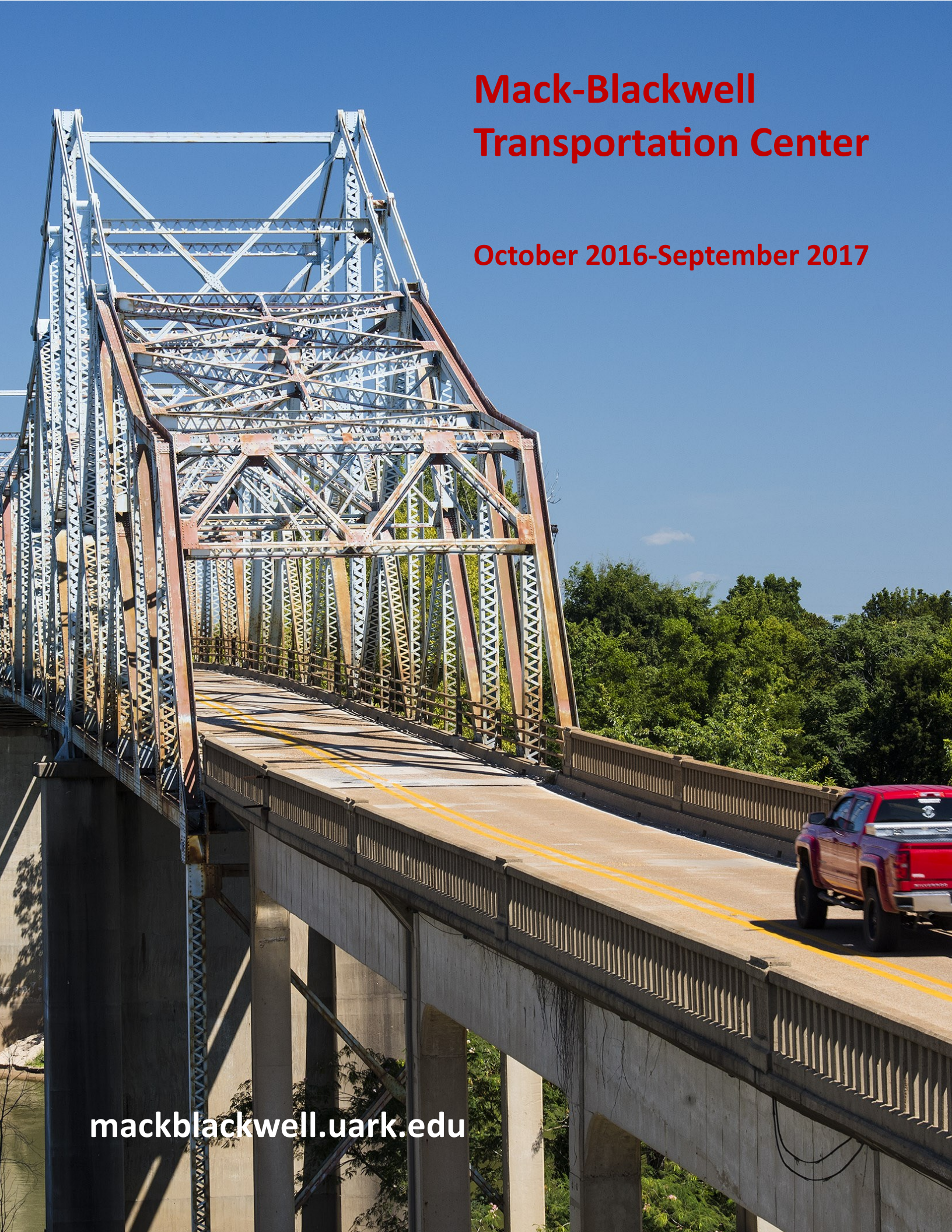

Mack-Blackwell Transportation Center

October 2016-September 2017

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MESSAGE FROM MBTC EXECUTIVE DIRECTOR

If forced to sum-up the past year in a single word, many of us might be tempted to use that word. Most of the spheres which intersect in our lives have witnessed significant change in the past year – political, social, technological, and many others. With change, inevitably, comes challenges; in the transportation world we see a mixture of the 'old' (deteriorating infrastructure, increased congestion, safety, climate -related effects) and 'new' (just-in-time home delivery, driverless vehicles, truly *transformational* innovation, workforce development in the 'new economy'). It is in times such as these that the value and importance of our nation's research centers comes into sharper focus. The Mack-Blackwell Transportation Center (MBTC) and its partners – MarTREC, SPTC, and CTTP – share a two-fold commitment: (1) pursue research and workforce development programs which address immediate and ongoing needs in the transportation community; and (2) provide vision to anticipate and clarify those issues and challenges not yet fully realized. I am very proud to work with the many students, researchers, and other transportation professionals associated with the activities of MBTC on both of these fronts.

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NEW MBTC RESEARCH PROJECTS

Data Simulation to Support Interdependence Modeling in Emergency Response and Multimodal Transportation Networks

Haitao Liao, Ph.D.
Heather Nachtmann, Ph.D.
Xuan Shi, Ph.D.
University of Arkansas
September 2017-August 2019

Access to data on the design and operation of interdependent critical infrastructures (ICIs) is now recognized as essential for developing new data analytic, design and decision-support tools. This NSF EArly-concept Grant for Exploratory Research (EAGER) project will create and make available synthetic and simulated data on ICIs by developing new data creation techniques and model-based approaches to simulating data on ICIs and human cognition and/or behavior with ICIs. It will provide research communities in broad areas, such as multimodal transportation, emergency services, wildfire and infectious disease, with tools for modeling complex ICIs involving human activities and decisions. The new knowledge will be broadly disseminated through journals and conferences in the areas of infrastructure risk management, applied statistics, reliability engineering, and spatiotemporal computation. The PIs will promote interdisciplinary education, recruit underrepresented students for maintaining workforce diversity, and expose K-12 teachers and students to cutting-edge research experiences. This project investigates a methodology for topology and data generation for ICIs. The research will (1) create a two-layer framework 2) simulate data for targeted ICIs and 3) demonstrate the feasibility of using the framework .

ONGOING MBTC RESEARCH PROJECTS

Dependence of Infrastructure Restoration on Transportation Networks

Sarah Nurre, Ph.D.
University of Arkansas
May 2016-October 2017

The restoration of critical infrastructure systems after extreme events is vital. We developed an optimization model which decides on the restoration of tasks in interdependent infrastructure networks, such as power, based on the availability and restoration of transportation over time. Previous models assume that any sequential completion of restoration tasks is feasible. We removed this common unrealistic assumption through the development of our model. We tested the model on real data sets representing the transportation and power networks of a coastal area prone to hurricanes, floods, and storm surges. We made many observations about the optimal restoration of the transportation and power network over time. Additionally, we observed favorable configurations of work crew skills and preplacement within an impacted area.

Effects of Weather Events on Truck Traffic Using Fixed and Mobile Traffic Sensors

Sarah Hernandez, Ph.D.
University of Arkansas
March 2016-October 2017

While previous studies have modeled the effects of weather on total traffic volumes, very few studies in this area have been conducted examining freight trucks. This project shows, as expected, truck traffic volume has spatial dependence which requires spatial regression modelling rather than previously used linear regression models. Results of the spatial models show that while truck volumes reductions occur on routes experiencing snowfall, fog, hail, winter storms, flash flood, flood, heavy rainfall, etc., trucks effectively re-route to non-impacted routes. While this may be an intuitive finding, this project provides quantification of the effect of each weather pattern. The study found that extreme cold events (i.e. snow) decreases daily truck volumes by 25.28% while heavy rainfall, flood, flash flood reduces daily truck volume by 13.08%.

Rapid and Continuous Assessment of Soil Conditions along Highway Alignments

Clint Wood, Ph.D., P.E.
University of Arkansas
April 2016-March 2018

For new highway alignments in the southern plains region and around the nation, shallow subsurface investigations are typically conducted using drilling and sampling methods. To improve upon this method of characterization, geophysical methods, particularly capacitively coupled resistivity (CCR), can be used to provide a rapid and continuous evaluation of the subsurface soil conditions along a new highway alignment. With this evaluation, localized changes in stratigraphy (expansive clay thickness) and localized anomalies (krast sinkholes, unknown landfills, etc.) can be detected. Currently, the project has completed testing along several highway alignments where typical drilling and sampling was conducted. We are currently assessing the soil properties which are best correlated with the resistivity measurements from CCR and evaluating the accuracy of the CCR method to determining subsurface stratigraphy. This information will be used to develop a new drilling and sampling plan that investigates regions of interest identified by the CCR testing.

