MarTREC

Maritime Transportation Research & Education Center

# USDOT Tier 1 University Transportation Center

## Semi-Annual Progress Report #10

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| 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, 479.575.6021 |
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| Project/Grant Period: | Start Date November 30, 2016<br>End Date: March 31, 2024 |
| Reporting Period Start Date: | April 1, 2023 |
| Reporting Period End Date: | September 30, 2023 |

Report Term or Frequency: six months

Signature: Heather Nachtmann

**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.

## 1. Accomplishments

### 1.1 Consortium-Level Accomplishments

#### 1.1.1 Research

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

Accomplishments:

| Research Effectiveness Metrics | Progress |
|---|---|
| # of peer-reviewed journal articles (published, accepted, submitted) | 12 |
| # of conference presentations given | 12 |
| # of students participating in transportation research projects funded by UTC | 50 |

#### 1.1.2 Leadership

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

Accomplishments:

| Leadership Effectiveness Metrics | Progress |
|---|---|
| # of national and regional leadership positions held | 44 |
| # of invited talks given | 4 |
| # of leadership and research awards received | 4 |

#### 1.1.3 Education and Workforce Development

Goal: MarTREC will develop educational resources for maritime and multimodal transportation systems.

Accomplishments:

| Education and Workforce Development Effectiveness Metrics | Progress |
|---|---|
| # of transportation-related courses offered | 37 |
| # of technician certification programs offered | 18 |
| # K-12 outreach programs offered | 9 |

### 1.1.4 Technology Transfer

Goal: MarTREC institutions will participate in national, regional, and local education and workforce development outreach to provide knowledge to private and public transportation organizations.

Accomplishments:

| Technology Transfer Effectiveness Metrics | Progress |
|---|---|
| # of project deliverables submitted | 15 |
| # of technical briefs | 1 |
| # of editorial journal positions held | 17 |

### 1.1.5 Collaboration

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

Accomplishments:

| Collaboration Effectiveness Metrics | Progress |
|---|---|
| # of existing collaborative partnerships | 69 |
| # of new collaborative partnerships formed | 9 |

### 1.1.6 Opportunities for Training and Professional Development

- 10 students presented at professional conferences
- 10 conference planning positions were held by MarTREC faculty researchers
- 44 leadership positions held by MarTREC faculty researchers
- 693 individuals completed transportation certified courses

### 1.1.7 Dissemination of Results (In this reporting period)

- 12 peer-reviewed journal articles
- 12 conference presentations
- Two books
- One technical brief

### 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.

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

- 62 total projects (life to date)
- 48 completed projects (life to date)
- Complete the remaining 14 projects

### 1.2.1 Maritime and Multimodal Logistics Management Projects

**A Supply Chain-oriented Methodology to Analyze Performance of Port-related Multimodal Freight Infrastructure**
**Jim Kruse, MBA**
**Texas A&M Transportation Institute**
**August 2022-August 2023**
**Accomplishments:** This project was built on past studies to develop a supply chain-oriented methodology to analyze performance of the port-related multimodal freight infrastructure. Specifically, the project team identified and matched the key freight corridors with ship activity to analyze what happens on relevant supply chain corridors at times of ship arrivals and departures.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**Analysis of Blockchain's Impacts on and Applicability to Maritime Industry**
**Jim Kruse, MBA**
**Texas A&M Transportation Institute**
**May 2019-October 2020**
**Accomplishments:** Currently, the most prominent blockchain projects in the maritime sector are initiatives by the shipping segment. However, the results presented in this research point toward the fact that ports and marine terminals have a pivotal role in the blockchain functionalities.
**Completed Project:** Final project report was submitted 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-September 2023**
**Accomplishments:** Since the 1969 passage of the National Environmental Protection Act, transportation planning has become a complex, interdisciplinary challenge. The need to meet environmental legislation and public participation demands have revealed innumerous problems of outdated techniques.
**Project Plans:** Final review of final report for submission

