

National Center for Intermodal Transportation for Economic Competitiveness

# NCITEC

## Project 2016 – 07

### Technology Transfer Products for NCITEC Projects at University of Mississippi

## Final Report: NCITEC Project 2016 - 07

### The University of Mississippi

**Dr. Waheed Uddin**, Director CAIT, Principal Investigator

**Dr. Yacoub "Jacob" Najjar**, Department Chair and Professor, CO-PI

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**Center for Advanced Infrastructure Technology**

**The University of Mississippi**

University, MS 38677-1848, USA

Voice: 662-915-5363 Fax: 662-915-5523

<http://www.olemiss.edu/projects/cait/>

[cait@olemiss.edu](mailto:cait@olemiss.edu) [cvuddin@gmail.com](mailto:cvuddin@gmail.com)

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# TECHNOLOGY TRANSFER PRODUCTS FOR NCITEC PROJECTS AT UNIVERSITY OF MISSISSIPPI

## Final Report: NCITEC Project 2016 - 07

### ABSTRACT

Transportation infrastructure networks are essential to sustain our economy, society and quality of life. Freight transportation of consumer goods and commercial/industrial products is critical for sustainable and efficient supply chain. Major transportation corridors and intermodal assets include highway network, rail infrastructure, inland river ports, sea ports and airports. The primary objectives of this project are to: (1) summarize key research results of each funded project in technology brief fact sheets for web access, (2) create YouTube videos and SlideShare posts, (3) present key results, and (4) showcase the workforce development and enhancement in courses at the University of Mississippi.

During years 2012-2016, the University of Mississippi researchers conducted 13 NCITEC research projects, which have been funded on topics related to mobility, freight transportation, revenue/funding aspects, economic viability, energy, safety, structural integrity of bridges, hazardous spills, flood risks, and disaster resiliency of integrating selected segments of infrastructure assets. Key results of the projects include:

- The projects developed geospatial maps, optimization models, benefit and cost results of proposed modal integration simulation studies.
- The project investigated the aspects of multimodal freight related to congestion, intermodal integration, and impacts of fuel savings and carbon dioxide emissions.
- The projects studied highway bridge structures subject to truck traffic, scouring, and floodwater impacts.
- The projects on media framing of transportation hazardous materials accidents and spills found that a large number of the most serious spill incidents during transportation received no news coverage.
- The project on the laboratory study of energy harvesting from vehicle-pavement vibrations showed that nano-coating of piezoelectric sensors enhanced the energy output.
- The commuter rail and intermodal freight corridor case studies produced “best practice guide” examples for consideration by government transportation agencies, private transport operators, and other global supply chain stakeholders.
- Several graduate students completed their degrees and undergraduate students were trained as a part of the workforce development and

It is recommended that the research products of these projects be applied by transportation agencies to increase safety, reduce shipping costs, and assess other societal benefits. These societal benefits include reduction in highway congestion and decrease in transportation related emissions of carbon dioxide and other harmful pollutants.

## ACKNOWLEDGEMENTS

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## 1. BACKGROUND AND OVERVIEW

### 1.1 Introduction

#### Background and Research Needs

This project addresses the NCITEC theme of efficient, safe, secure, and sustainable national intermodal transportation network that can be made resilient to disasters. In today's "global economy" the global supply chain interconnects each country's transportation hubs through import/export demand of agriculture commodities, manufacturing goods, and fossil fuels. Ships, air cargo, and land transport are used as freight carriers for most import and export goods. Bulk ships and supertankers are used to transport most of the agriculture products, raw industrial materials, and fossil fuel supplies, which include coal, crude oil, and liquefied gas. The global supply chain can be seriously disrupted by natural disasters. For example the earthquake and tsunami disaster that struck Japan in March 2011 even had an effect on car manufacturing facilities in the U.S. that lasted for several months. Similarly, the 2011 mega flood of central Thailand (Infra 2011) interrupted many industrial estates around Bangkok resulting in supply shortages of clothes, electronics, and several other manufactured items to Europe and North America. This problem of disruption in the supply chain can seriously hurt local economies which depend on distribution through surface transportation modes; even if the goods are brought in from abroad as with the Federal Express aviation cargo hub at Memphis International Airport. Similarly, other global supply chain and inventory management system stakeholders depend on a smooth seamless flow of freight through interconnecting shipping ports, airports, rails, and roads.

Efficient, safe, and disaster resilient transportation infrastructure assets are the backbone of the U.S. economy by providing passenger mobility and freight transportation of commodities within the states. Intermodal integration of ports-rail-highway is the key for reducing travel time and emissions related to distribution of imports and exports of its agriculture commodities, lumber, and coal among other products. The efficient freight transportation network in the U.S. led to a global competitive edge for many decades. Currently, these transportation infrastructure systems are aging, not being expanded and modernized at a rate comparable to those of other global competitors (and emerging economies such as China and Brazil), and in addition economic competitiveness is diminishing. Global supply chain and inventory management system stakeholders (e.g., Walmart), global manufacturing industries (e.g., Caterpillar), and freight logistics companies depend on a smooth seamless flow of freight through interconnecting shipping ports, airports, rails, and roads. These modes operate independently in the U.S. with no operational integration, except some to rail and road intermodal transport terminals. One freight mobility area for economically competitive markets that can benefit tremendously from intermodal integration is the efficient freight transport through seamless connectivity among surface transport (rail for long-haul and road for short-haul trucks), inland waterways, and marine ports.

The total inbound freight (604,409 ton-miles) in 2011 from all foreign origins to the US had the following modal distribution: 58% ships, 14% pipeline, 13% rail, 13% truck, 1% air, and the rest 1% unknown (Oak Ridge, <http://faf.ornl.gov/fafweb/Extraction3.aspx>). Of this inbound freight in 2011, the largest trading partner was Canada (25% freight) followed by Eastern Asia (22%), Rest-of-America (12%), Mexico (9%), and Europe (8%). In today's "global economy" the global supply chain interconnects each country's transportation hubs through import/export demand of agriculture commodities, manufacturing products, consumer goods, and fossil fuels.

According to the Association of American Railroads (AAR 2011): "America's freight railroads move 43 percent of intercity freight traffic and move 1/3 of U.S. exports to ports. In some cases some modes on long haul routes, like highway freight trucks, compete with freight rail service. Comparing shipment values in millions of dollars, trucks account for 85% to Mississippi and 48% to Louisiana. About 49 percent of 151.9 million ton shipment in 2008 through the Mississippi Gulf Coast corridor was by through truck traffic, according to the 2035 Multiplan report of the Mississippi DOT (MDOT 2011). The modal split is 70.7% trucks, 17% by waterways, and 12.3% rail. A major portion of this truck traffic was through I-10 which in turn produces congestion and traffic bottlenecks around major cities on the Mississippi Gulf Coast.

