaler, L. (student), M. Abkowitz and H. Baroud, "Sustainable Resilience of Flood Protection Infrastructure in the U.S.: Failure Mode and Implications Analysis," *Safety Science*, (under review).
11. Janssen, C. (student), W. Barbour, E. Hafkenschiel, M. Abkowitz and J. Camp, "Evaluating Flood Resilience in Rural Communities: A Case-Based Assessment of Dyer County, Tennessee," *Natural Hazards*, (under review).
12. Johnson, P. (student), C. Brady, C. Philip, H. Baroud, J. Camp, M. Abkowitz, "A Factor Analysis Approach to Unify Community Vulnerability and Resilience Indices for Natural Hazards," *Risk Analysis*, (under review).
13. Kermanshah, A., H. Baroud, and M. Abkowitz, "Cyber-Physical Technologies in Freight Operations and Sustainability: A Case Study of Smart GPS Technology in Trucking," *Sustainable Cities and Society*, 102017, (under review 2020)
14. Khan, M.S., Thornton, D., Ivoke, J. and Nobahar, M., "Numerical Investigation of Slope Stabilization using Recycled Plastic Pin on Yazoo Clay", *ASCE Journal of Materials in Civil Engineering*, (under review 2019).

15. Nelson, K.S. and J. Camp, "Quantifying the Benefits of Home Buyouts, Demonstration of an Approach and Local Application to an Urban Area," *Anthropocene (special issue) - Urban Hydroclimatic Risks in the 21st Century: Integrating Engineering, Natural, Physical and Social Sciences to Build Resilience*, (under review).
16. Nobahar, M., Khan, M. S., & Ivoke, J., "Combined Effect of Rainfall and Shear Strength on the Stability of Highway Embankments Made of Yazoo Clay in Mississippi," *Geotechnical and Geological Engineering*, 1-16, (under review 2020)
17. Oztanriseven, Furkan, and Heather Nachtmann, "Modeling Dynamic Behavior of Navigable Inland Waterways," *Maritime Economics and Logistics* (2019 - published)
18. Stefanko, Ana Uroic (student), Danuta Leszczynska, "Impact of biomass source and pyrolysis parameters on physicochemical properties of biochar manufactured for innovative applications," *Frontiers*, (under review).
19. Suvočarev K, Castellví F, Reba ML, Runkle BRK (2019) "Surface renewal measurements of H, LE and CO2 fluxes over two different agricultural systems, *Agricultural and Forest Meteorology*," 279, 107763, <https://www.sciencedirect.com/science/article/pii/S016819231930379X>
20. 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).
21. Wen, K., Li, Y., Huang, W., Armwood, C., Amini, F., & Li, L. (2019), "Mechanical behaviors of hydrogel-impregnated sand," *Construction and Building Materials*, 207, 174-180.
22. Yu, J. and H. Baroud, "Modeling Uncertain and Dynamic Interdependencies of Infrastructure Systems Using Stochastic Block Models," *ASCE-ASME Journal of Risk and Uncertainty Engineering*, (accepted 2020).

Conference Papers

1. Asbornio, M., Hernandez, S., and Akter, T. (student), "Multicommodity Port Throughput from Truck GPS and Lock Performance Data Fusion," Annual Meeting of the Transportation Research Board, 2020
2. Bipasha, Tarana (student), Jose Azucena (student), Basem Alkhaleel (student), Haitao Liao, and Heather Nachtmann, "Data Simulation to Support Interdependence Modeling of a Multimodal Transportation Network," 2019 Winter Simulation Conference Proceedings, December 2019.
3. Camp, J., K. Nelson, C. Philip, M. Moravec, D. Scheffler, P. Johnson, "Utilizing Agent-based Modeling to Evaluate Operational Impacts of an Incident and Possible Alternatives on U.S. Waterways. *Transportation Research Record*," (under review and accepted for presentation at the 2020 TRB Annual Meeting).
4. Guojing Hu, Feng Wang, Weike Lu, Tor A. Kwembe and Robert W. Whalin; "A Cooperative Bypassing Algorithm for Connected and Autonomous Vehicles in Mixed Traffic," *IET Intelligent Transport Systems*, (revised manuscript submitted) March 2020.
5. Guojing Hu, Weike Lu, Feng Wang and Robert W. Whalin; "Macroscopic Fundamental Diagram Based Discrete Transportation Network Design," *Journal of Advanced Transportation* in January 2020. (<https://doi.org/10.1155/2020/4951953>)
6. Oztanriseven, Furkan, Fan Bu (student), and Heather Nachtmann, "Measuring Economic Impacts of Inland Waterway Transportation," *American Society for Engineering Management Conference Proceedings*, October 2019.
7. Tarhumi, Abir (student), "Causes of Traffic Congestion in Developing Countries: A Case of Cairo", *ACSP*, October 2019.