**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-October 2020**
**Accomplishments:** This project developed a method to fuse truck and marine vessel tracking data to better estimate performance of multi-modal supply chains that use inland waterway ports**.**
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**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 to be the case. This study shed light on the relationship between multimodal flows which will enable agencies and organizations to increase efficiency.
**Completed Project:** 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**
**Accomplishments:** The focus of this research project is to perform analysis on the Texas portion of the Gulf Intracoastal Waterway (GIWW). The Texas GIWW presents a level of complexity significantly greater than rivers because of the intersections with ship channels and the fact that some barges go into and exit port areas while others pass through. Established origins and destinations. Segmented the waterway into links. Analyzed AIS data to identify vessel transits and associated transit times on the links. Developed a methodology for predicting travel times. Evaluated the effect of special conditions.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**Driving Simulators as Educational Outreach for Freight Transportation**
**Sarah Hernandez, PhD, PE**
**University of Arkansas**
**August 2021-July 2023**
**Accomplishments:** This project was conducted to enhance outreach efforts for middle and high school student groups for freight career awareness by using truck driving simulators. There is a shortage of truck drivers which contributes to inefficiency in the freight system. There are many complex factors leading to the driver shortage, lack of awareness of the trucking profession is one. Through outreach programs, it may be possible to attract a new generation to freight careers. A paper was submitted to the ASEE conference.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**Evaluating the resilience of port operations to local and regional transportation infrastructure**
**Jim Kruse, MBA**
**Texas A&M Transportation Institute**
**December 2021-August 2023**
**Accomplishments:** This project developed a quantitative model of the local and regional road and rail network that serves a port and the flow of goods to and from the port.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**Inland Waterway Travel Time Prediction**
**Jim Kruse, MBA**
**Texas A&M Transportation Institute**
**November 2020-April 2022**
**Accomplishments:** This project built an inland waterways travel time prediction model that builds on and improves existing work at the Corps of Engineers Engineer Research and Development Center.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**Interdisciplinary Educational Outreach with Traffic Sensor Build Kits**
**Sarah Hernandez, PhD, PE**
**University of Arkansas**
**May 2019-August 2020**
**Accomplishments:** This project designed and implemented freight oriented educational outreach activities centered on traffic sensing technologies for middle, high, and first-year college students.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**Learning from USACE Open Data for Locks**
**Justin Chimka, PhD**
**University of Arkansas**
**August 2018-May 2021**
**Accomplishments:** In August 2017, the USACE began to enable unprecedented data access by publishing its Open Data for Navigation online. This project sought to explore the new USACE Open Data for Locks, describe its relevant datasets and inventory their contents, identify responses or variables across relevant datasets, and diagnose efficient statistical models.
**Completed Project:** 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**
**January 2022-September 2023**
The project will conduct in-depth interviews and surveys of dozens of Coalition participants representative of the entire marine shipping value chain and gain unique insight that can be used as a baseline as the work of the Coalition develops.
**Project Plans:** Final review of final report for submission

**Modal Comparison Update: 2001-2019**
**Jim Kruse, MBA**
**Texas A&M Transportation Institute**
**March 2021-October 2021**
**Accomplishments:** In December 2007, the Texas A&M Transportation Institute submitted a report to the U.S. Maritime Administration and the National Waterways Foundation titled "A Modal Comparison of Domestic Freight Transportation Effects on the General Public". Since that time, several updates to the study have been performed, with the last update covering the period 2001 to 2014. Effects will cover congestion, emissions, energy efficiency, safety, and infrastructure impacts from 2001 to 2019.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**Modeling Dynamic Behavior of Navigable Inland Waterways**
**Heather Nachtmann, PhD and Justin Chimka, PhD**
**University of Arkansas**
**August 2018-December 2023**
**Accomplishments:** This project is expanding prior MarTREC research. A literature search and review of prior research on and implementation of container-on-barge was published in the Maritime Economics and Logistics journal (August 2021).
**Project Plans:** We submitted a journal article manuscript on a value-focused framework to assess the feasibility of container-on-barge in the United States to the Engineering Management Journal in April 2023. We are near completion on a machine learning study to perform container volume forecasting for COB transportation within the United States.

**Measures of Freight Network Resiliency: An expanded data capture of Truck Drivers and Support Services under Pandemic Distress**
**Sarah Hernandez, PhD, PE**
**University of Arkansas**
**May 2020-September 2020**
**Accomplishments:** The purpose of this research was to collect timely data on the impacts of the Covid-19 pandemic on truckdriver and trucking operations with a specific focus on issues that affect driver health and safety. An online opt-in panel survey was developed using the Qualtrics survey platform. The survey questionnaire contained 65 questions with skip logic dependent on responses.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**Policy and Infrastructure Evaluation Model of Commodity Flows through Inland Waterway Ports**
**Sarah Hernandez, PhD, PE and Sandra Eksioglu, PhD**
**University of Arkansas**
**August 2020-September 2022**
**Accomplishments:** The purpose of this project was to guide strategic investment into port capacity through the development of a policy and infrastructure evaluation model of inland waterway commodity flows.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**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.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**The Changing Legal Landscape of Intermodalism**
**Bethany Stich, PhD**
**University of New Orleans**
**Janey Camp, PhD, PE**
**Vanderbilt University**
**July 2021-September 2023**
**Accomplishments:** This project investigated the ongoing legal challenges surrounding chassis. In 2020, Intermodal Motor Carriers Conference (IMCC) of American Trucking Associations and the Ocean Carriers Equipment Management Association (OCEMA) were involved in negotiations to resolve what IMCC charged were high-priced and inferior quality chassis at many of the nation's ports.
**Completed Project:** Final review of final report for submission