A report by the National Academies states 65% of goods originate or terminate in cities (NCFRP 2012). About 9 percent of all highway fatalities in 2009 involved large trucks. Fatality rate per 100 million vehicle-mile-traveled is higher for large truck related fatality (1.585 per 100 million truck mile traveled) than other vehicles (1.336 per 100 million non-truck mile traveled). This fatality rate is less than 1.0 for many European countries who use it as a national road safety performance measure while relying heavily on rail freight and rail passenger transport. Reducing numbers of large freight trucks from congested highways, to reduce congestion and transport emissions, should be given serious attention considering that road safety and sustainability is a clear priority by the US Congress as stated in the "Moving Ahead for Progress in the 21st Century (MAP-21)" reauthorization of the transportation bill. This has been a priority in the Fixing America's Surface Transportation Act, or "FAST Act," signed by President Obama into law on December 4, 2015. <https://www.transportation.gov/fastact>

These statistics are indicative of the importance of the lifeline supply chain to support our society and everyday life. Traffic congestion on highways significantly impacts air quality degradation, greenhouse gas emissions, and global warming. Transportation contributes 28% of energy related greenhouse gas emissions in the U.S. (Uddin 2012).

The four transportation modes (shipping port, aviation, rail, and highway) are owned and operated by different entities in the U.S. For example, shipping channels are mostly maintained by the US Army Corps of Engineers/ERDC. Inland waterways like Mississippi River need annual funding for dredging operations and maintaining locks and dams for bulk barge traffic. However, ports are owned by local government bodies. Ports are generally revenue producing operations unlike highway networks. Despite being publicly owned ports are largely operated by



private companies who lease space from municipalities and port authorities. In addition, the on doc labor is provided most frequently by longshoremen of the ILWU. Ports needs funding to upgrade for intermodal infrastructure and modern container ships designed for 8,000 or more Twenty Foot Equivalent Unit (TEU) containers. Highway infrastructure assets (pavement, bridge, right of way) are owned by states/federal government with the bulk of funding support from Highway Trust Fund's federal appropriations through US DOT. The truck freight operation is wholly owned and operated by private sector companies. Trucks pay only the nominal annual registration license fee to the US DOT. On the other hand, rail infrastructure and rail vehicle stock as well as rail freight operation have historically been wholly owned and operated by private sector companies in the U.S. unlike most other countries where these are owned by the government.

Unlike freight trucks whose infrastructure is supported by state and federal tax dollars, the freight rail industry has to manage their aging infrastructure by investing capital from their own profits without public involvement. Ships and supertankers are used for transporting most of the fossil fuel supplies, which include coal, crude oil, and liquefied petroleum gas. Barges in the inland waterways and surface rail corridors are used for bulk raw materials and container traffic, which will immensely benefit from intermodal integration of these two modes through connectivity by efficient short-haul trucks operating on clean natural gas. The global supply chain can be seriously disrupted by natural disasters. This disruption is imminent even if the goods are ordered from abroad such as through the Federal Express aviation cargo hub at Memphis International Airport. Intermodal integration can help in reducing the ripple effects of disruptions related to disasters, which can cripple one part of the intermodal network.

## Goals

Since year 2012, the University of Mississippi researchers conducted 13 research projects, which have been funded by the NCITEC grants. Only a limited number of technology transfer products have been produced which include a white paper on the Gulf Coast Rail study, You Tube videos and Slide Share on some projects. The Primary goal of this project is to develop more web based technology transfer products on these NCITEC projects in order to provide access for the UM projects research results to the transportation community and agencies in the state, region, states, and worldwide audience.

## Objectives

The primary objectives of this project are to:

1. summarize key research results of each funded project in brief fact sheets for web access,
2. develop good quality visualization products based on geospatial mapping and computational modeling results for producing You Tube videos and SlideShare posts,
3. present the results the life cycle economic evaluation, impacts on travel time efficiency and safety, reduction in freight transport emissions and carbon footprints, and



4. showcase the workforce development and enhancement in courses at the University of Mississippi.

The scope is limited to the results of NCITEC projects at UM, papers and presentations, and relevant materials in M.S. these and doctoral dissertations.. The project will enhance intermodal transportation education by supporting graduate and UG students.

### **Project Timeline**

The final project period was from March 1, 2016 to August 31, 2016.

### **Research Team and Collaborators**

#### *Key Investigators and Roles:*

Dr. Waheed Uddin (PI), University of Mississippi (UM) [cvuddin@olemiss.edu](mailto:cvuddin@olemiss.edu) Professor of Civil Engineering and Director, Center for Advanced Infrastructure Technology (CAIT)

Dr. Yacoub “Jacob” Najjar (co-PI), Professor and Chair, Department of Civil Engineering, of Mississippi [ymnajjar@olemiss.edu](mailto:ymnajjar@olemiss.edu)

#### *Other UM Researchers*

Support from the following CAIT/Civil Engineering students: Two PhD students, one M.S. student, three UG students

#### *Other collaborators or contacts been involved*

- Dr. Uddin is an appointed member of Board of Directors of the Mississippi Transportation Institute (MTI) since March 2014 and the Gulf Region Intelligent Transportation Society from 2009 to 2013. These are important state transportation organizations to benefit from the key results of the NCITEC projects.

### **Research Methodology**

The CAIT project research team (CAIT 2014) implemented the following research methodology:

1. Review and synthesize work accomplished and key results for each of the NCITEC projects completed at UM.
2. Develop the following technology transfer and media products and disseminate through CAIT-NCITEC web page, email distribution, and tweets:
  - Two-page Technology Brief fact sheets for projects describing the project title and objectives, work accomplished, key results, and implementation statements.
  - White papers on selected topics.
  - You Tube video clips in 2-3 min segments and posted online.
  - SlideShare posts based on the summary papers.
  - Blog posts on summary results and impacts on the stakeholders, economy, and society.
  - Scholarly papers for conferences and peer reviewed journals.

3. Publish a dedicated feature article in School of Engineering online news and e-magazine “Ole Miss Engineer” about the NCITEC projects and their impacts on UM’s research infrastructure, workforce development, graduate students, and enhancement of related courses.
4. Provide the Tech Briefs for consideration by government transportation agencies, private transport operators, and all other supply chain stakeholders.

## 1.2 Project Accomplishments

### Key Outcomes

Key outcomes and other achievements are summarized, as follow:

1. The researchers reviewed and synthesized work accomplished and key results for each of the NCITEC projects completed at UM. The following technology transfer and media products were developed and disseminated through CAIT-NCITEC web page, email distribution, and tweets:
  - Technology Brief for each project consisting of two-page summary fact sheets describing the project title and objectives, work accomplished, key results, and implementation statements.
  - White papers on selected topics.
  - You Tube video clips in 2-3 min segments for posting online.
  - SlideShare posts based on the summary papers.
  - Blog posts on key results and impacts on the stakeholders, economy, and society.
  - A dedicated feature article in School of Engineering online news on the NCITEC projects and their impacts on UM’s research infrastructure, workforce development, graduate students, and enhancement of related courses.
  - Another feature article submitted for publication in School of Engineering “Ole Miss Engineer” and posting on e-newsletter of the Department of Civil Engineering.
  - Scholarly papers by primary investigators of each project for conferences and peer reviewed journals.
2. Training of undergraduate (UG) and graduate students in transportation network analysis and development of geospatial workforce are additional benefits.
3. The project results have been presented at regional and national meetings and disseminated through social media.