8. Yu, J. and H. Baroud, "A Probabilistic Approach for Modeling the Resilience of Interdependent Power and Water Infrastructure Networks," Proceedings of the 29th European Safety and Reliability Conference. Hannover, Germany, October 2019.
9. Yu, J. and H. Baroud, "Modeling the Resilience of Interdependent Infrastructure Systems under Uncertainty," 13th International Conference on Applications of Statistics and Probability in Civil Engineering, ICASP13. Seoul South Korea, November 2019.

Books/Other One-Time Publications – Nothing to report

Editorial Journal Positions – Tech transfer

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, ASCE Journal of Infrastructure Systems
5. Associate Editor, IEEE Transaction on Reliability
6. Associate Editor, Journal of Military Operations Research
7. Associate Editor, Journal of Risk and Reliability
8. Associate Editor, Operations Research Letters
9. Editorial board member, ASCE Journal of Infrastructure Systems
10. Editorial board member, Environment Systems and Decisions
11. Editorial Board, Stochastics and Quality Control
12. Editor-in-Chief, Engineering Management Journal
13. Guest editor, Natural Hazards Review
14. Member, Editorial Board, Sustainability
15. Member, Editorial Board, Transportation Research Part D: Transport and Environment
16. Section Editor, Disasters & Resilience, Part D: Transport and Environment

3.2 Websites

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

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

- Ten at University of New Orleans
- Four at Vanderbilt
- One at University of Arkansas

K-12 Programs and Pre-College Events

- K-12 classroom visits – 1893 students total, 799 female, 858 underrepresented
- College fairs – 999 students total, 446 female, 491 underrepresented

4.2 Passage of new policies, regulation, rulemaking, or legislation - Nothing to report

4.3 Increases in body of knowledge

Conference Presentations

1. Abkowitz, Mark, "Managed Retreat - When, Whether and How?," 2nd International Conference on Resilience to Natural Hazards and Extreme Weather Events, Washington, DC, November 2019.
2. Asborno, M., (student) "Combining truck and vessel data to estimate performance of inland ports," Jack Buffington Student Poster Session, Fayetteville, Arkansas, November 2019.
3. Asborno, M., Taslima Akter, (students) Sarah Hernandez, "Multi-Commodity Port throughput from truck GPS and Lock Performance Data Fusion," 2020 Annual Meeting of the Transportation Research Board, Washington D.C., January 2020.
4. Bipasha, Tarana (student), Jose Azucena (student), Basem Alkhaleel (student), Haitao Liao, and Heather Nachtmann, "Data Simulation to Support Interdependence Modeling of a Multimodal Transportation Network," 2019 Winter Simulation Conference, December 2019.
5. Camp, J., K. Nelson, C. Philip, M. Moravec, D. Scheffler, P. Johnson, "Utilizing Agent-based Modeling to Evaluate Operational Impacts of an Incident and Possible Alternatives on U.S. Waterways," 2020 TRB Annual Meeting, Washington, D.C., January 2020.
6. Crews, M., (student) "Interdisciplinary Build Kits," Jack Buffington Student Poster Session, Fayetteville, Arkansas, November 2019.
7. Khan, M.S., "Slope Stabilization using Recycled Plastic Pin", Louisiana Transportation Conference, Baton Rouge, LA, March 2020.
8. Mallum, Faisal, (student) "Triple Bottom -Line Assessment of Green Infrastructure Implementation," New Orleans, ACSP (poster presentation), October 2019.
9. Nachtmann, Heather, Frances Alston, Suzanna Long, and Elizabeth Schott, "Women in Engineering Management Panel," American Society for Engineering Management International Annual Conference, Philadelphia, Pennsylvania, October 2019.
10. Oztanriseven, Furkan, Fan Bu (student), and Heather Nachtmann, "Measuring Economic Impacts of Inland Waterway Transportation," American Society for Engineering Management Conference, October 2019.
11. Renne, J., "FAU Research Encounter," Osher Lifelong Learning Institute, February 2020.
12. Stich, Bethany, "Chassis: What in the World Will We Do," 2020 Louisiana Transportation Conference, Baton Rouge, LA, March 2020.