**Novel Big Data and Artificial Intelligence Analytics Methods for Tracking and Monitoring Maritime Traf.**
**Tor A. Kwembe, PhD**
**Jackson State University**
**November 2021-September 2023**
**Accomplishments:** This project will utilize Automatic Identification System (AIS) datasets to design scalable Maritime Traffic Monitoring and Analysis (MTMA) applications and tools. Critical applications

such as the detection of anomalies, offshore and onshore attacks and data intrusions, require fast mechanisms for Artificial Intelligence (AI) analysis of thousands of events per second, as well as efficient techniques for the analysis of massive historical AIS data. An automated generation of the AutoML end-to-end pipeline model is complete. Data acquired from SPIRE. Testing complete. Module lecture series developed to teach the mathematics and statistical principles for models and model selections.
**Project Plan:** Working on final report

**Network Science-based Analysis of the US Marine Highway Network and a Random Graph Model for the Intermodal Port Network**
**Natarajan Meghanathan, PhD**
**Jackson State University**
**November 2021-September 2023**
**Accomplishments:** Marine highways in the US correspond to navigable waterways that run closer to major interstate roads in the country. Unlike the US Interstate road network and the airport network, the US marine highway network (MHN) and the US marine intermodal port network (MIPN) have not been analyzed and no results have been so far reported in the literature. We propose to analyze the MHN using algorithms for community detection, cluster analysis and centrality assessment to identify the critical marine highways and their intersection points that could potentially be a bottleneck. Collecting the distances and routes (on the marine highways) between any two intermodal ports. We have identified close to 75 major intermodal ports within the US and 16 marine highways connecting them.
**Project Plan:** Working on final report

**Mississippi Multimodal Freight Analysis Model**
**Tzusheng Pei, PhD**
**Jackson State University**
**November 2021-September 2023**
**Accomplishments:** Enable policy makers, transportation planners and logistic analysts in various federal, state, and local agencies for assessing the demand for transportation facilities and services, energy use, and safety risk and environmental concerns. Completed algorithm and development data.
**Project Plan:** Working on final report

**Assessing Maritime Infrastructure along the Mississippi: Chokepoints and Implications for Food Security**
**Berneece S. Herbert, PhD**
**Jackson State University**
**November 2021-September 2023**
**Accomplishments:** Supply chains are inherently complex due to their interdependency with critical infrastructure systems including maritime and multimodal transportation with the largest risk to agricultural trade resulting from age and inadequate or inappropriate infrastructure. It is imperative to close the infrastructure gap. We have assessed hazards to maritime infrastructure and resulting delays in agricultural trade. The second phase of the JSU-UC Berkerley program was conducted in MS supported by a total of 12 students, faculty and researchers. We focused on the transportation issues along the Mississippi River in Vicksburg with the students making recommendations. We also focused on flooding issues along the Pearl River in Jackson.
**Project Plan:** Working on final report

### 1.2.2 Maritime and Multimodal Infrastructure Preservation Projects

**A Digital Twin for Visualizing, Evaluating and Maintaining Multimodal Transportation**
**Haitao Liao, PhD, Shengfan Zhang, PhD, and Heather Nachtmann, PhD**
**University of Arkansas**
**August 2021-September 2023**

**Accomplishments:** This research project will develop a digital twin that enables visualizing, evaluating and maintaining multimodal transportation infrastructure. The ultimate goal is to provide an opensource software tool and machine learning-based decision-making approaches that assist the relevant stakeholders in improving their information collection and tracking capabilities, as well as enhancing the resilience of multimodal transportation infrastructure and beyond. We have created a complete dataset for the boats and land transportation.
**Project Plan:** Working on final report

**Multimodal Transportation Infrastructure in Mississippi**
**Sadik Kahn, PhD, PE**
**Jackson State University**
**April 2020 – September 2023**

**Accomplishments**: The existence of Yazoo clay in Mississippi frequently causes distress in levee and highway embankment slopes, which are an integral component of maritime and multimodal transportation infrastructure. This project will investigate the effect of the vetiver grassroots to stabilize levee slopes at the maritime and multimodal transportation infrastructures at Mississippi. Study were presented in TRB AKG 90 Standing Committee on Stabilization of Geomaterials and Recycled Materials.
**Project Plan:** Working on final report