The economic competitiveness, safety, security and disaster resilience of freight transport can be significantly enhanced if owners, operators, and users of all transportation modes understand the importance of operational integration of transportation modes. Similarly, integration of passenger services can reduce wastage of millions of hours of travel time of single occupancy vehicle commuters that will result in cost avoidance of fuel wastage on congested highway corridors and reduce transportation related Carbon Dioxide (CO<sub>2</sub>) emissions and other harmful pollutants.

## Overview of Technology Briefs

Technology briefs were prepared for the following studies, which were completed under NCITEC project grants at UM (last names of primary UM researchers shown in parenthesis):

- Infrastructure funding issues and road safety evaluation (Uddin and Holland)
- Optimization of freight routes and logistics (Cao and Goggans; Uddin)
- Intermodal freight integration for NAFTA routes, CO-CA corridor, highway/waterway (Uddin)
- Computational modeling of flood simulation impacts on infrastructure (Uddin and Altinakar)
- 3D-Finite element modeling of bridges and simulation of floodwater impacts (Uddin)
- Field and finite element studies of highway bridges for scouring damage (Swann and Mullen)
- Structural health monitoring highway bridge structures (Ervin, Aranchuk, Mullen)
- Passenger rail revival along the Mississippi Gulf Coast (Uddin)
- Energy harvesting from vehicle-pavement vibrations (McCarty and Sharma)
- Risk framing of transportation related toxic spills in news and social media (Swain)

## 1.3 Results Dissemination and Outreach

### *UM School of Engineering Online*

The University of Mississippi School of Engineering featured a full page story in July 2016 issue.

2016/07-ENGINEERING NEWS JULY 2016, ENGINEERING NEWS ARCHIVE, SCHOOL OF ENGINEERING

“UM Engineering Partnership Producing Problem-Solving Research

National Center for Intermodal Transportation for Economic Competitiveness funds projects”

<http://news.olemiss.edu/um-engineering-partnership-producing-problem-solving-research/>

### *Presentations to External Organizations*

Dr. Uddin participated in one international conference and other venues of invited lectures at the following universities. These include:

*July 26-29, 2016, MAIREPAV8 International Conference, Singapore:* Dr. Uddin was presented international iSMARTi achievement award at the conference.

*July 21, 2016, Asian Institute of Technology (AIT), Bangkok, Thailand:* Invited seminar presentation at AIT Workshop “Disaster Resilience Education Capacity Building in South-East Asia”.

*August 1, 2016, Universiti Sains Malaysia (USM), Penang, Malaysia:* Invited lecture "Natural Disaster Resilience of Public Infrastructure Assets."

### *Collaboration at University of Mississippi*

The following departments and research units in the School of Engineering and non-engineering research units and departments benefitted from the NCITEC project grants at UM:

- Department of Civil Engineering (Projects 2012-24, 2012-25, 2012-27, 2013-26, 2013-27, 2013-32, 2013-33)
- Department of Electrical Engineering (Projects 2012-26)
- Department of Mechanical Engineering (Projects 2013-31)
- National Center for Computational Hydroscience and Engineering (NCCHE) (Project 2012-25)
- Mississippi Mineral Resource Institute (MMRI) (Project 2013-25)
- National Center for Physical Acoustics (NCPA) (Project 2012-24)
- Meek School of Journalism and New Media (Projects 2013-30, 2016-08)
- Department of Public Policy Leadership (contribution to Project 2012-27)

### *External Collaboration*

The PI collaborated with the following organizations, who provided support to the project team throughout the NCITEC projects during 2012-2016:

- Intergraph for continuing academic license of GeoMedia Pro at no cost to the University of Mississippi for use on CAIT projects (worth \$118,000 per year).
- As Intergraph Registered Research Lab, CAIT Remote Sensing and Geospatial Analysis Laboratory and CAIT Transportation Modeling and Visualization Laboratory is receiving geospatial industry support for education and training of students in GIS applications through the project research tasks.
- Since January 2014 the statewide license has been provided by MARIS. This software and ArcGIS software, provided by Mississippi Mineral Resource Institute, were used to create planimetrics of roads, bridges, and buildings from high resolution aerial imagery.

The following organizations were cooperative features for this project:

- 1) Intergraph/MARIS: The GeoMedia Pro software grant is a cooperative feature.
- 2) Mississippi Department of Transportation (MDOT): MDOT Roadway Design Division has been contacted for access to aerial imagery.
- 3) MDOT Planning Division through contact with Dr. Uddin's former student and EIT for accessing overlapping aerial imagery scenes of the study sites.
- 4) MDOT Transportation Information Director (Mike Cresap) and MDOT Director of Structures -State Bridge Engineer (Justin Walker) were especially helpful to provide bridge drawings and photos in northern Mississippi and updated geospatial database of all state maintained highways and bridges of Mississippi. These were very important and useful contributions to this project.
- 5) US Army ERDC Hydraulics Lab, Vicksburg, Mississippi (Dr. Kenneth Ned Mitchell)

## 1.4 Impacts on The Principal Discipline(s), Research Infrastructure, and Workforce

The project improved computing facilities, geospatial laboratory, geospatial software, and transportation corridor/traffic flow simulation capabilities.

- Enhancement of CAIT Transportation Modeling and Visualization Lab at off-campus location of Ole Miss Jackson Center was a major impact of the project. (An additional eight computer workstations and visualization equipment were procured using project funds and installed in CAIT Transportation Modeling & Visualization Laboratory in UM Jackson Center after approval by the DOT RITA sponsors.) These new computers and 6 old computers from CE Graphics Lab have been functioning fully since Fall 2013 after installation of geospatial software and other programs.
- The Lab is being used mostly to conduct research, offer geospatial UG and graduate courses, and train students in geospatial visualization and mapping technologies. New 2014 versions of GeoMediaPro geospatial software packs were installed on all CAIT Lab computers after creating full backup up of all project files and folders by project staff. The Lab is being used mostly to conduct research, offer geospatial UG/graduate courses, and train students in geospatial visualization and mapping technologies. The CAIT lab expanded recently with new high performance computer equipment, new computer furniture, large video monitor for presentations, and seminar/meeting tables, chairs, and accessories. The geospatial course has been taught in this facility since 2013 and most of the NCITEC project research work is conducted in this lab.
- The UM's CAIT Transportation Modeling & Visualization Lab (Figure 1) also houses a model ITS Laboratory (Figure 2). The Mississippi DOT's Intelligent Transportation System (ITS) section has been collaborating for many years with the University of Mississippi to provide traffic video display wall and extend the fiberoptic backbone to the JAC building and the CAIT Transportation Modeling & Visualization Laboratory facility in order to establish a model ITS lab. In October 2014 the CAIT Transportation laboratory was provided a video panel wall by the Mississippi DOT ITS section as a part of a model ITS lab to monitor real-time traffic flow on roads and barge under bridges over the Mississippi River. Since Fall 2015 the lab has been used for real-time traffic data collection and teaching UG for research use to monitor flow attributes by UG and graduate students.
- New graduate and undergraduate CAIT student workers were trained for geospatial analysis and transportation demand modeling research. The contents of the Transportation and Geospatial course are enhanced using the NCITEC project products.
- Key faculty investigators in NCITEC projects are implementing research results in their respective courses, especially bridge related structural courses in the department of civil engineering.
- CE495 (Geospatial Visualization for Engineering Applications) will be offered by Dr. Uddin as regular UG technical course every year starting in Spring 2017 semester.