Evaluation of Surface Treatments to Mitigate Alkali-Silica Reaction

Micah Hale, Ph.D., P.E.
University of Arkansas
October 2013-May 2018

Alkali-silica reaction (ASR) is the most common form of alkali-aggregate reaction and has become a problem in concrete structures throughout the world. This research focuses on mitigating ASR once it has occurred. The project examines using silane and other sealers to mitigate ASR in concrete structures. In the laboratory, field exposure blocks containing reactive silica have been cast. Each block was instrumented so that expansion and relative humidity can be monitored. These blocks were also treated with silane and other sealers to determine the most effective treatment that can mitigate ASR expansion by reducing internal relative humidity. The results showed that silane was effective in reducing expansion and internal relative humidity. However, blocks treated with linseed oil expanded more than the control blocks which were left untreated. This was due to the linseed oil trapping moisture within the concrete. Current research is examining methods of measuring the relative humidity within the blocks.

Impact of Extreme Summer Temperatures on Bridge Structures

Micah Hale, Ph.D., P.E.
University of Arkansas
Royce W. Floyd, Ph.D., P.E.
University of Oklahoma
October 2013-May 2018

During the first task of this study, four full-scale segments of AASHTO I-beam girders were fabricated. Two Type II and two Type IV girders were cast. Two girders were placed in Fayetteville, Arkansas, and two were placed in Norman, Oklahoma. An additional Type V girder was cast in Fayetteville, AR. The temperatures of these girders were monitored for 12 months while constantly exposed to environmental conditions. Using internal and external thermocouples, temperature readings were collected at 29 locations throughout the cross section. The ends of each beam were insulated to prevent heat loss. Environmental data was collected concurrently to analyze impacts of factors such as daily temperature range and wind speed. Data collected from the study showed that the current AASHTO prediction models do not accurately estimate the thermal gradients in narrow flanged, prestressed bulb tee girders.

Photo courtesy of ARDOT

MBTC COMPLETED RESEARCH PROJECTS

Development of the MASW Method for Pavement Evaluation

Clinton Wood, Ph.D., P.E.
University of Arkansas
October 2013-July 2016

Infrastructure deterioration is a major issue for transportation infrastructure in the southern plains region and around the nation. Delamination, cracking, and many other failure modes in bridge decks and pavement systems are a daily issue in the constant maintenance of transportation systems. Extreme weather further exasperates the problem of failing infrastructure by increasing the wear and tear on transportation systems through more frequent freeze-thaw cycles and larger temperature swings. Highway departments need non-destructive testing (NDT) methods to determine the condition of infrastructure. This project explored the use of the Multi-Channel Analysis of Surface Waves (MASW) as a NDT method for characterization of pavements. Tests have been conducted on concrete samples and full size pavement sections affected by alkali-silica reaction (ASR) to determine the relationship between shear wave velocity developed using the MASW method and strain increases due to ASR expansion of the concrete. Results indicate that the MASW method is capable of detecting the damage due to ASR for low to moderate damage levels in the concrete, additional work needs to be completed to determine accuracy for heavily damaged concrete.

Evaluation and Repair of Existing Bridges in Extreme Environments

Royce Floyd, Ph.D., P.E.
University of Oklahoma
Gary Prinz, Ph.D., P.E.
University of Arkansas
October 2013-July 2016

The goal of this project was to increase the longevity of existing structures through development of comprehensive strategies for evaluation and resilient repair of pre-stressed concrete and steel bridge girders subjected to extreme environments. Regarding concrete bridges, the effect of end region steel corrosion on girder capacity is examined. Regarding steel bridges, innovative corrosion resistant fatigue retrofits are explored. We identified multi-girder systems as the most prevalent steel bridge construction type within the southern plains region. Detailed finite element simulations indicate that the partial-depth cross-frame-to-girder attachments within these multi-girder systems are the most fatigue critical regions. Pre-stressed carbon fiber fatigue retrofits having specially tuned pre-stressed levels were developed to ensure infinite fatigue life within the affected connection regions. Laboratory tests equipped with the prototype retrofits were successful in shifting the mean stress in an instrumented steel beam. The result is a cost-effective and corrosion resistant “bridge band-aid” that can be applied to mitigate fatigue cracks in a wide array of steel bridge geometries.

Final project reports available @ www.sptc.org/projects/

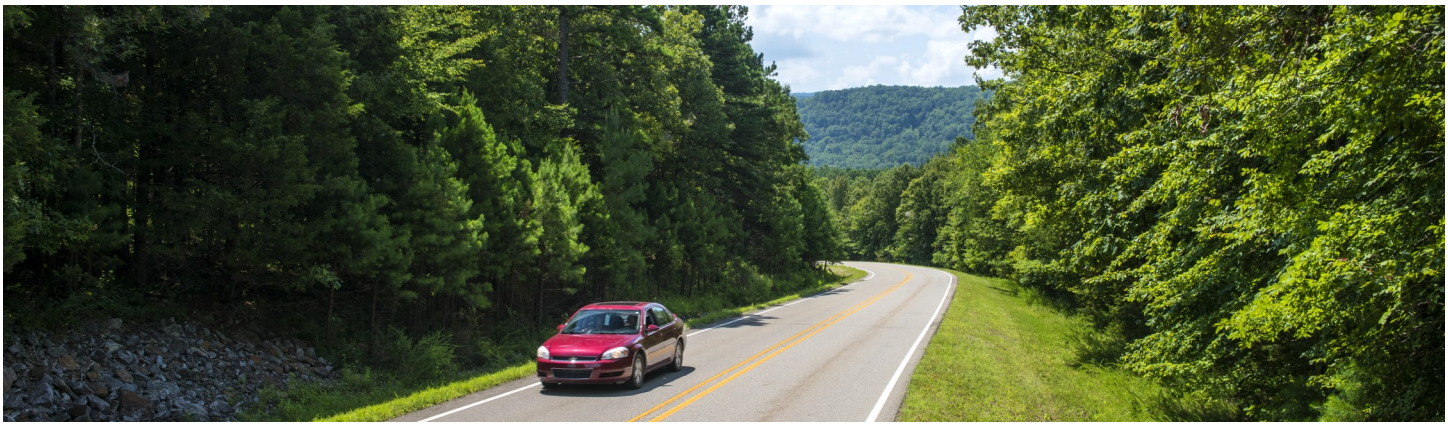


Photo courtesy of ARDOT

CENTER FOR TRAINING TRANSPORTATION PROFESSIONALS

Pictured: **Frances Griffith**, **Stacy Williams**, **Roselie Conley**, **Mary Fleck**, **Talley Faulkner**, **Katie Juniel**, and **Austin Williams**.

It's been another busy year at the Center for Training Transportation Professionals (CTTP). To date, thirty classes have been completed in 2017, with expectations to meet or exceed last year's record-setting total of 43 classes. This level of training needs is indicative of the increased activity in the state's construction industry, which is also apparent to the traveling public. To meet the increased demand for courses in Basic Aggregates, Concrete Field Testing, Hot Mix Asphalt, Soils, and Concrete Strength Testing, Talley Faulkner has joined the CTTP team as the CTTP Program Specialist. In this role, Talley provides classroom and laboratory instruction, and is also managing the CTTP website. The National Pollutant Discharge Elimination System (NPDES) course requests have also increased in response to a requirement for contractor certification in this topic. Additional courses have been scheduled through 2018 to allow contractors to meet the October 1 certification deadline. Laboratory certification requests have also increased, with 7 new labs enrolling this year, resulting in a total of 105 laboratories currently participating in the program.

Online training usage has strengthened, particularly as a study aid for those attending CTTP training courses. Additional online participation has been generated by the Basic Aggregates refresher training, which is required during the 2017 calendar year for all technicians certified in Basic Aggregates, as this certification is a pre-requisite for all other materials certifications. CTTP's online training modules have gained national attention, and are being used in a number of states as a training aid for both state and local agencies.