**Climate Financing for Marine Transport: Analyzing the Impact of Climate Adaptation Investments in Inland Waterways**
**Hiba Baroud, PhD and Craig Philip, PhD**
**Vanderbilt University**
**October 2022-June 2023**

**Accomplishments:** We developed a state-of-the-art, data-driven approach to evaluate climate financing strategies for inland waterways based on future costs of inland waterway supply chain disruptions due to climate change. The approach combines recent developments in financial analysis, climate modeling, simulation, statistical inference, and economic modeling. With this methodology in place, we can then evaluate cases where investments in resilient, waterborne infrastructure can offer cost-effective means of mitigating projected impacts of climate change. Our project paves the way for researchers being able to quantify the return on investment from climate adaptation strategies based on economic impacts of climate change on inland waterway supply chains and can help policymakers better allocate funding for mitigating future supply chain disruptions.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**Continued Study of Rapidly Deployable Soil-Cement Mixtures**
**Cameron Murray, PhD, PE and Michelle Barry, PhD, PE**
**University of Arkansas**
**September 2021-October 2023**

**Accomplishments:** The maintenance and repair of maritime infrastructure is critical to maintaining important shipping channels and preventing unnecessary loss of life or economic impact from severe weather events. The fastest repair, reconstruction, and maintenance techniques may become more desirable as labor costs increase and delays become costlier. The objective of this research is to identify

the properties and proportions of Belitic Calcium Sulfoaluminate (BCSA) soil-cement mixtures most effective for use in waterway structures. BCSA cement is a rapid setting, low-shrinkage cement which can be used in a similar fashion to portland cement.
**Project Plans:** Working on final report

**K8 MEMES: K-8 Maritime Education Modules to Engage Students**
**Gary Prinz, PhD, PE**
**University of Arkansas**
**September 2021-October 2023**
**Accomplishments:** This education development project will create entertaining, informative, and STEM promoting "plug-and-play" curriculum learning modules for K-8 educators, using maritime transportation and infrastructure related topics to teach STEM concepts. Coupling music memory, fun STEM theories, and innovative experiential demonstrations into entertaining video learning modules. Three of the learning modules have been outlined, the educational songs have been written and recorded. The educational songs have been written, recorded, and music videos have been completed.
**Project Plans:** Working on final report

**Dredging Projects Selection when the Random Shoaling Effect is Considered**
**Bruce Wang, PhD**
**Texas A&M University**
**October 2019-December 2021**
**Accomplishments:** 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. Literature review complete. Problem formulation developed.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**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.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**Effect of Permeability Variation of Expansive Yazoo Clay, Maritime and Multimodal Trans Infra MS**
**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:** Final project report was submitted and distributed as per grant guidelines.

**Engaging the Business and Tourism Industry in Visualizing Sea Level Rise Impacts to Trans Infra HI**
**Brian Wolshon, PhD, PE, PTOE**
**Louisiana State University**
**March 2018-December 2020**
**Accomplishments:** The goal of this research was to assess the use of 3D virtual and augmented reality as a tool for improved coastal planning for better understanding of sea level rise impacts among the business and tourism industries in Waikiki. The study found that participants were better able to understand the data about flood impacts in the future due to SLR after watching a 3D video.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**Evaluation of Hydrogel–stabilized Expansive Soils in Mississippi for Sustainable Maritime Infrastructure Design**
**Yadong Li, PhD**
**Jackson State University**
**August 2019-December 2021**
**Accomplishments:** Expansive soil causes a variety of maritime transportation infrastructure problems, such as cracks, damage of pipeline, and the differential settlement of foundation. Results showed that cracks appeared on the surface of the hydrogel-treated Yazoo clay samples when subjected to moisture.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**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.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**Green Technology Approach for Capturing Pollution Washed from Transportation Infrastructures**
**Danuta Leszczynska, PhD**
**Jackson State University**
**March 2018-December 2019**
**Accomplishments:** This study produced and investigated 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:** Final project report was submitted and distributed as per grant guidelines.

**Identifying Critical Waterway Infrastructure and Managing Risk Associated with Natural Disasters**
**Michelle Barry, PhD, PE and Shengfan Zhang, PhD**
**University of Arkansas**
**July 2020-September 2023**
**Accomplishments:** The transportation system in the U.S. is extremely vulnerable to disruptions and delays from natural disasters. The overall goal of this research is to develop a risk assessment framework that can be used to aid decision making and mitigation strategies for maritime infrastructure deemed critical to the U.S. transportation system and economy.
**Project Plans:** Working on final report

**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 exposure to outdoor environment.
**Completed Project:** 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.
**Completed Project:** 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:** Final project report was submitted and distributed as per grant guidelines.