- Dr. Uddin incorporated research results in several transportation related courses, as follows:
  - The contents of geospatial courses CE495 (3 credit hours) and ENGR597 Section 25 (3 credit hours) updated using the NCITEC project work.
  - CE 481 – Transportation Engineering I course (3 credit hours)
  - CE 570 – Infrastructure Management course (3 credit hours)
  - CE 585 – Highway Pavements course (3 credit hours)
  - CE 590 – Airport Planning and Design
  - New course ENGR 692 Section 2 (3 credit hours) – Numerical Methods and Optimization and Nonlinear Time Series Modeling
- CE 570 course was offered by Dr. Uddin in Fall 2013 and Fall 2014; and it is being taught in Fall 2016 to UG seniors and graduate students. The new textbook for CE570 course was 2013 McGraw-Hill book *Public Infrastructure Asset Management* (Uddin, Hudson, Haas).
- It is expected that the research accomplishments will lead to a specialized transportation course and disaster mitigation and safeguard courses, as well as a trained geospatial workforce.

#### *Students Supported and Degrees Completed*

All NCITEC projects supported the following graduate and UG students:

9 PhD, 10 M.S., 14 UG.

Graduate students who received project funding and completed degrees on all NCITEC projects:

2 PhD, 7 M.S.

(2 more PhD and 1 more M.S. degrees expected to complete in Fall 2016/Spring 2016)



Figure 1. (left) CAIT Transportation Modeling & Visualization Lab, JAC 102, Oxford, MS

Figure 2. (right) Model ITS Laboratory, JAC 102, Oxford, MS (video wall for accessing statewide traffic video network in cooperation with the MDOT Traffic Engineering Division)

The project has a significant impact on transportation workforce development. For example, the project:

- Provided opportunities to UG students, Master's and Doctoral graduate students, other participating specialists for research in transportation intermodal integration, supply chain logistics, intermodal network optimization, geospatial visualization, and related disciplines.
- Enhanced intermodal transportation education by supporting graduate and UG students.
- Improved the performance and modern computer modeling and visualization skills of main stream professionals and members of underrepresented groups (minority students) that will improve their access to or retention in transportation research, teaching, and other related professions.
- Developed and disseminated new educational/training materials and provide exposure to transportation, science and technology for practitioners, public works professionals, teachers, young people, media, supply chain stakeholders, and general public. This has been accomplished through geospatial workforce training in the teaching lab, classroom, tweets, YouTube videos, and SlideShare presentations.
- Involved the Student Chapter of the Institute of Transportation Engineers (ITE) and both graduate and undergraduate transportation students in project activities. A major goal to support undergraduate students is to motivate them to pursue graduate studies in transportation systems and professional careers in transportation engineering discipline.
- Enhanced information resources and electronic means through CAIT web pages, news interviews by journalism students, YouTube video and SlideShare production, blog posts, tweets, and scientific papers.
- Continued tweeting about related topics. The Twitter social media has proven highly effective to access the latest research efforts and studies by transportation and logistics industry organizations.

## **1.5 Website(s) or other Internet site(s)**

*Web Site, Social Media and Online Postings*

UM CAIT web page: <http://www.olemiss.edu/projects/cait/ncitec/>

The NCITEC project tab on the University of Mississippi CAIT web site, linked to Mississippi State web site, provides useful background of NCITEC goals, university partners, and UM project summaries.

Dr. Uddin prepared and posted SlideShare presentations that include background on the passenger train restoration on the Gulf Coast and project updates on supply chain, flood simulation, and highway-waterway freight intermodal integration.

*Blog:* <http://infrastructureglobal.com/>  
disasters around the globe.

Dr. Uddin's blog about infrastructure and natural



*SlideShare:* Over 16,000 SlideShare views of 8 NCITEC projects related posts.

<http://slidesha.re/1CiiDn> <https://www.slideshare.net/waheeduddin/uddin-caitncitecprojects11-oct2013slsh>

The following SlideShare post on the Gulf Coast Rail White Paper had over 12,600 views and 138 tweets. <http://www.slideshare.net/waheeduddin/mississippi-gulf-coast-rail-revival-ncitec-white-paper-background-cait>

*Twitter:* <https://twitter.com/drwaheeduddin> Started in January 2012; several lists and “Global Infrastructure” timeline created; over 46,500 tweets; and August 2016 Summary of 497 tweets, over 104,100 Tweet impressions, 2,634 Profile visits.

*YouTube Videos:* Over 9,000 views of NCITEC projects related YouTube videos were reported.

<http://youtu.be/8JjM2QEexFE> <https://youtu.be/8JjM2QEexFE>

## 2. TECHNOLOGY BRIEFS FOR UM NCITEC RESEARCH PROJECTS, 2012-2016

### University of Mississippi NCITEC Projects, 2012-2016

The following table lists all UM NCITEC Projects conducted during 2012-2016, which is followed by Technology Briefs based on the final project reports already submitted to the NCITEC Director at Mississippi State University.

Sequence Number	NCITEC Project	PI	Project Title
1	2012-24	Ervin	Three Integrated Projects to Enhance Non-Contact Rail Inspection Technology for Application to Substructure Health Evaluation on Both Rail and Road Bridges
2	2012-25	Uddin	Disaster Protection of Transport Infrastructure and Mobility Using Flood Risk Modeling and Geospatial Visualization
3	2012-26	Cao and Goggans	Terminal Location Planning in Intermodal Transportation with Bayesian Inference Method
4	2012-27	Uddin	Integrated Intermodal Transportation Corridors for Economically Viable and Safe Global Supply Chain
5	2013-25	Swann	Predicting Erosion Impact on Highway and Railway Bridge Substructures
6	2013-26	Mullen	Detecting Weakened Highway and Railroad Bridge Substructures at Deck Level
7	2013-27	Ervin	Rapid Noncontact Measurement using Multiple Point Laser Doppler Vibrometry for Health Evaluation of Rail and Road Bridges
8	2013-29	Swain	Risk Framing of U.S. Intermodal Transportation Toxic Spills in News and Social Media (Note 1)
9	2013-31	McCarty	Harvesting Vibrational Energy Due to Intermodal Transport Systems via Nano Coated Piezo Electric Devices
10	2013-32	Uddin	Intermodal Optimization for Economically Viable Integration of Surface and Waterborne Freight Transport
11	2013-33	Uddin	Restoration of Gulf Coast Passenger Rail Service for Sustainable and Economically Efficient Intermodal Corridor Integration
12	2016-07	Uddin	Technology Transfer Products for NCITEC Projects at University of Mississippi (Note 2)
13	2016-08	Swain	Toxic Transportation Spills: Invisible or Ignored? (Note 1)

Notes: 1. There is one Technology Brief combined for two Projects 2013-29 and 2016-08.