CTTP has also been very active with the Technology Transfer (T^2) program, which is managed by the Arkansas Department of Transportation (ArDOT). So far this year, CTTP has instructed over 250 technicians in topics including Asphalt Pavement Maintenance, Safety Countermeasures, and Pavement Management. The newly developed course "Guide for Traffic Signs, Markings, and Signals" has also been very popular for local agencies desiring to ensure compliance with the latest updates to the Manual on Uniform Traffic Control Devices. Participation with the Arkansas Unpaved Roads grant program has continued, entering the second year of funded projects. Six training courses have been scheduled for this program cycle, and will be conducted in conjunction with the Arkansas Department of Rural Services and The Nature Conservancy. Pavement management has also been a hot topic, and CTTP has provided assistance to several local agencies in the early stages of pavement management program development. More information about CTTP at www.cttp.org.

MBTC STUDENT ACHIEVEMENTS

2016 Jack Buffington Outstanding Student Poster Award

Khatereh Ahadi was awarded the 2016 Jack Buffington Outstanding Student Poster Award at our Mack-Blackwell Annual Advisory Board Meeting in November 2016. Ahadi's poster, *Efficient Dredging Strategies for Improving Transportation Infrastructure Resilience,* is based on a MarTREC research project.

Ahadi is a Ph.D. Industrial Engineering student at the University of Arkansas working with Dr. Kelly Sullivan, Assistant Professor of Industrial Engineering. Her graduate work and dissertation "*Optimization Models and Methods for Maintaining Complex Systems"* will be completed in May 2018.

Airport Cooperative Research Program Graduate Research Award

In August 2017, **Joseph Daniels III** was awarded the Airport Cooperative Research Program Graduate Research Award for his research project titled *Development of Anti-Icing Airfield Heated Pavement System Using Solar Energy*. Daniels is a Ph.D. student at the University of Arkansas working with Dr. Ernie Heymsfield, Associate Professor of Civil Engineering.

Daniels will present his research and final research paper at the 2017 Annual Transportation Research Board Conference in Washington, D.C.

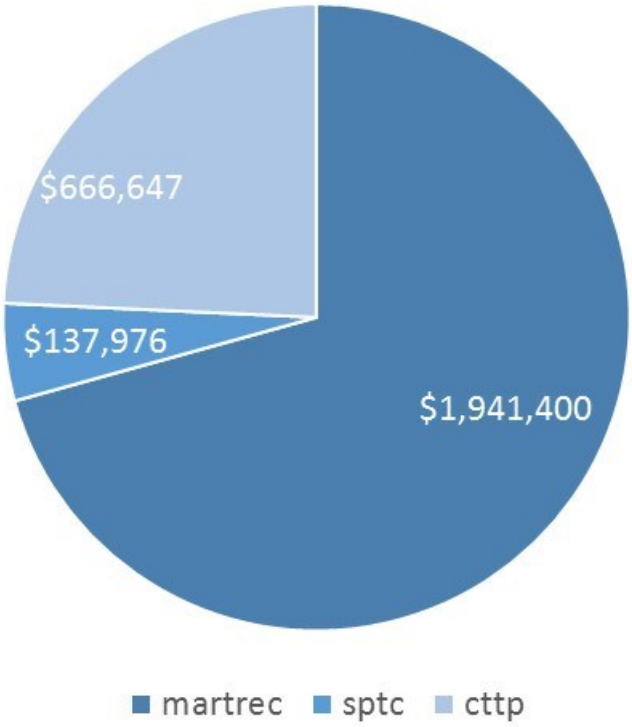
2017 Arkansas Good Roads Scholarships

Pictured Jack Buffington, Emanuel Banks, Kevin Weston, Colton Horn, Bob Crafton, Harold Beaver, and Dan Flowers

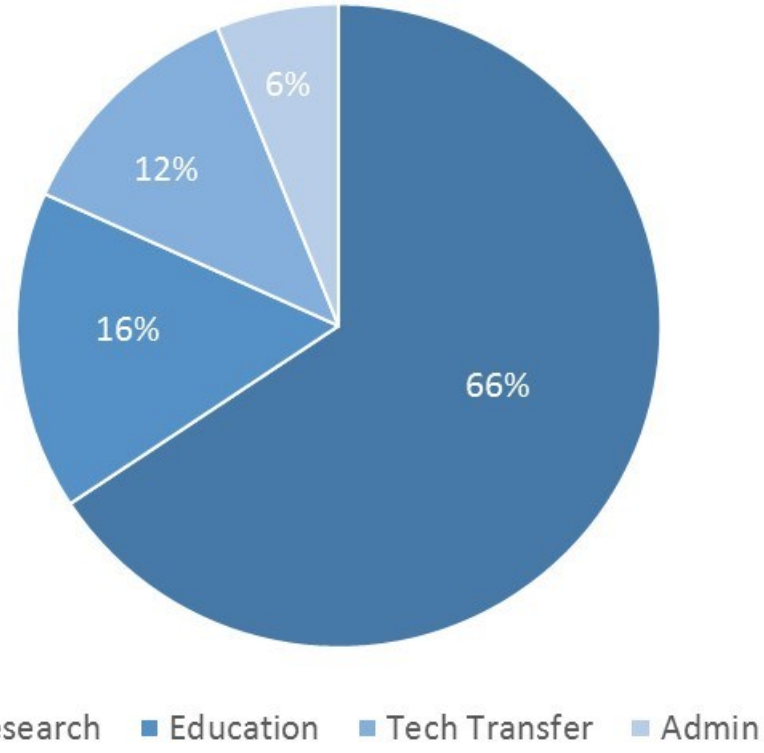
Colton Horn and **Kevin Weston** have been selected as 2017 Arkansas Good Roads scholarship recipients. The organization grants scholarships to outstanding civil engineering students in their junior or senior year. Recipients of the scholarship commit to work in the transportation field in Arkansas for a minimum of one year after graduation. The organization creates awareness of the benefits of improving roads, bridges, and other key transportation infrastructure in Arkansas by researching, evaluating and publicizing data focused on transportation.

MBTC FINANCIALS

Center Expenditure Breakdown
FY17 Expenditures = $2,746,023



Expenditure Activity Distribution
FY17 Expenditures = $2,746,023



MESSAGE FROM MarTREC DIRECTOR

We are thrilled that MarTREC will continue to lead a U.S. Department of Transportation Tier 1 University Transportation Center under the FAST Act and are pleased to announce that Texas A&M Transportation Institute, Texas A&M University, and Vanderbilt University have joined our consortium. The Beyond Traffic 2045 report predicts that imports and exports will double over the next 30 years leading to greater congestion at America's coastal ports, and our existing navigation channels are already helping to avoid 58 million truck trips on the road each year. MarTREC is working to preserve the nation's transportation system through efficient, resilient, and sustainable maritime and multimodal logistics and infrastructure through the research and workforce development efforts of our consortium team. Enjoy reading about our accomplishments this year!

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Photo courtesy of ARDOT

MarTREC

Maritime Transportation Research & Education Center

ABOUT

MarTREC is a U.S. Department of Transportation Tier 1 University Transportation Center funded through the Office of the Assistant Secretary for Research and Technology. Under MAP-21, MarTREC is building economic competitiveness through efficient, resilient, and sustainable maritime and multimodal transportation systems. MarTREC, through continued funding under the FAST Act, is also working to preserve the Nation's transportation system through efficient, resilient, and sustainable maritime and multimodal logistics and infrastructure.

VISION

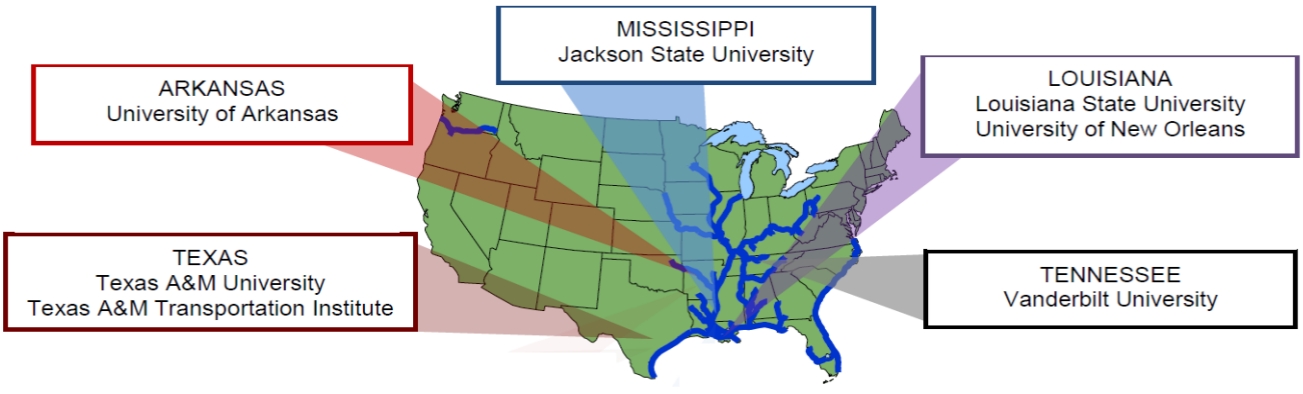
Our vision is to be recognized as the Nation's premier source for expertise on maritime and multimodal transportation research and education. The MarTREC consortium consists of renowned maritime transportation researchers dedicated to transferrable research and inclusive education and workforce development.