**Multimodal Network Approach to the Inland and Coastal Waterway System**
**Bruce Wang, PhD**
**Texas A&M University**
**July 2017-January 2019**
**Accomplishments:** This project has developed a multimodal freight network model that includes both waterway landside components in order to analyze the impact of waterway operations. Tests show that the solutions are not sensitive to these parameters. The model illustrates changing the total amount of available budget into five different scenarios, each having an amount allocated to the locks and dams.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**Port Infrastructure Resilience through Combined Wind-Surge Demand Characterization**
**Gary Prinz, PhD, PE**
**University of Arkansas**
**July 2020-August 2023**
**Accomplishments:** This project aimed to understand the interactive effects of severe wind and storm surge demands on port infrastructure and to develop hazard demand models to aid improvements to infrastructure design. An integrated analytical and experimental research approach combined information from detailed fluid-structure-interaction simulations and scaled wind-wave experiments to support port resilience.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**Rapid Assessment of Internal Erosion Damage and Erodibility in Levees**
**Michelle Barry, PhD, PE and Clint Wood, PhD, PE**
**University of Arkansas**
**July 2020-September 2023**
**Accomplishments:** Recent flooding events have tested our nation's levee systems and highlighted the vulnerability of our transportation system to disruptions and delays caused by natural disasters. Traditional drilling and sampling techniques only provide discrete data points. This project seeks to make a correlation between geophysical properties and vital engineering properties such as erodibility. Development of the Hole Erosion Test (HET) apparatus has been completed including the addition and calibration of an internal waterproof camera. This novel adaptation will allow for more accurate measurements and more efficient testing to be conducted, as well as potentially lead to an entirely new method for analyzing HET data. The team has identified and tested a number of benchmark samples that will provide a wide range of soil property and erosion behavior data that can be used to develop correlations capable of predicting erosion potential for a given soil. The team also collected field samples from the Crawford County levee and conducted HET and laboratory resistivity testing.
**Project Plans:** Working on final report

**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 was 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 was packaged into a webinar that can be delivered on-line for practicing professionals.
**Completed Project:** 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-August 2021**
**Accomplishments:** The goal of this study was to proportion a mortar mixture using BCSA cement suitable for underwater use. The mixture developed is expected to be suitable as a repair material. The mixture was intended to achieve a compressive strength of 4000 psi (27.6 MPa) within 3 hours when placed underwater while being self-consolidating. Mortar flow was measured as well as compressive strength for “dry-cast” and “wet-cast” specimens. A follow up project has been approved.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

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

**Analysis of the Impacts of the COVID-19 Pandemic on Vessel and Cargo Movements in the U.S.**
**Brian Wolshon, PhD., P.E., PTOE**
**Louisiana State University**
**August 2022-September 2023**
**Accomplishments**: This research seeks to understand changes in national and international shipping trends. We will investigate shifts in cargo movements, by commodity for both import and export operations for several ports across the US. We will also examine changes in origin/destination patterns.
**Project Plans:** Working on final report

**Assessment of Evacuation Network Performance under Different Evacuation Scenarios**
**Brian Wolshon, PhD., P.E., PTOE**
**Louisiana State University**
**July 2019-September 2023**
**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.
**Project Plans:** Working on final report

**Development and Implementation of Sustainable Transportation Resilience Indicators**
**Mark Abkowitz, PhD**
**Vanderbilt University**
**June 2017-March 2019**
**Accomplishments:** This project established a protocol and method for evaluating a community's level of sustainable transportation resilience. If deficiencies exist, attention can be focused on mitigating those concerns. The project was applied to a river valley community to demonstrate proof-of-concept.
**Completed Project:** 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-August 2022**
**Accomplishments:** Natural disasters like hurricanes and floods leave coastal areas most vulnerable. 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.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**Evacuation Behavior and its Mobility Impacts in Coastal Communities from Across the Nation**
**Brian Wolshon, PhD., P.E., PTOE**
**Louisiana State University**
**July 2020-September 2023**
**Accomplishments:** Coastal communities are at risk from a multitude of potentially disruptive events. Severe weather, climate change, and sea-level rise all pose serious and long-term societal challenges. This research seeks to develop a better understanding of the travel flow principles that govern the evacuation process and its impact on the mobility of a community, for different hazard types.
**Project Plans:** Working on final report

**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 was 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:** Final project report was submitted and distributed as per grant guidelines.