2. The Technology Brief of Project 2016-07 is on the next sheet and other project briefs follow the sequence number.



## NCITEC PROJECT 2016-07



### Technology Transfer Products for NCITEC Projects at University of Mississippi

*National Center for Intermodal Transportation for Economic Competitiveness (NCITEC):* University of Mississippi – Center for Advanced Infrastructure Technology (CAIT) partnered with Mississippi State University led University Consortium for NCITEC grant of \$ 6.9 million from the U.S. Department of Transportation (DOT) - Research and Innovative Technology Administration (RITA). Other consortium universities include University of Denver, Louisiana State University, and Hampton University in Virginia. The theme of NCITEC is to promote the development of an integrated, economically competitive, efficient, safe, secure, and sustainable national intermodal transportation network by integrating all transportation modes for both freight and passenger mobility.

*Overview:* During years 2012-2016 using a total grant of \$ 1.26 million from NCITEC, the University of Mississippi researchers conducted 13 research projects, which have been funded on topics related to mobility, freight transportation, safety, energy, hazardous spills, flood risks, and infrastructure assets.

The research topics include:

- Global supply chain, NAFTA freight studies, highway-rail-waterway and intermodal integration.
- Studies of highway bridge structures subject to truck traffic, scouring, and floodwater impacts.
- Energy harvesting from vehicle-pavement vibrations.
- Media framing of transportation hazardous materials accidents
- Passenger rail revival along the Mississippi Gulf Coast; technology transfer products

*Project Faculty and Researchers:* The University of Mississippi investigators contributed from the following academic disciplines; School of Engineering (Civil, Electrical, Mechanical, NCCHE, MMRI), NCPA, Meek School of Journalism and New Media, and Trent Lott Institute of Public Policy Leadership.

*Research Accomplishments:* The primary research accomplishments include:

- Technology Briefs on key research results of each funded project for distribution and web access.
- Transportation visualization products based on geospatial analysis and computational modeling.
- Results of the life cycle economic evaluation, impacts on travel time efficiency and safety, freight shipping costs, and reduction in freight transport emissions and carbon footprints.
- Workforce development and enhancement of undergraduate and graduate courses.

*Workforce Development and Education Accomplishments:*

- Funding support was provided to researchers, graduate students, and undergraduate students.
- Total two PhD students and seven M.S. students completed their degrees at the University of Mississippi.
- One PhD student on CAIT/NCCHE project received 2013 NCITEC Student of the Year (SOY) award.
- Project investigators presented at regional and national conferences, and published papers in journals and conference proceedings.
- Additionally, a white paper on the Gulf Coast Rail study, YouTube videos, and Slide Share posts were produced to disseminate the research results of the UM projects to the transportation community and agencies in the region, states, and worldwide audience.



For further information, contact: University of Mississippi  
Dr. Waheed Uddin, Professor and Director CAIT  
<http://www.olemiss.edu/projects/cait/ncitec/>



• Example Figures

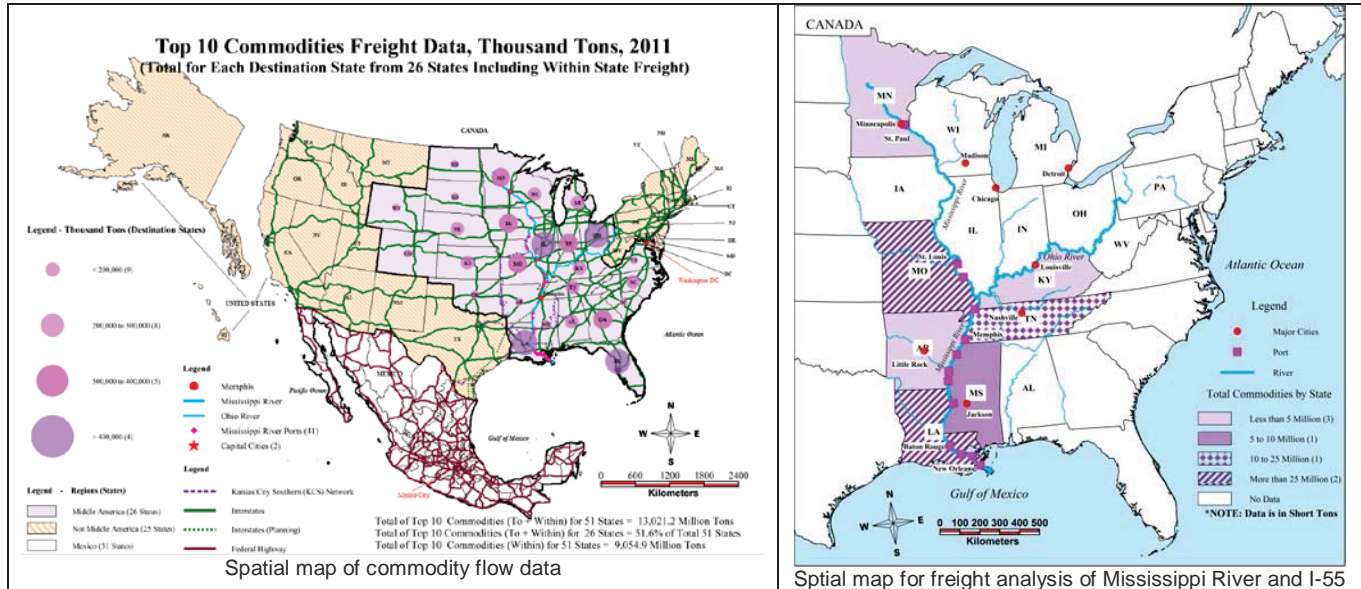


Figure 1. Spatial analysis of intermodal freight integration



Figure 2. View of US 178 B-002 highway bridge and fixed base FE model

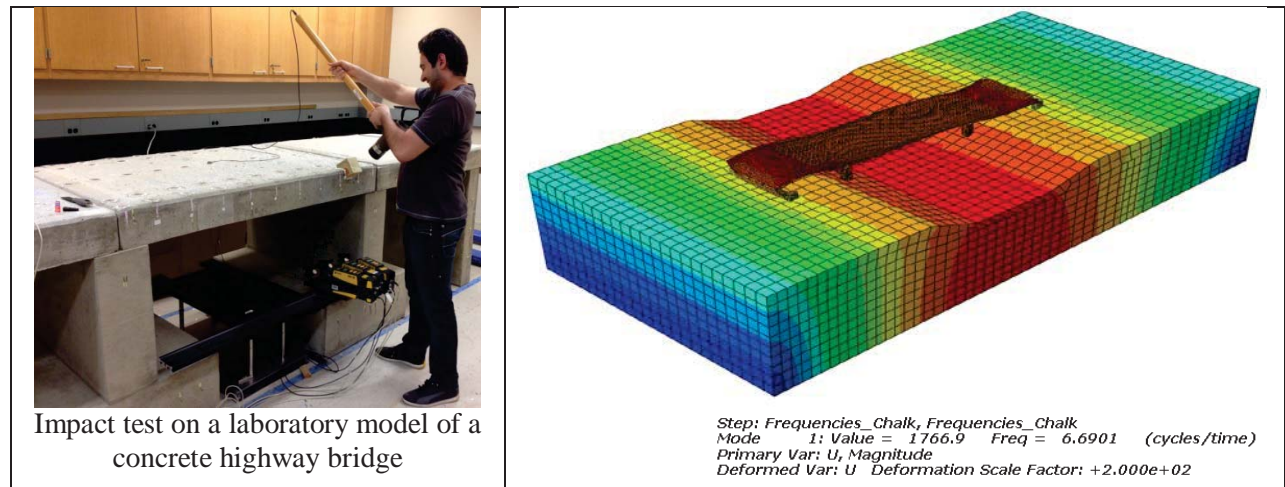


Figure 3. Laboratory scale bridge model      Figure 4. 3D-FE SSI model of B005 bridge