CONSORTIUM

Our consortium includes the University of Arkansas (UARK), Jackson State University (JSU), Louisiana State University (LSU), Texas A&M University/Texas A&M Transportation Institute (TAMU/TTI), University of New Orleans (UNO), and Vanderbilt University (VU). Each consortium member is strategically located to support MarTREC's theme: UARK, JSU, LSU, and UNO are located along the Mississippi River; VU along the Cumberland River; and JSU, LSU, UNO, and TAMU/TTI along the Gulf Coast.

RESEARCH

MarTREC conducts research activities in three topic areas: 1) Maritime and Multimodal Logistics Management to expand decision support and facilitate improved operations within the Nation's multimodal supply chain networks; 2) Maritime and Multimodal Infrastructure Preservation to advance state-of-the-art resilient multimodal transportation infrastructure preservation, repair, design, and construction; and 3) Disaster Response and Transportation Planning for Coastal and River Valley Communities to enable the resilience, safety, efficiency, and effectiveness of multimodal transportation systems during disaster response or other major events.



NEW MarTREC PROJECTS

Development and Implementation of Sustainable Transportation Resilience Indicators

Mark Abkowitz, Ph.D.
Vanderbilt University
June 2017-August 2018 (FAST Act)

Much has been discussed about resilient transportation infrastructure as well as sustainable practices, but only recently have their interdependencies been brought to light in terms of a community's ability to develop sustainable (economic, social and environmental) resource capacity necessary to be resilient in the face of natural hazard events that could lead to catastrophic consequences. In order to evaluate whether a community has achieved an acceptable level of sustainable transportation resilience, it requires performance indicators that are both relevant and measurable. This project will establish a protocol and method for evaluating a community's level of sustainable transportation resilience.

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

Jim Kruse, M.S., M.B.A.
David Ellis, Ph.D.
Texas A&M Transportation Institute
September 2017-August 2018 (FAST Act)

An economic impact analysis of the Gulf Intracoastal Waterway (GIWW) on the five states it serves (TX, LA, MS, AL, and FL) will focus on the economic importance of the GIWW to the various states and assume only sufficient investment to maintain current system performance. The underlying methodology will evaluate what an abandonment (or closure) of the canal would mean in terms of economic impact. It will compare the transportation and related supply-chain costs faced by current waterway users to the costs they would face if the GIWW were to become permanently unavailable and they had to use the next best transportation alternative.

Effect of Swell-Shrink Characteristics on Landslides in Yazoo Clay

Mohammad Sadik Khan, Ph.D., P.E.
Jackson State University
July 2017 - June 2018

Slope failures are frequent in highway embankments as well as in waterway infrastructures (levees) on expansive Yazoo clay in Mississippi which cause significant maintenance problems and require millions of state and federal dollars to fix it. After construction, the strength of the high plastic clay degrades with time due to the seasonal temperature and moisture variation, which is one of the major factor of slope failure. The research will investigate the repeated drop in the shear strength of the Yazoo clay soil with wet-dry cycles which cause slope failure.

Supporting Secure and Resilient Inland Waterways: Phase Two

Heather Nachtmann, Ph.D.
Justin Chimka, Ph.D.
University of Arkansas
July 2017-June 2018

Unexpected disruptions to the inland waterway system due to natural disasters, vessel accidents, or terrorist attacks can cause non-navigable water levels or destroy major navigation infrastructures, resulting in closures of the inland waterway. We are extending our current Phase One project by expanding our current model to consider uncertainty into the decision. Future commodities transported, barge traffic, and water and land capacities are all unknown parameters that will be considered.

ONGOING MarTREC PROJECTS

Climate Impacts on Lock Use and Performance

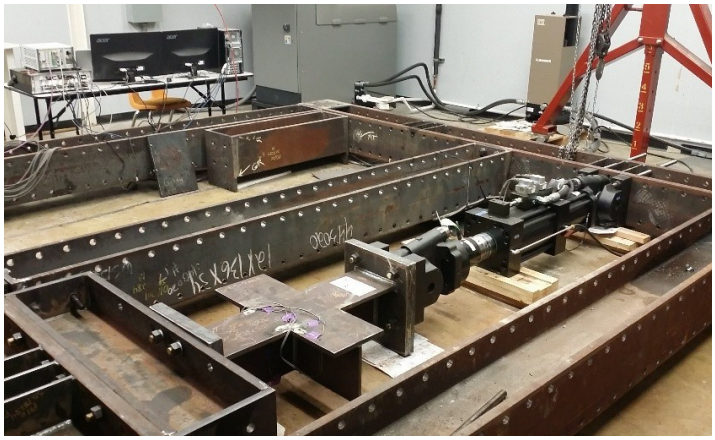
Justin Chimka, Ph.D.
University of Arkansas
July 2016-June 2018

It is the policy of U.S. Army Corps of Engineers (USACE) to integrate climate change preparedness and resilience planning and actions in all activities for the purpose of enhancing the resilience of our built and natural water-resource infrastructure (USACE Climate Preparedness and Resilience Policy Statement 2014). Inland waterways may experience greater floods due to changing land-use patterns and precipitation, drought can lower vessel drafts, and less ice on navigable waterways could increase seasonal windows for passage. The objective of this work is to integrate resilience planning and climate change preparedness for water-resource infrastructure. New datasets have been created by collecting relevant online climate data and matching them to existing lock unavailability data and newly created spatial lag variables which allow us to begin exploring statistical models of lock unavailability as a function of climate data and spatial lags, for different measures of unavailability and different waterways (AR, IL, MS, OH).

Corrosion-Tolerant Pre-Stressed CFRP Fatigue Retrofits for Improved Waterway Lock Reliability

Gary Prinz, Ph.D., P.E.
Clint Wood, Ph.D., P.E.
University of Arkansas
July 2016-June 2018

Retrofits for improved waterway lock reliability are essential to waterway transport for many river and canal systems, allowing passage of ships through areas of differing water elevation. Over 23M cargo tons passed USACE locks in January 2015 alone, and dozens of locks aid water transport throughout AR, LA, and MS. These locks typically consist of large steel gates that are subject to large alternating forces as water levels are changed, and as lock gates open/close. Repeated loads, corrosive waterway environments, and component geometry can all contribute to fatigue/fracture issues that can limit lock gate service and inhibit the overall reliability of waterway transport. The project addresses fatigue issues within lock gates, identifying critical components and exploring methods for preventing fatigue cracks for the entire gate component service life. A prototype retrofit has been created and is being tested for pre-stress loss, surface preparation requirements, and pre-stress application. In addition, high-fidelity finite element simulations of the installed retrofit were conducted to evaluate pre-stressing formulas developed during earlier project reporting periods. Preliminary analyses indicate an extension in fatigue life of approximately 10 years using the retrofit strategies.



Development of a Design Protocol: Sustainable Stabilization of Slope using Recycled Plastic Pin in Mississippi

Sadik Khan, Ph.D., P.E.
Jackson State University
May 2016-October 2017

The maritime and multimodal system is an integral part of the efficient movement of the nation's freight. Slopes and embankments are a major component of maritime and multimodal transportation infrastructure, which are often subjected to shallow landslides due to the existence of expansive clay soil. As a cost effective alternative, Recycled Plastic Pins can be utilized to stabilize shallow slope failures, to offer a sustainable option and increase the economic competitiveness to maintain multimodal transportation infrastructure.