**Impacts of COVID Restrictions on Freight Transportation in Coastal and Intermodal Port Regions**
**Brian Wolshon, PhD., P.E., PTOE**
**Louisiana State University**
**February 2022-September 2023**
**Accomplishments:** The global COVID pandemic of 2020 impacted travel patterns across the world. This research will identify and quantitatively assess the impact of COVID-related restrictions on travel activities, with a particular focus on freight and economic activity.
**Project Plans:** Working on final report

**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-December 2021**
**Accomplishments:** Agriculture supply chains are inherently complex due to their interdependency with critical infrastructure systems including energy, water, and maritime and multimodal transportation. We created a mathematical model to characterize multi-modal transportation flow while incorporating interdependencies between agriculture and transportation.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**Informing Post-Disaster Restoration through Modeling Interdependent Agriculture and Transportation Networks - Phase II VU**
**Janey Camp, PhD, PE, GISP, CFM**
**Vanderbilt University**
**October 2018-September 2023**
**Accomplishments:** While disruptions due to weather, etc. can affect any sector, agriculture is unique in its time sensitivity for planting, harvesting, etc. Agriculture is interdependent on other sectors, particularly the transport of products. This project will develop models that determine how to use transportation and coordinate restoration efforts to make ag supply chains more resilient.
**Project Plans:** Working on final report

**Interdependency of Port Clusters during Regional Disasters**
**Brian Wolshon, PhD, PE, PTOE**
**Louisiana State University**
**January 2018-August 2019**
**Accomplishments:** The research built upon prior knowledge and expanded the scientific understanding of regional disruptions to port clusters, areas of the country with multiple ports servicing the same region. The results showed that regionally, ports are more resilient to disruptive events.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**International Port Dependencies and Resilience to Supply Chain Disruptions**
**Brian Wolshon, PhD., P.E., PTOE**
**Louisiana State University**
**August 2022-September 2023**
**Accomplishments**: This research will further identify the most central ports in the network and determine groups of highly interconnected ports.
**Project Plans:** Working on final report

**Modifying Ramp Management Strategies to Enhance Resiliency of Freeway Facilities**
**Brian Wolshon, PhD., P.E., PTOE**
**Louisiana State University**
**July 2020-September 2023**
**Accomplishments:** Increased traffic demand of coastal areas during emergency evacuations have been shown to affect transportation systems negatively. Application of the ramp management algorithms modified by this method becomes increasingly important during emergency evacuation.
**Project Plans:** Working on final report

**Planning for Managed Retreat: Decision Making in the Face of Climate Uncertainty**
**Leah A. Dundon, JD, PhD and Mark Abkowitz, PhD**
**Vanderbilt University**
**December 2019-September 2023**
**Accomplishments:** 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 with a particular focus on transportation and its interdependencies with other critical infrastructure systems.
**Project Plans** Final review of final report for submission

**Prediction of Port Recovery Time after a Severe Storm Project**
**Bruce Wang, PhD**
**Texas A&M University**
**September 2022-September 2023**
**Accomplishments**: This study will explore the relationship of potential influencing factors on port recovery under adverse storm events. Using multi-source data and applying machine learning algorithms, a model will be developed to predict the port recovery after adverse storm events. The study will benefit transportation agencies and ports by enhancing resilience, safety, and efficiency.
**Project Plans** Final review of final report for submission

**The Unintended Consequences of Flood Mitigation along Inland Waterways – A Look at Resilience and Social Vulnerabilities**
**Janey Camp, PhD, PE, GISP, CFM**
**Vanderbilt University**
**July 2020 – March 2023**
**Accomplishments:** The objective of this project is to evaluate different flood mitigation efforts in terms of the community costs such as residential buyouts or elevation of structures. We utilized agent-based models and empirical data from select communities where significant buyouts have taken place to simulate and estimate the extent to which buyouts may negatively affect community resilience.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**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-March 2021**
**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. The results showed that the resilience metrics and methods implemented in this study seemed to have captured the resilience of the freeway using simulation. The results of the analysis also showed that active ramp metering improved the resilience of the freeway.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**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:** Final project report was submitted and distributed as per grant guidelines.

**Vehicle to Infrastructure (V2I) and Vehicle to Vehicle (V2V) passenger and freight vehicle applications to enhance safety and efficiency in coastal evacuations**
**Brian Wolshon, PhD., P.E., PTOE**
**Louisiana State University**
**August 2022-September 2023**
**Accomplishments**: this study seeks to address this limitation by using a driving simulator to assess and understand how drivers interact with V2V and V2I advisories during emergency evacuation scenarios.
**Project Plans:** Working on final report

**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 was to test and compare new technologies in community-meetings in South Florida to assess the effectiveness of 3D visualization technology, improving residents' understanding of the impacts of sea level rise on their communities and infrastructure.
**Completed Project:** Final project report was submitted and distributed as per grant guidelines.