For further information about this project and other research reports, please contact: Dr. John Usher [www.ncitec.msstate.edu/](http://www.ncitec.msstate.edu/)  
Dr. Waheed Uddin, Director CAIT, Department of Civil Engineering, University of Mississippi, MS 38677-1848, USA  
<http://www.olemiss.edu/projects/cait/> Tel 1-662-915-5363 [cvuddin@olemiss.edu](mailto:cvuddin@olemiss.edu) [cvuddin@gmail.com](mailto:cvuddin@gmail.com)



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## University of Mississippi Research Project 2012-24

### Three Integrated Projects to Enhance Non-Contact Rail Inspection Technology for Application to Substructure Health Evaluation on Both Rail and Road Bridges

**PI:** Dr. Elizabeth K. Ervin      University of Mississippi (UM), Civil Engineering

Collaboration With: Dr. Vyacheslav Aranchuk, University of Mississippi (UM), NCPA

Dr. Christopher Mullen, University of Mississippi (UM), Civil Engineering

Dr. James Chambers, University of Mississippi (UM), NCPA/Mechanical Engineering

**Project Period:** August 1, 2012 – December 31, 2013

#### Background

American infrastructure is in a precarious state. Bridges are susceptible to damage through both aging and abnormal events, and their remaining life is difficult to estimate. For example, the gusset plate defect was known before the I-35 collapse in Minneapolis; the effect of that local inspection to the overall health of the structure was not identifiable. The technical gap is the identification of global dynamic property changes resulting from significant local component damage, such as stress corrosion cracking, a barge impacting a pier, or hurricane storm surge.

#### Objective

The primary objectives of this project are to:

- Perform a noncontact rail inspection.
- Construct a bridge scale model, and obtain a baseline for dynamic characteristics.
- Perform a full scale bridge test.
- Develop of a structural health monitoring (SHM) algorithm.
- Perform finite element (FE) modeling

The scope of this project is limited to rail and road bridges that have a substructure that has been exposed to the elements.

#### Synopsis

Causing loss of use and sometimes life, bridge collapses are always high profile and hit many wallets. The economic benefits of condition-based maintenance are well established, including reduced visual inspection and potentially longer structural life.

- This project has extended rail technology towards the generation of an inspection methodology for bridge substructure. Non-destructive optical inspection techniques have been used for assessment of rail structural integrity, but lasers have not been employed for assessment of supporting components underneath the rail.
- Results are presented for three experimental efforts: a railroad, a scaled reinforced concrete bridge, and an operational on-campus bridge.
- Traditional cabled accelerometer sensing was used as a basis to determine the feasibility of a vibrometer as an infrastructure inspection tool.
- Civil structures are ideal damage detection applications because they experience incremental changes while aging. Figure 1 shows an example of an aged bridge located on the University of Mississippi campus.



Figure 1. Photo Collage of the Eastgate Bridge Testing



## Key Results

Key outcomes or other achievements follow:

- The conducted experiments qualitatively show that structural defects of a railway track can be detected by measuring the rail vibrations. Both the accelerometer and the LDV showed enough sensitivity to observe variable frequency content between the damaged cases: split and amplified modes were identifiable. The motion of the LDV did not noticeably increase the LDV noise, but the speed of LDV in the experiments was slow, just 20 mm/s (Figures 2 and 3).
- The overall result is signal interference that may appear as highly coupled signals. The completed full-scale experiment shows that using a single point LDV located at a bridge abutment employing a low grazing angle is likely to be unsuccessful: the configuration does not allow measurements of separate vibration components of the bridge.
- Utilizing the completed model, eigenvalue analysis was performed using the software to obtain the frequencies less than 250 Hz. The first three modes cause deck deformation and thus are deemed characteristic (longitudinal translation, torsion with lateral translation, and vertical bending). As predicted by the planning study, all natural frequencies and in some cases mode order vary with assumed Young's modulus for the contact elements. The center deck vertical bending mode varies from 127 Hz to 170 Hz depending upon the contact stiffness while a smaller variation is observed in the deck torsion mode.
- Eigenvalue analysis was performed to obtain the natural frequencies less than 250 Hz. With the large number of DOF, hundreds of resonances were found. Emphasis was thus placed upon identifying mode shapes representing significant movement of the system's center of gravity. That is, global deck motions were deemed characteristic while modes with local girder deformation, for example, were omitted. Some key frequencies that were found were 4.99 Hz (center deck vertical translation), 5.41 Hz (center deck mid span rotation), and 9.21 Hz (center deck mid span rotation).



Figure 2. Instrumented rail experiment for LDV sensitivity

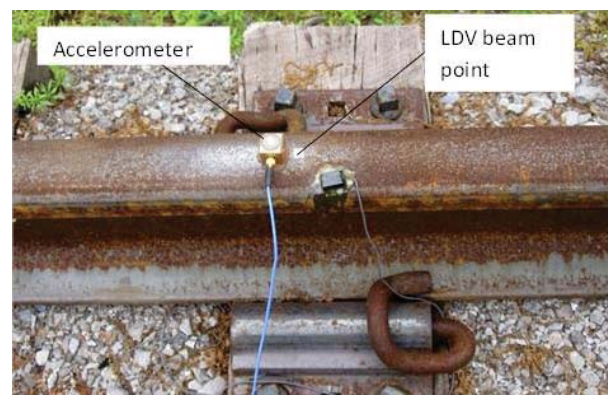


Figure 3. Measurement Target Area

**Implementation Statement:** Employing reasonable spatial grids, LDV vibration measurements were sufficient to capture modal content in multiple experiments. The damage detection program output provided confidence that LDV velocity signals are sensitive enough to use for damage detection, and health indicators can judge the severity and approximate location of damage. Once attached to a sturdy base, the moving LDV also provided good resonance information despite some slight interference. Limitations include measurement distance and geometrical resolution. In short, LDV use is a feasible option to augment inspection of rail and road bridges.

**Students Supported on Project:** 1 PhD, 1 M.S.

**Graduate M.S. Report/Thesis and PhD Dissertation:** 1 M.S.

Worley, Steven. "Development and Validation of the Structural Health Evaluation (SHE<sup>TM</sup>) Program." M.S. Thesis, University of Mississippi, May 2014.

### Published Papers and Presentations

Ervin, Elizabeth K., "Algorithm Comparison for Structural Health Metrics," BP133, 2013 Structures Congress, ASCE Structural Engineering Institute, Pittsburgh, PA, May 2-4, 2013. *Presented on May 2.*

Worley, Steven B. and Elizabeth K. Ervin, "Field Testing of the Ford Center Bridge," Mid-South Annual Engineering and Sciences Conference, Oxford, Mississippi, October 28-29, 2013.