Evaluating the Performance of Intermodal Connectors

Sarah Hernandez, Ph.D.
University of Arkansas
August 2016-June 2018

This project focuses on evaluating the performance of Intermodal Connectors (IC)- critical "last mile" roadways connecting intermodal freight facilities such as maritime ports to the National Highway System (NHS). ICs account for less than 1% of NHS mileage, but are critical for timely and efficient multimodal freight movements. ICs are currently not well monitored or understood and are frequently missing from statewide planning, programming, and forecasting models. ICs are in relatively poor condition compared to the NHS as a whole. This has cascading effects on the reliability of multimodal freight operations- a 1- or 2-hour delay in a drayage movement can result in a 24-hour holdup in a domestic multimodal shipment. We have made progress on sensor development. Currently our Lidar based sensor accurately measures vehicle speed and length (i.e. effective vehicle length), and traffic volume. The sensor is bundled with a low-cost video camera.

Quantifying Resiliency of Maritime Transportation Systems

Brian Wolshon, Ph.D., P.E., PTOE
Louisiana State University
October 2015-May 2018

This research leverages and adapts archival NAIS data for resilience analyses of coastal port operations following disruptive events. As part of this effort, archival vessel position reports will be used to establish a baseline of channel operations under "routine" non-event conditions. Observed losses in system functionality following a major disruption will be used to quantify the resiliency of the waterway using time dependent performance analysis. This type of analysis is critical when investigating the efficacy of the recovery process protocols and management strategies employed in the days and weeks that follow a major disruptive event. The primary contribution of this research is creating a systematic, objective means of measuring commercial port resiliency. The methods developed can be used for future studies of post-disaster operations and protocols, such as evaluations of channel operations after a disruption to better understand characteristics that increase resiliency.

Supporting Secure and Resilient Inland Waterways

Heather Nachtmann, Ph.D.
Justin Chimka, Ph.D.
University of Arkansas
August 2014-October 2017

To mitigate inland waterway disruption impacts, we developed the cargo prioritization and terminal allocation problem (CPTAP) to minimize the total value loss of disrupted barge cargoes. The final solution identifies an accessible alternative terminal for each disrupted barge and the prioritized offload turn that each barge takes at its assigned terminal. Implementation of CPTAP results reduced cargo value loss and response time when compared to a naïve minimize distance approach. We are currently extending our earlier work through CPTAP model enhancement in order to provide timely knowledge and awareness of what cargoes should be prioritized for offloading during disruption response and what infrastructure exhibits low resiliency in terms of modal capacity to potential attacks or natural disasters against inland waterway transportation systems. We have formulated and tested a linearized version of the CPTAP model which shows result improvements compared to our initial approach. Our ongoing work has improved this new solution approach with the goal of enhanced decision support for maritime transportation users.

COMPLETED MarTREC PROJECTS

Multimodal Transport and TransLoad Facilities in Arkansas

Justin R. Chimka, Ph.D.
University of Arkansas
July 2014-December 2014

National priorities include building a clean and efficient 21st century transportation sector, and multimodal transportation is one of five Transportation System Efficiency strategies at the U.S. Department of Energy. However, additional multimodal transport may require added transload facilities where freight is moved from truck to railcar or vice versa. Greater than 550 short line and regional railroads operating in 49 states account for almost 30% of the U.S. rail network. These small businesses compete and cooperate with trucking interests to cost-efficiently connect local economies with the larger Class I railroad system. With three Class I railroads and 24 short lines in Arkansas, research finds the state may be poised to ease state highway congestion, safeguard the environment, and support local economies by adding transload facilities.

Photo courtesy of ARDOT

Identifying High-Risk Roadways for Infrastructure Investment Using Naturalistic Driving Data

Brian Wolshon, Ph.D., P.E., PTOE
Louisiana State University
October 2013-June 2015

The state-of-the-practice for most municipal traffic agencies seeking to identify high-risk road segments has been to use prior crash history. While historic traffic crash data is recognized to be valuable in improving roadway safety, it relies on prior observation rather than future crash likelihood. Recently, however, researchers are developing predictive crash methods based on "abnormal driving events." These include abrupt and atypical vehicle movements thought to be indicative of crash avoidance maneuvers and/or near-crashes. Because these types of near-crash events occur far more frequent than actual crashes, it is hypothesized that they can be used as an indicator of high-risk locations and, even more valuably, to identify where crashes are likely to occur in the future. Statistical analyses revealed that clusters of high magnitude jerk events while decelerating were significantly correlated to long-term crash rates at these same locations. These significant and consistent relationships between jerks and crashes suggest that these events can be used as surrogate measures of safety and as a way of predicting safety problems before even a single crash has occurred.

Road Sign Recognition during Computer Testing versus Driving Simulator Performance for Stroke and Stroke+Aphasia Groups

Neila J. Donovan, Ph.D.
Louisiana State University
July 2014-June 2015

Brain damage from stroke can affect physical mobility, sensorimotor, cognition, communication, visual perception, and visual processing which are all critical processes needed for driving. A recent study that tested road sign interpretation tasks among groups of healthy and poststroke older drivers assessed the effects of poststroke aphasia on driving. Results showed that aphasia significantly impacted accuracy and response time of road sign interpretation. As language and symbol complexity increased on road signs, the aphasia-affected drivers performed with

Final project reports are located @ martrec.uark.edu/research/index.php

less accuracy and required more time. Findings suggest further research may show implications for the design of road signs and decision making for healthcare professionals regarding poststroke patients.

Development of a Large-Scale Traffic Simulation Model for Hurricane Evacuation of Mississippi Coastal Region

Feng Wang, Ph.D., P.E.
Jackson State University
July 2014-July 2015

This study developed an optimization model to obtain improved traffic flow assignment with a minimization of the total travel cost in a localized no-notice evacuation network. In this study, we made the following observations: (1) numerical results show that the implementation of a gate control strategy could effectively decrease the total travel cost and reduce the degree of conflicts related to traffic movements and trip routes, (2) experimental results show that in a no-notice or short notice evacuation, the number of nodes selected for a gating strategy may also impact the evacuation performance, and (3) traffic simulations of an evacuation scenario with a large scale network show that applying the gate control strategy could improve evacuation performance.

Regional Economic Impact Study of the McClellan-Kerr Arkansas River Navigation System

Heather Nachtmann, Ph.D.
University of Arkansas
April 2014 -August 2015

In this research, funded by the Arkansas Department of Transportation as a MarTREC match project, we implemented a multiregional social accounting matrix framework to estimate the economic impacts of the McClellan-Kerr Arkansas River Navigation System (MKARNS) activities on the study regions of AR, OK, KS, MO, TX, and the rest of the United States. Our study considers economic impacts from 1) Hydropower Energy Generation, 2) USACE O&M Expenditures, 3) Private Sector Investment Expenditures, 4) Port Activities, 5) Shippers' Activities, 6) Transportation Cost Savings, and 7) Recreation Benefits. We combined our analysis with a 2014 Oklahoma Department of Transportation study led by Dr. Dennis Robinson of University of Arkansas - Little Rock and found that the total economic impacts of the MKARNS nationwide are $8.5 billion in sales, $4.3 billion in gross domestic product (GDP), and $2.5 billion in labor income. In addition, 55,872 jobs are created due to the activities related to the MKARNS. Port Activities are the largest component of the total economic impacts of the MKARNS followed by Shippers' Activities and Transportation Cost Savings.