**2. Participants & Collaborating Organizations**
Arkansas and Missouri Rail, Arkansas Trucking Industry, Arkansas Waterways Commission, Caltrans, Department of Homeland Security, HBCU Fellowship Program, INROADS, International Freight Forwarders & Customs Brokers Association of New Orleans, MARAD, MITRE Corporation, Moment AI, National Waterways Foundation, New Orleans Regional Planning Commission, NSF Regional Innovation Engines, Oak Ridge National Laboratory, Port Freeport Texas, Port of Beaumont, Port of New Orleans, Roadway Management Technologies, Seven State(s) Department of Transportation, USACE, and more

## 3. Outputs

### 3.1 Publications

*Peer Reviewed Journal Articles*

1. Bian, R., P. Murray-Tuite, and B. Wolshon, “Analyzing and Modeling Grocery Store Visits during the Early Outbreak of COVID-19,” Transportation Research Record: Journal of the Transportation Research Board, Vol. 2677, No. 4, pp. 79-91, Published, April 2023.
2. Bu, Fan, and Heather Nachtmann, "Value-Focused Thinking Assessment of Container on Barge Maritime Transportation Readiness," Engineering Management Journal, Under Review, April 2023.
3. Bu, Fan, Jingming Li, Haitao Liao, and Heather Nachtmann, "An Alternative Solution to Congestion Relief of U.S. Seaports by Container-on-Barge: A Simulation Study," Simulation Modelling Practice and Theory, Accepted, September 2023.
4. Cole, G., B. Wolshon, and J. Schmidt, “Incident Diversionary Routing: Survey of Influences and Decisions," Transportation Research Record: Journal of the Transportation Research Board, Under review, August 2023.
5. Dundon, L. A., Abkowitz, M., & Camp, J., “Governing Transition: Case Studies in Transformative Adaptation,” Environment, 7(1), Published April 2023.
6. He, Bowen, J. Camp, J. Gilligan, “An Index of Social Fabric for Assessing Community Vulnerability to Natural hazards: Model Development and Analysis of Uncertainty and Sensitivity,” International Journal of Disaster Risk Reduction, 96, 103913, Published, August 2023.
7. Mahmoudzadeh, Ahmadreza, Magdalena Asborno, Ali Khodadadi, Bruce Wang, Ned Mitchell, Michael Hartman, Chaolun Ma, “Unraveling the Dynamics of Shoaling Rates: A Statistical Analysis for Enhanced Waterway Maintenance along the Ohio River,” Transportation Research Procedia, In press, July 2023.
8. Mayeux, C. R., S. Parr, and B. Wolshon, “Quantifying the Effect of COVID-19 on Port Congestion: A Global Perspective on Vessel Delay and Container Volume," Transportation Research Record: Journal of the Transportation Research Board, Under review, August 2023.
9. Salunke, R. and Khan, S., “A Multi-Sensor Approach for Rapid Characterization of Highway Slopes Prone to Landslides,” Transportation Research Record (TRR): Journal of the Transportation Research Board, Under review, June 2023.
10. Spears, A., Khan, S., Alzeghoul, O., and Whalin, R. “Climate Resilient Slope Stability Improvement Using Vetiver on a Test Levee,” Natural Hazards Review, Under review, April 2023.
11. Spears, A., Khan, S., and Whalin, R., “Predicting the Water Balance of a Test Levee Slope Improved with Vetiver Grass”, Transportation Research Record (TRR): Journal of the Transportation Research Board, Under review, April 2023.
12. Stich, Bethany, and Faisal B. Mallum, “The New Orleans Adopt-A-Catch Basin Program and Citizen Involvement,” Public Works Management & Policy, Vol 0, P 1–18, Published, June 2023.

*Books*

1. Smith, Morgan and Tor A. Kwembe, “Application of Machine Learning Classifiers Interfacing Google Colab and SKlearn to Intrusion Detection CSE-CIC IDS2017 Dataset,” American Council on Science & Education, CSCE 2023 BOOK of ABSTRACTS, ISBN # 1-60132-518-5, July 2023. https://www.american-cse.org/csce2023/
2. Meghanathan, N, "Complex Network Analysis of the US Marine Highway Network,” Proceedings of the 20th International Conference on Information Technology-New Generations (ITNG 2023), Springer Advances in Intelligent Systems and Computing, vol. 1445. pp. 437-443, April 2023. https://link.springer.com/chapter/10.1007/978-3-031-28332-1_51

**3.2 Website:** martrec.uark.edu

**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**

- Brian Wolshon, Innovator and Influencer, Resilient Roads Roundtable Transportation Industry.
- Demetric Baines, JSU, Mississippi Academy of Science, Best Oral Presentation.
- Heather Nachtmann, Arkansas Research Alliance Fellow, program recognizes scientists and engineers in Arkansas for their contributions to the state's core research areas.
- Hiba Baroud, Excellence in Teaching Award, Vanderbilt.