*Key Words:* transportation, rail, non-contact, substructure, finite element

For further information about this project and other research reports, please contact: Dr. John Usher [www.ncitec.msstate.edu/](http://www.ncitec.msstate.edu/)  
Dr. Waheed Uddin, Director CAIT, Department of Civil Engineering, University of Mississippi, MS 38677-1848, USA  
<http://www.olemiss.edu/projects/cait/> Tel 1-662-915-5363 [cvuddin@olemiss.edu](mailto:cvuddin@olemiss.edu) [cvuddin@gmail.com](mailto:cvuddin@gmail.com)



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## University of Mississippi Research Project 2012-25

### Disaster Protection of Transport Infrastructure and Mobility Using Flood Risk Modeling and Geospatial Visualization

**PI:** Dr. Waheed Uddin                      University of Mississippi (UM), Civil Engineering / CAIT

**Co-PI:** Dr. Mustafa Altinakar            University of Mississippi (UM), NCCHE

**Collaboration With:** IAVO Research and Scientific, Mississippi Department of Transportation (MDOT)  
Dr. Kenneth N. Mitchell, US Army ERDC Hydraulics Laboratory, Vicksburg, MS

**In Cooperation With:** Mississippi Automated Resource Information System (MARIS)

**Project Period:** July 1, 2012 – December 31, 2014

#### Background

Flood disasters cause catastrophic damages to transportation road infrastructure including road pavements and bridges. Washing away of bridges and highway segments disrupt public mobility, freight traffic and supply chain, emergency management, and even disaster evacuation routes. Each year millions of dollars are devoted to emergency funds and mitigation of damaged transport infrastructure. Higher frequency and ferocity of rainfall and coastal hurricanes due to climate change impacts have increased the risk of flood hazards. This project addresses the NCITEC theme of efficient, safe, secure, and sustainable national intermodal transportation network that can be made resilient to disasters.

#### Objective

The primary objectives of this project are to:

- Use remote sensing and geospatial technologies for modeling and visualization of terrain and built infrastructure.
- Model and conduct simulations of extreme flood inundation events and flood risk mapping.
- Assess extreme flood impacts on critical transportation infrastructure assets.

The scope of this project is limited to downstream Little Tallahatchie River Sardis site in Northern Mississippi. The project objective is accomplished by using expertise in geospatial visualization of built infrastructure and expertise in flood modeling and flood risk mapping.

#### Synopsis

Extreme weather events are occurring at an increasing frequency as experienced by devastating floods in recent years on the East Coast. Lifeline transportation infrastructure assets are under a continuous risk of flood hazards and significant damage, such as washing away of pavements and bridges. Damaged infrastructure and disruption in transportation services lead to economic losses. Furthermore, inundation with floodwater as well as floodwater velocity can threaten the structural integrity of roads, bridges and other infrastructure assets. This study used a numerical flood model to evaluate floodplain inundation effects on transportation infrastructure assets in a rural area of the Southeastern United States.

- The downstream Little Tallahatchie River Sardis site in the Northern Mississippi is used for the pilot study. The background aerial imagery of 2ft ground resolution was acquired from MARIS. Flood simulations were conducted using the Digital Elevation Model (DEM) with ground resolution of 8.2 ft (2.5m) at 4.7 ft (1.55 m) elevation accuracy. Simulations were conducted using a two-dimensional numerical flood simulation model, CCHE2D-FLOOD, developed by the National Center for Computational Hydroscience and Engineering (NCCHE).
- The preliminary flood simulation was conducted for an extreme flood event were performed with 1/3 arc second data which roughly corresponds to computational cell size of 10m ground resolution.
  - This preliminary simulation results considering bare ground indicate that a total area of 31 sq mi (80 km<sup>2</sup>) was completely inundated (Figure 1). Flood propagation, flood inundation depth, floodwater velocity and flood arrival times were calculated at locations of bridges, and other selected transportation and building infrastructure assets.
  - Geospatial mapping of flooded area in this preliminary simulation shows that 12.4 miles (20 km) of flood inundation affected two major highways and bridges over the river, a rail line and a bridge over the river, two minor highways and 21 other bridges, and an airfield. These infrastructure assets were inundated by 19–39 ft (6–12 m) of floodwater.
  - The floodwater overflowed by 13–16 ft (4–5 m) above the top of major highways, rail and bridges (Figure 2). These results are important for assessing the structural integrity of bridges and highway embankments subjected to the extreme flood inundation.
- Final simulations were made using 10m computational cell size and the hydrograph of full reservoir spillway simulation (Figure 3) on the pilot site.



- To investigate the impact of floodwater near highway, rail line, and other civil infrastructure, the elevations of the top of these features were raised by their heights above the ground levels. More simulations were conducted using the computational cell size sizes of 5m and 3m resolutions.

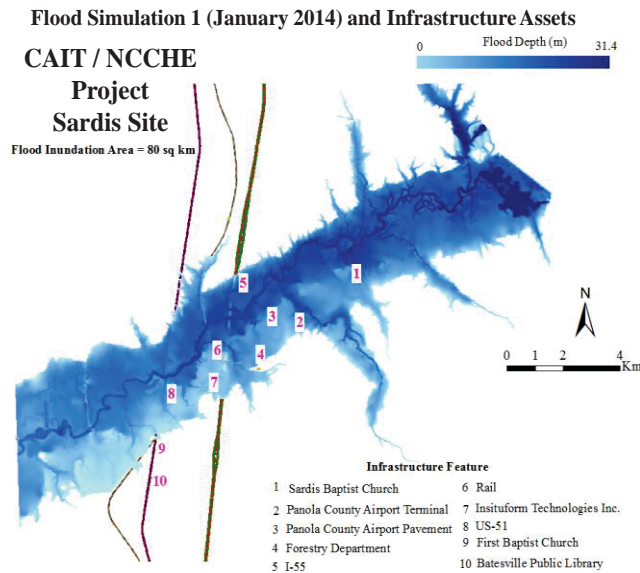


Figure 1. Flood Simulation of Floodplain Pilot Site



Figure 2. Highway Bridges on I-55 and US-51 in Northern Mississippi

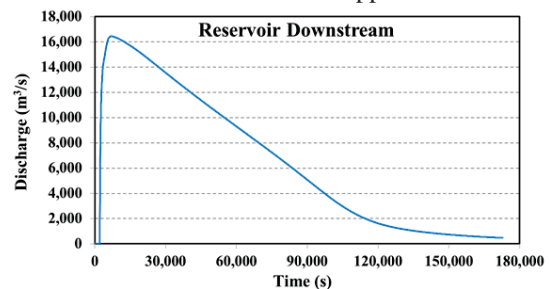


Figure 3. Flow Hydrograph of Full Spillway Simulation at Downstream Reservoir, Northern Mississippi

## Key Results

Key outcomes and other achievements are:

- The flood simulation using 10m computational cell size showed that total 57.8 km<sup>2</sup> area was inundated and the maximum channel depth was about 8m at the bridge locations of I-55, Rail, and US-51.
- The flood simulation with the 3m computational cell size showed that the floodwater overtopped the I-55 highway. The local scour around the 10 ft-diameter bridge piers in the main channel is estimated as 17.30 ft. Unless the pier foundations are sufficiently deep and appropriate local scour prevention measures are taken, the bridge may be at risk due to excessive scour.
- A detailed structural integrity assessment of US-51 bridge model analyzed the overturning floodwater moment from lateral floodwater forces and the corresponding moment of resistance by the concrete girders. The most critical condition occurs when the factor of safety (FS) approaches about 1.0 to 1.5 for the floodwater level at the top of the concrete girders.
- This project developed a geospatial decision support system for flood risk assessment and vulnerability assessment of transportation infrastructure. The key criterion is to have the superstructure above the extreme flood levels.
- Training of UG and graduate students for geospatial workforce development and enhancing infrastructure asset management are additional benefits. One PhD degree was completed in July 2016 and a second PhD is expected to complete in 2016-2017.