13. Stich, Bethany, "Chassis: What in the World Will We Do," International Urban Freight Conference, Irvine, CA, October 2019.
14. Stich, Bethany, "Hurricane Katrina Response and Recovery Efforts Post Katrina: A 13 Year Analysis," Freight and Logistics Symposium, Minneapolis, MN, December 2019.
15. Tarhumi, Abir, (student) "Applying Safety Policies: A Case of LA 23/New Orleans & Gulf Coast Railway Corridor," Innovate UNO, November 2019.
16. Wolshon, B. "Optimum Volume of Freeway Corridors," Session 1496, 99th Annual Meeting of the Transportation Research Board, Washington, DC, January 2020.
17. Wolshon, B. "Planning, Designing, and Operating Resilient Transportation Systems and Infrastructure: Policy and Practice," Transportation Resilience Forum, PRiMO 2020 – Building a Resilient Pacific, Pacific Risk Management Ohana (PRiMO), Honolulu, HI, March 2020.

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

Nothing to report

4.5 Enlargement of the pool of trained transportation professions

Center for Training Transportation Professionals

- Workshop and Certification Courses
 - 14 programs, 30 sessions, 569 students
 - Examples: Asphalt Basics, Concrete Basics, Manual on Uniform Traffic Control Devices, Storm water Management, Basic Aggregates, Concrete Field Testing, Concrete Strength, Hot Mix Asphalt, National Pollutant Discharge Elimination System and Soils

4.6 Adoption of new technologies, techniques or practices - Nothing to report

5. Impacts (*through project deliverables and diversity*)

5.1 Effectiveness of the Transportation System – Nothing to report

5.2 Technology Transfer

Final Reports during this period

1. Effect of Permeability Variation of Expansive Yazoo Clay at the Maritime and Multimodal Transportation Infrastructure in Mississippi
2. Green Technology Approach for Capturing Pollution Washed from Transportation Infrastructures
3. Liquefied Natural Gas Phase II: The Future of LNG for the US and Gulf Coast Economies
4. Liquefied Natural Gas Phase III: Export Competition in a Well Supplied, Flow-Shifting Global Economy
5. Shipping Container Chassis in the US: The Legacy of Ocean Carriers
6. Trade-Off Analytics for Infrastructure Preservation
7. Utilizing Graceful Failure as An Opportunity for Flood Mitigation Downstream to Protect Communities and Infrastructure
8. Visualizing Sea Level Rise Impacts in Transportation Planning

Research Impacts

- MarTREC was selected by MARAD to conduct the Transportation and Maritime Analytics Partnerships Hub (TransMap) project. The project is funded at \$1.5M from September 2019-September 2022.
- Project - *Using CSA Cement for Novel Waterway Repair Materials*: A series of BCSA cement mortars (>15 mixtures) have been developed at varying water/cement and varying sand/cement ratios for use underwater. The data pertaining to these mixtures has been collected and is being analyzed by the MS student on the project. Current work in the spring involves improving the mix design and testing under more specialized conditions (under hydraulic pressure). Work is ongoing on developing fast setting cement stabilized soil for levee repairs. This work will continue into the summer of 2020. The data from the mixtures will be used to provide guidance on proportioning rapid setting underwater mortars. It is expected that the developed mix designs and future analysis of the data will help end users design their own non-proprietary rapid-setting underwater mortars and concretes. No other research has investigated making flowable, underwater mortars with the cement used in this project. This will be a new contribution to the literature and will have wide applications in industry and further research applications.

5.3 Increase in the Body of Scientific Knowledge

- Eight final reports successfully submitted
- Six peer-reviewed journal articles were published

5.4 Transfer of Results to Government/Industry Entities – Nothing to report

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
- 40% of our student research participation is from underrepresented populations:
 - 13 female students
 - 6 female minority students
 - 5 male minority students
- Throughout the reporting period, the University of Arkansas hosts outreach classroom visits for K-12, 50% of our participants are from underrepresented groups. We also host pre-college events (college fairs and tours), 49% of our participants are from underrepresented groups.

5.7 Development and Dissemination of New Educational Materials

- Trade-Off Analytics for Infrastructure Preservation project developed and applied at the University of Arkansas, created several educational modules.

6. Changes/Problems – COVID 19 has in some cases interrupted/delayed research that is normally done at specific sites. With social distancing requirements and travel restrictions, it has made it difficult and sometimes impossible for research teams to gather or access a site.

7. Special Reporting Requirements – Due to COVID 19, we were allowed an extra 30 days to submit this report. Thank you.