LNG Bunkering for Marine Vessels at the Port of New Orleans: Siting and Facility Components

Bethany Stich, Ph.D.
James R. Amdal, Sr.
University of New Orleans
April 2014-January 2016

The team was approached by the Port of New Orleans in 2014 to develop an assessment of best practices regarding the construction of shore-side Liquefied Natural Gas (LNG) bunkering facilities and the overall feasibility of the LNG fueling facility. When this request was made, the maritime industry was expected to convert their fleets from diesel to LNG, due to fuel cost savings and in compliance with planned environmental regulations. However, when OPEC began dra-

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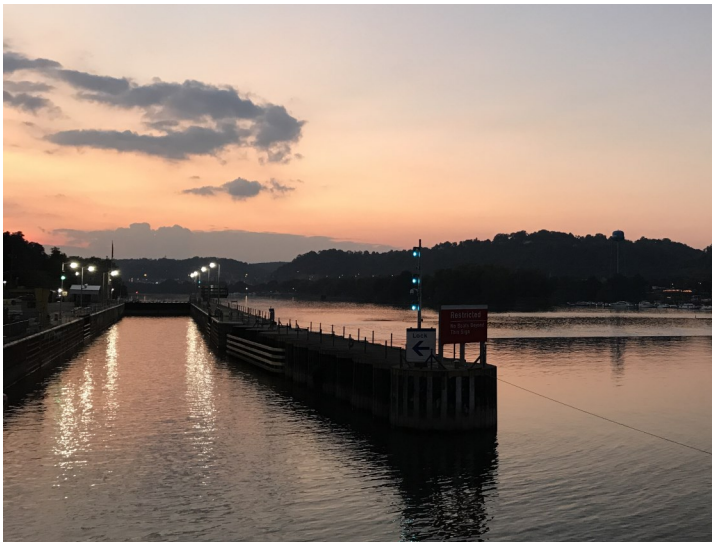
matically decreasing the price of crude oil in the mid-2010s, these cost incentives ceased to exist, especially the economic factor. The best recommendation that can be made from this research is for the Port of New Orleans to join with the International Chamber of Shipping in encouraging the International Maritime Organization (IMO) division of the United Nations to continue taking the lead in globally-applied emissions standards. Therefore the Port is best advised to aggressively support an IMO-derived driven global implementation of policies which would make this fleet conversion ultimately more cost effective than continued reliance upon cheap diesel as a marine fuel.



Economic Impacts of Lock Usage and Unavailability

Justin R. Chimka, Ph.D.
University of Arkansas
August 2014-June 2016

Freight statistics should provide an objective baseline for transportation policy decisions, and national economic benefits of maritime transport necessitate improving inland waterways infrastructure. This work included consolidating and learning from Lock Use, Performance, and Characteristics data collected by the USACE and published by the Navigation Data Center. The research objective is to estimate annual tons locked by commodity group and lock, as a function of lock usage and unavailability (1993-2013). Usage data includes average delay and processing time, barges empty and loaded, flotillas and vessels, lockages, and percent vessels delayed. Unavailability data includes scheduled and unscheduled lock unavailabilities, and unavailable times. Estimation required consolidation and statistical models of Lock Use, Performance, and Characteristics published by the USACE Navigation Data Center. Results include effects of lock usage and unavailability on tons locked by commodity group (coal, petroleum, chemicals, crude materials, primary manufactured goods, food, and manufactured equipment). Twenty-two out of the 42 datasets resulted in at least one useful subset where we could employ our alternative to stepwise regression to find a linear model which is efficient and practically appropriate according to our definitions of those characteristics.

Exploration of Novel Multifunctional Open Graded Friction Courses for In-situ Highway Runoff Treatment

Yadong Li, Ph.D., P.E.
Lin Li, Ph.D., P.E.
Jackson State University
July 2014-June 2016

Pollutants on roadways and parking lots can come from various sources. Storm water runoffs from roadways contain both organic and inorganic contaminants of which large portions are eventually conveyed to the nearby water bodies such as rivers and lakes. Copper (Cu) and Zinc (Zn) have been identified to be the major inorganic contaminants in roadway runoffs. The goal of this study was to examine the removal of the major heavy metals Cu and Zn in roadway runoffs through pervious concrete pavement (PCP) and Modified PCP (MPCP) and by adding innovative additives to Open Graded Friction Courses to create a new material that has high heavy metal removal capacities. The results of this study bring an important conclusion that not only can the pervious concrete pavement bring traffic-related benefits but also environmental benefits because of its long-term removal capacities for Cu and Zn, which are the major heavy metal contaminants in roadway runoffs. The use of PCP in roadways and parking lots brings positive impacts for the sake of environmental protection.

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In-Situ Monitoring and Assessment of Post Barge-Bridge Collision Damage for Minimizing Traffic Delay and Detour

Wei Zheng, Ph.D., P.E.
Jackson State University
July 2014-June 2016

Piers of bridges across major navigation waterways frequently suffer from barge collisions, resulting in the closure of both bridges and waterways to traffic for assessing the potential damage. This project developed an efficient in-situ monitoring and data processing scheme for assisting bridge professionals to reliably assess the barge-bridge collision damage and make prompt and informative decision on the operation the bridge and navigation waterways. Once a barge-bridge collision event happens, field dynamic measurements can be collected from the collided bridge structure with the sensor network. The best feature vectors were extracted and input into the best classification models of each of the trained classifiers. With the identified threshold of each classifier, the prediction probability of the damage locating in each of the sub-regions were determined.

Optimal Dredge Fleet Scheduling within Environmental Work Windows

Chase Rainwater, Ph.D.
Heather Nachtmann, Ph.D.
University of Arkansas
August 2014-August 2016

The USACE annually dredges hundreds of navigation projects through its fleet of government dredges and individual contracts with private industry. This project examined the decision of allocating dredge resources to projects system-wide under necessary constraints including environmental restrictions concerning when dredging can take place due to migration patterns of turtles, birds, fish, and other wildlife, dredge equipment resource availability, and varying equipment productivity rates that affect project completion times. We expanded optimization tools to allow for multiple dredge resources to work on a single job, resources that dredge in non-consecutive intervals and environmental windows to be enforced in a dredge-specific fashion. The impact of the implementations can measured quantitatively. Of equal importance is the impact of this work on the future of decision analysis within USACE. After initial success with the base model, maritime professionals were intrigued by the use of operations research to aid in their decision process. The potential of the initial tool was met with concern over the fact that many realistic components were not considered. The main impact of the project is that every concern presented by USACE has now been addressed from a modeling perspective. The decision makers understand that optimization tools can be flexible and extendable and, with the appropriate amount of attention, complex challenges can be modeled.

Optimal Dredge Fleet Scheduling - Phase 2 Research

Chase Rainwater, Ph.D.
Heather Nachtmann, Ph.D.
University of Arkansas
August 2016-August 2017

Oversight of dredging operations is a challenging problem because a decision-maker must (i) choose from numerous potential locations that are in need of dredging and (ii) schedule selected jobs within allowable environmental windows. In its simplest form, this series of decisions can be broken into two problems: (1) job selection problem and (2) job scheduling problem. Prior research projects supported by Mar-

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TREC, a dredge scheduling methodology has already been integrated into USACE computing systems. Previous work assumes that the decision-maker has been provided a preselected set of jobs for scheduling consideration. A quantitative system for comprehensive consideration of dredge job selection does not exist. The failure to integrate the selection and scheduling process suggests that opportunity exists for significant financial and operational benefits for transportation planners. This research has adapted new quantitative tools that address this need by leveraging the expertise developed in this area by the team of investigators.

Dynamic Decision Modeling for Inland Waterway Disruptions

Shengfan Zhang, Ph.D.
Heather Nachtmann, Ph.D.
University of Arkansas
August 2014-December 2016

There is much uncertainty associated with inland waterway transportation. Natural or man-made disruption on the inland waterway system can have widespread economic and societal impacts, and their consequences can be significant. In our research, we developed the framework of the decision making process and devised the supporting tool for practitioner. The framework provides structural justification of the decision making model and fundamental motivation of the development. It shows the sequential procedure of decision making and elements of each stage including specific techniques and tools applied. The decision making support tool was developed. It reads and manages data through spreadsheets; calculates expected delivery cost; and gives several resources to support decision making.

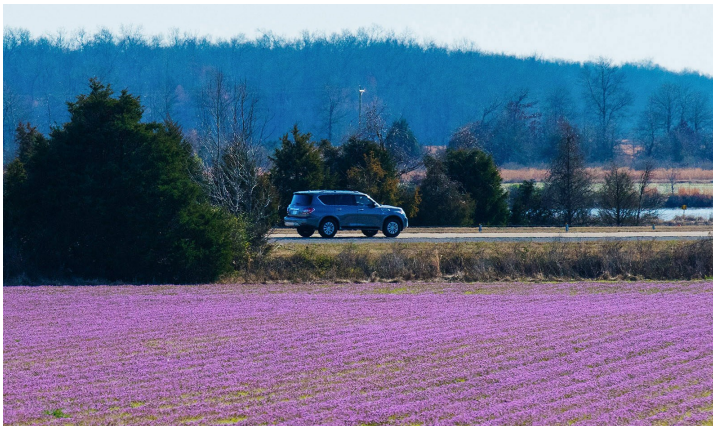

Photo courtesy of ARDOT

Efficient Dredging Strategies for Improving Transportation Infrastructure Resilience

Kelly Sullivan, Ph.D.
University of Arkansas
August 2014-December 2016

The viability of the inland marine transportation system is dependent upon highly random processes including weather, shoaling, and lock degradation. This project, seeks to determine efficient uses of maintenance dollars. Results demonstrate the tradeoff between investment in maintenance dredging and both the network's overall capacity for transporting commodities and risk associated with having insufficient budget to complete emergency projects.