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

**4.3 Increases in body of knowledge -** *Conference Presentations*

1. Briuglio, Sam, "Planning approach," U.S. Army Corps of Engineers, Fort Worth, TX, April 2023.
2. Briuglio, Sam, "Asset Management," U.S. Army Corps of Engineers, Huntsville, AL, July 2023.
3. Briuglio, Sam, "EV Charging Stations," U.S. Army Installation Management Command, San Antonio TX, August 2023.
4. Bu, Fan, and Heather Nachtmann, "Predicting Container-on-Barge Waterway Traffic in the United States," Institute of Industrial and Systems Engineering Annual Conference, New Orleans, LA, May 2023.
5. Camp, Janey, "Decarbonizing Inland Maritime Sector," Wartsilia, Finland, June 2023.
6. Khan, Sadik, "Evaluation of Transportation Geo infrastructure Health using Near-Surface Remote Sensing and Geophysical Testing," Southeast Symposium on Contemporary Engineering Topics (SSCET) and the Arkansas Engineering Forum (AEF), University of Arkansas LR, September 2023.
7. Khan, Sadik, "Vetiver Grass Application for Landfill," Solid Waste Association Annual Conference, Corpus Christi, TX, June 2023.
8. Mahmoudzadeh, Ahmadreza, "Preventive Maintenance Planning for an Inland Waterway Transportation System Using Deep Reinforcement Learning," Institute of Industrial and Systems Engineers Annual Conference and Expo, New Orleans, LA, May 2023.
9. Mahmoudzadeh, Ahmadreza, Magdalena Asborno, Ali Khodadadi, Bruce Wang, Ned Mitchell, Michael Hartman, Chaolun Ma, "Unraveling the Dynamics of Shoaling Rates: A Statistical Analysis for Enhanced Waterway Maintenance along the Ohio River," World Conference on Transport Research, Montreal, Canada, July 2023.
10. Meghanathan, Natarajan, "Complex Network Analysis of the US Marine Intermodal Port Network," Artificial Intelligence Application in Networks and Systems: Proceedings of 12th Computer Science On-line Conference, April 2023.
11. Smith, Morgan, and Tor A. Kwembe, "Application of Machine Learning Classifiers Interfacing Google Colab and SKlearn to Intrusion Detection," 22nd International Conference on Information & Knowledge Engineering, Las Vegas, NV, July 2023.

12. Stich, Bethany and Carol Short, "The Impacts of Changing Trade Policies on Trade Volumes, Jobs and Economic Growth," Tenn-Tom Waterway Conference, Point Clear, AL, August 2023.

**4.4 Improved processes, technologies, techniques, and skills**

- Project, *Evaluating the resilience of port operations to local and regional transportation infrastructure,* developed a database of transportation infrastructure (roads and rail) with elevation data, useful in evaluating effects of storm surges and flooding.

**4.5 Enlargement of the pool of trained transportation professionals**

- 12 students graduated with a BS, MS, or PhD
- 693 individuals completed transportation certified courses

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

**5. Impacts**

**5.1 Effectiveness of the Transportation System –** Nothing to report

**5.2 Technology Transfer**

- Project - *Network Science-based Analysis of the US Marine Highway Network and a Random Graph Model for the Intermodal Port Network,* developed a web-based application to visually represent the marine highway network and marine intermodal port network for shortest paths between any two intermodal ports.

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

- 15 projects completed in period
- 17 Editorial positions

**5.4 Transfer of Results**

- The Texas Department of Transportation has contracted Texas A&M University Transportation Institute to explore the findings and further develop the work done: *A supply chain-oriented methodology to analyze performance of port-related multimodal freight infrastructure* project.

**5.5 Commercialization of Technology –** Nothing to report

**5.6 Underrepresented Groups**

- Department of Urban and Regional Planning students invited to DRMT education event

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

- *Interdisciplinary Educational Outreach with Traffic Sensor Build Kits* – project and final report
- *K8 MEMES: K-8 Maritime Education Modules to Engage Student* - project and final report

**6. Changes/Problems**

- USDOT approved a no-cost grant extension to March 31, 2024, due to operational disruptions and programmatic delays related to the COVID pandemic.

**7. Special Reporting Requirements –** Nothing to report