Vulnerability of Fuel Distribution Systems to Hazards in Coastal Communities

John Pardue, Ph.D., P.E.
Louisiana State University
May 2015-December 2016

Coastal communities are vulnerable to disruptions in fuel availability for their transportation networks due to their susceptibility to flooding and storm surge events. Fueling station design criteria do not change in coastal communities and supply chains rely on road networks that lack the redundancy present in more inland areas. This study examined fuel distribution disruptions from past storms and the time for restoration of fuel availability after coastal hazard events. We developed extensive network model of coastal Louisiana communities capturing roads, fueling stations, and bulk terminals. The combined fueling station and road network constructed for this project is the first spatial representation of this system for a Louisiana coastal parish. We presented the network to the state's Supply Chain / Transportation Council. This organization was formed after the catastrophic floods of 2016 to better prepare the state's transportations network, and by extension, other critical infrastructure systems, from failure during these events.

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Quantification of Multimodal Transportation Network Vulnerability: A Pilot Study in Mississippi

Himangshu Das, Ph.D., P.E.
Jackson State University
May 2016-April 2017

We developed a conceptual quantitative framework and database identifying critical transportation infrastructure and its vulnerability to natural hazards using existing data and modeling while incorporating downscaled climate scenario specific to the Mississippi Gulf Coast. It is recommended that the current inventory database should be supplemented with other critical transportation assets managed by state and metropolitan planning organizations. This enhanced database will be helpful to explore future vulnerability and sustainability of multimodal transportation and infrastructure network under a wide variety of hazard conditions. Inventory of critical transportation infrastructures that have already been developed must be linked into a network algorithm. Response and recovery of the disturbed networks were quantified through what-if scenarios.

Evaluating Coastal and River Valley Communities Evacuation Network Performance Using Macroscopic Productivity

Scott Parr, Ph.D., E.I.T.
Louisiana State University
May 2015-April 2017

Coastal and river valley communities are particularly vulnerable to catastrophic events due to their proximity to large bodies of water. A robust and resilient transportation system is therefore imperative in these communities to mitigate the added risk of flash flooding, hurricanes, storm surge, and sea-level-rise. The findings of this research demonstrate the application of a novel performance and computational technique to assess the operation of traffic networks, system-wide, independent of their size or duration of analysis. This technique is ideal for evacuation planning and alternative comparison in megaregions. By estimating a function for "network productivity," emergency management and transportation decision-makers can use "trip completion" as a measure of evacuee departures out of a threat area. This permits a systematic and qualitative basis for assessing evacuee demand management measures that can improve regional mass evacuations.

Innovative Bio-Mediated Particulate Materials for Sustainable Maritime Transportation Infrastructure

Lin Li, Ph.D., P.E.
Jackson State University
November 2015-June 2017

The results of this study show that microbial induced calcite precipitation (MICP) treated material was weak at wet-dry durability and freeze-thaw durability. MICP-treated beach sand material was better at resisting these two weather conditions possibly because of its irregular shaped particles. The use of fiber or multiple treatments during the MICP treatment can provide resistance to the weathered deteriorations of MICP-treated soil. The MICP treatment establishes a cost-effective and in situ improvement of the engineering properties of sandy soils in coastal area for maritime transportation infrastructure construction.

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Measurement of Traffic Network Vulnerability for Mississippi Coastal Region

Feng Wang, Ph.D., P.E.
Jackson State University
November 2015-July 2017

Hurricanes are one of the most catastrophic events resulting in severe consequences including loss of life and property damage. This project studied the vulnerability of the coastal transportation network. The study show that evacuees are more prone to taking flooding risks in selecting evacuation routes as they are more sensitive to the travel time or cost on the routes. On the other hand, the total travel time or cost in all the links of the evacuation paths shows an increasing trend along with the increase of the impact factor on flooding risk, which means the evacuees are more willing to take detours in selecting less risky evacuation routes as they are more sensitive to the flooding risk on the links and routes. The analysis of the evacuation network in Mississippi coast area using the proposed method suggests that links near the evacuation destinations tend to be more critical, and important traffic corridors such as I-10 in the evacuation network has a high degree of criticality.

Rapid and Non-Destructive Assessment of Levees for Strength and Liquefaction Resistance

Clinton Wood, Ph.D., P.E.
Michelle Bernhardt , Ph.D.
University of Arkansas
January 2015-June 2017

This research developed a rapid, non-destructive geophysical testing program and probabilistic framework that can be used to proactively evaluate levees. There is a clear correlation between resistivity and the degree of saturation and bulk density of a soil. An increase in either parameter is associated with a decrease in electrical resistivity. The resistivity values were found to be highly dependent on the degree of saturation up to approximately 60%, at which point increasing saturation does not result in significantly different resistivity values. When the soil is close to saturation, the effect of density or water quality on resistivity diminishes which makes the task of identifying soil type easier. It was observed that an estimate of the degree of saturation in conjunction with electrical resistivity offers the best estimate of soil type. The methods were shown to be capable of detecting many common defects in levees and earthen dams including the location of soft layers, old river meanders, inclusions or utilities, and internal erosion, any of which could lead to failure of the levee during a high water event.

Statistical Analysis of Vehicle Crashes in Mississippi Based on Crash Data from 2010 to 2014

Feng Wang, Ph.D., P.E.
Jackson State University
November 2015-July 2017

The current traffic safety situation in Mississippi has been of great concern. The Mississippi Department of Transportation crash dataset shows that more than 640,000 traffic crashes on Mississippi highways were recorded over the period from May 2010 to February 2014. The analyses showed that the frequencies of vehicle crashes in a metropolitan area are relatively high and the severities of crashes in the rural and coastal areas are relatively high. The crash distribution in MDOT maintenance districts shows that high crash severity is not correlated with high population density in a metropolitan area.

National Inventory and Analysis of Transit Oriented Development in Proximity to Coasts and Port Facilities

John L. Renne, Ph.D., AICP
University of New Orleans
October 2013-September 2017

There is often a tension between the development of mixed-use transit oriented developments and heavy industry near coastal areas and major rivers and near port facilities. This study quantified and examined the number of jobs and residents in station areas near coastal areas, major rivers and near port facilities across the U.S. and forecasts future development and job potential of underbuilt station areas, which could become TODs over the next several decades.

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INTRODUCTION OF NEW MarTREC TEAM MEMBERS

Craig Philip is a Research Professor of Civil and Environmental Engineering at Vanderbilt University, and Director of Vanderbilt's Center for Transportation Research (VECTOR). Dr. Philip's research focus includes infrastructure resilience and the application of risk management tools to public policymaking, management and sustainability of transportation networks and operations, carrier safety management and regulations, and balancing multi-stakeholder interests. Dr. Philip spent more than 35 years with companies in the rail, intermodal and maritime industries. He joined Ingram in 1982 and from 1999 until 2014, he served as President/CEO of Ingram Barge Company as it grew to become the largest American marine transportation carrier.

Hiba Baroud is an Assistant Professor in the Department of Civil and Environmental Engineering at Vanderbilt University. Her work explores data analytics and statistical methods to measure and analyze the risk, reliability, and resilience in critical infrastructure systems. In particular, she has studied data-driven Bayesian methods to predict the occurrence of disruptive events in infrastructure systems and stochastically model the recovery process of the physically disrupted system as well as other interdependent and indirectly impacted systems. Dr. Baroud also developed decision analysis tools to assess different preparedness and recovery investment strategies for the protection of civil infrastructures.

Bruce Wang is an Associate Professor with the Zachry Department of Civil Engineering at Texas A&M University. He obtained his Ph.D. from the University of California, Irvine. Dr. Wang actively conducts freight research, is past chair of the Transportation Research Board (TRB) Freight Planning and Logistics Committee, and serves as the current chair of its subcommittee for Freight Modeling. He has conducted a number of freight projects funded by the federal Department of Energy, Department of Transportation, and TRB. His research is mainly about applying operations research to transportation.

Jim Kruse is the Director of the Center for Ports and Waterways at the Texas A&M Transportation Institute (TTI). He is responsible for identifying research and extension needs in the port community and mobilizing resources to meet those needs. Mr. Kruse served in a senior executive capacity for nine years at the Port of Brownsville, Texas (1988-1997), eight years as port director. Following his service at the Port of Brownsville, he worked as a Regional Program Manager for Foster Wheeler Environmental's Ports Harbors & Waterways Program and assisted on port-related projects around the country.

MarTREC TEAM ACHIEVEMENTS

Jim Kruse, MarTREC director **Heather Nachtmann,** and **Craig Philip** were selected by the Transportation Research Board Executive Committee with approval of the Chairman of the National Research Council to serve as members of the Marine Transportation System Research and Technology Conference to be held June 19-21 in Washington, D.C. The ad hoc committee will organize a conference to disseminate and discuss the results of current research, practitioner experiences and future challenges associated with the U.S. marine transportation system. The conference will seek to identify research needs, gaps and potential technology gains related to harnessing robust, integrated, high fidelity multimodal freight transportation modeling and data sets.

Carol Short, Associate Director of the University of New Orleans Transportation Institute (UNOTI), was named Member of the Year from the greater New Orleans chapter of the Women in Transportation Seminar (WTS). Short's Member of the Year Award honors a chapter member who has promoted the reputation of WTS within the transportation community. In addition to serving as associate director of UNOTI, Short is co-author and administrator of University of New Orleans Master of Science in Transportation degree program. She has extensive experience in the maritime industry and serves as the institute's liaison to that community.

Brian Wolshon, LSU MarTREC site director, was interviewed by several media outlets during the 2017 hurricane season including CNN, Discovery Channel, and The New York Times. Wolshon who designs evacuation plans explained the challenge of planning for metropolitan transit system disruptions, "Planners will often open all lanes on a road or highway to outbound traffic to ease congestion, but you can't do that with the Overseas Highway." He added that "emergency managers worry about situations like someone having a heart attack and medical crews unable to respond" due to disruptions in the transportation system.

DAN FLOWERS DISTINGUISHED LECTURE

On November 17, 2016, **Craig Philip** visited the University of Arkansas campus to deliver our Fall 2016 Dan Flowers Distinguished Lecture. Philip is retired President/CEO of Ingram Barge Company and is now a Research Professor of Civil and Environmental Engineering and MarTREC site director at Vanderbilt University. His lecture topic focused on logistics and supply chains in the 21st century and how transportation researchers and practitioners can support the future demands of our Nation's transportation system. The series is named in honor of retired ARDOT director Dan Flowers.

MarTREC STUDENT ACHIEVEMENTS

Tim Moody, MarTREC's **2016 UTC Outstanding Student of the Year**, was presented his award at the Annual Transportation Research Board Meeting in Washington D.C. in January 2017. Moody's award winning work supports MarTREC research project, *Rapid and Non-destructive Evaluation of Levees Using Geophysical Methods.*

Moody received his bachelor's degree in Civil Engineering from the University of Arkansas in 2015 and is currently a Civil Engineering Master's student at the University of Arkansas under the supervision of Dr. Clint Wood, Assistant Professor of Civil Engineering.

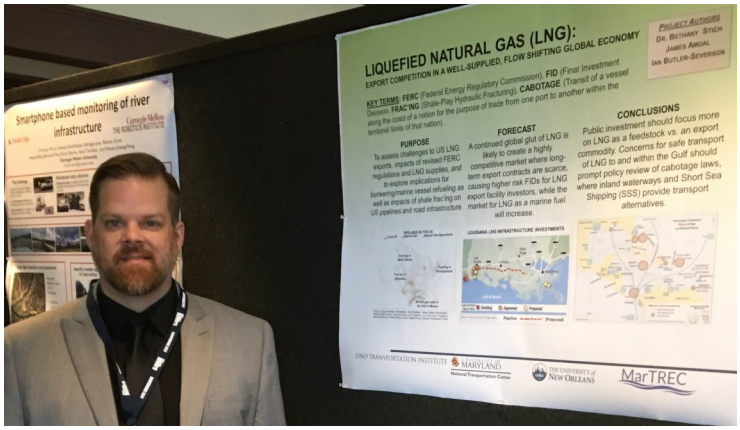
In June 2017, **Christine Lozano**, Civil Engineering Master's student at the University of Arkansas, presented her research to a panel at the U.S. Army Corps of Engineers (USACE) in Vicksburg, Mississippi.

Lozano was invited to present to the USACE because of their interest in her MarTREC research project, *Corrosion-Tolerant Pre-Stressed CFRP Fatigue Retrofits for Improved Waterway Lock Reliability* under the supervision of Dr. Gary Prinz, Assistant Professor Civil Engineering. Subsequently Lozano was offered a job with the USACE and will begin her career with the Corps following her graduation in December 2017.

Jackson State University students presented at the 2017 Southeast Symposium on Contemporary Engineering Topics (SSCET) held at the University of New Orleans this September. The students made presentations on two MarTREC research projects, *Characteristics and Factors of Traffic Crashes in Mississippi* and *Hurricane Surge Vulnerability Study of US Highway 90 along Mississippi Gulf Coastline*.

From left to right: **Xiaohua Luo** (Ph.D student) **Haitao Gong** (Ph.D student), **Dr. Feng Wang** (MarTREC Site Director at JSU), and **Lei Bu** (Ph.D student).

In September 2017, **Ian Severson**, Master's student in Transportation Planning at the University of New Orleans presented a poster at the Smart Rivers conference in Pittsburgh, PA. His poster was on *Liquefied Natural Gas (LNG) Export Competition in a Well Supplied Flow Shifting Global Economy* based on MarTREC research led by Dr. Bethany Stich, MarTREC Site Director at UNO.



MarTREC OUTREACH

2017 MarTREC Summer Research Intern

Nuri Omolara, a bioengineering Undergraduate student from North Carolina Agricultural & Technical State University in Greensboro, NC, spent her summer completing a research internship at the University of Arkansas. In 2016, Omolara visited the campus to participate in the AIM (Attracting Intelligent Minds) Conference. This visit led her to coming back the following year to be MarTREC's summer research intern. Omolara is interested in a Master's degree in Industrial Engineering. Her research internship was supervised by Dr. Justin Chimka, Associate Professor of Industrial Engineering and supported MarTREC project, *Climate Impacts on Lock Use and Performance*.

University of New Orleans Transportation Institute Partners with Son of a Saint

The University of New Orleans Transportation Institute conducted its National Summer Transportation Institute in July 2017 for a group of 14 young men who spent the day visiting transportation hubs around New Orleans. The summer institute was funded by the Federal Highway Administration to promote awareness of educational and career opportunities among disadvantaged and at-risk youth.

MATH Circle Summer Enrichment Program

In June 2017, LSU and Dr. Brian Wolshon (MarTREC LSU Site Director) hosted the LSU Math Circle summer enrichment program, a four-week summer program at LSU geared toward rising 9th-12th graders interested in investigating concepts in mathematics that are not usually introduced at the high school level.

GirlTREC

MarTREC hosted thirty-five fifth and sixth grade girls in July at our new GirlTREC summer camp. The camp focused on hands-on activities related to transportation engineering from roads to rail to waterways and was designed to build courage and interest towards studying STEM fields and considering a career in the transportation industry.

Our interactive activities were taught by faculty from the University of Arkansas' civil and industrial engineering departments. Activities included learning about abutment design in bridge construction with Dr. Michelle Bernhardt, examining social media data during a disaster response with Dr. Ashlea Milburn, designing traffic control systems with Dr. Sarah Hernandez, handling risk and uncertainty with Dr. Sarah Nurre and Dr. Shengfan Zhang, examining lock and dam operations with Dr. Heather Nachtmann, and structural design analysis with Dr. Gary Prinz.

The students also took a field trip to Ozark-Jetta Taylor Lock and Dam #12. Guided by Lock Master Kevin Dunn, the girls learned about water safety, how the lock allows the vessels to pass through, and the economics behind barge travel. The campers even got to ride on an opening lock gate!

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MarTREC

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Cover photo by Heather Nachtmann

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