**Implementation Statement:** The recommended geospatial decision support system approach for highway and bridge asset management can help to prioritize critical transportation infrastructure, which are most vulnerable to extreme flood hazards, take safeguard measures, and save billions of dollars in cost avoidance of infrastructure destruction and reconstruction. This approach will improve efficiency of emergency management operations and save communities from flood disaster related damages and displacement of people from their homes.

**Students Supported on Project:** 4 PhD, 3 UG

## Graduate M.S. Report/Thesis and PhD Dissertation

Durmus, Alper. (2016). Flood Disaster Resilient Bridge Structures for Sustainable Bridge Management Systems. PhD Dissertation. University of Mississippi, August 2016.

## Published Papers and Presentations

- Durmus, A., Nguyen, Q., McGrath, M.Z., Altinakar, M.S., and Uddin, W. (2015). Numerical Modeling and Simulation of Extreme Flood Inundation to Assess Vulnerability of Transportation Infrastructure Assets. Paper No. 15-1606, Online Proceedings, the 94th Annual Meeting of The Transportation Research Board, Washington, DC, January 10-15, 2015.
- Durmus, A. and W. Uddin. (2015). Extreme Flood Simulation and Inundation Impacts on Structural Integrity of Bridges. *The NHWC Transmission*, September 2015.

**Key Words:** bridge, disaster, flood, highway, infrastructure, simulation, transportation

For further information about this project and other research reports, please contact: Dr. John Usher [www.ncitec.msstate.edu/](http://www.ncitec.msstate.edu/)  
Dr. Waheed Uddin, Director CAIT, Department of Civil Engineering, University of Mississippi, MS 38677-1848, USA  
<http://www.olemiss.edu/projects/cait/> Tel 1-662-915-5363 [cvuddin@olemiss.edu](mailto:cvuddin@olemiss.edu) [cvuddin@gmail.com](mailto:cvuddin@gmail.com)



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## University of Mississippi Research Project 2012-26

### Terminal Location Planning in Intermodal Transportation with Bayesian Inference Method

**PI:** Dr. Lei Cao University of Mississippi (UM), Electrical Engineering

Collaboration With: Dr. Paul Goggans, University of Mississippi, Electrical Engineering

**Project Period:** July 16, 2012 – December 31, 2013

#### Background

Intermodal transportation can significantly increase the economic competitiveness, by improving productivity and efficiency with reduced delay, congestion and operational cost compared to current transportation systems. The transportation system is responsible for about 30% of the total greenhouse gas emission. Therefore, design of efficient intermodal transportation systems also helps to sustain a more amiable environment by significantly reducing the total CO<sub>2</sub> emissions.

#### Objective

The primary objectives of this project are to:

- Develop a two-layer Markov Chain Monte Carlo (MCMC)-based method to implement the terminal location planning.
- Analyze the probabilistic nature in transportation networks into consideration.

The scope of this project is limited to cities that are serve as a major transportation hub.

#### Synopsis

The project investigated the planning of terminal locations for intermodal transportation systems. With a given number of potential terminals and multiple service pairs, the appropriate terminals locations would be provide the most economical and efficient intermodal operations (Figure 1).

The objective function represents the total transportation cost associated with all transportation flows within the network. Figure 2 shows the terminal locations that were investigated.

Key features of the study include:

- Development of a two-layer Markov Chain Monte Carlo (MCMC)-based method to implement the terminal location planning. This involved:
  - A lower-layer optimal routing algorithm for the service pairs that considered efficiency and fairness for a given planning.
  - A Upper-layer panning algorithm based on MCMC with a stationary distribution mapped from the transportation cost function.

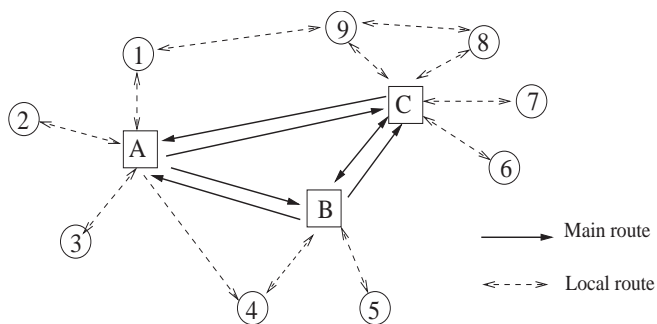


Figure 1. Intermodal Transportation System

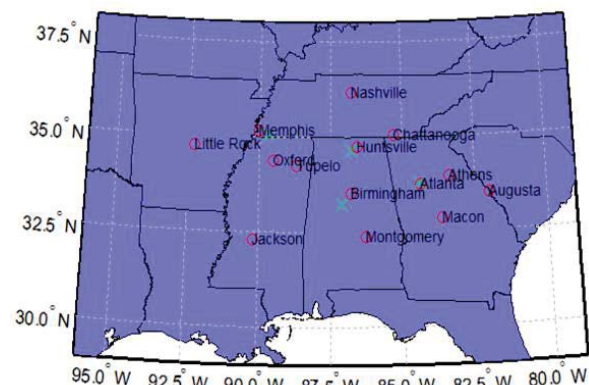


Figure 2. Map illustrating service nodes ('o') and terminals ('x')

- Bringing the probabilistic nature in transportation networks into consideration.

- Estimates of traffic needing to use the network, capacity of terminals and costs of using portions of the network vary time to time.
- Effects of these variations have not been previously studied in the literature.
- Then, the design problem can be converted into a Bayesian inference problem of finding parameter set solutions with high posteriori probability that is proportional to the product of the prior PDF and the likelihood. We have developed theoretic methods for uniform sampling multi-dimensional simplex volume and implemented the Nested Sampling method to rank solutions based on their evidence values.

## Key Results

- The kind of historical intermodal transportation data we need is not freely available, so instead a test case was invented that attempts to be realistic.
- This test case considered 14 cities and 4 existing rail terminals in five states (Mississippi, Alabama, Tennessee, Arkansas, and Georgia). The rail lines and terminals are all part of the existing Norfolk Southern intermodal freight network.
- The Norfolk southern intermodal freight network includes four main terminals:
  - Nashville
  - Memphis
  - Birmingham
  - Atlanta
- The amount of freight demand coming from these cities is proportional to their populations. The proportion of the demand coming from one city going to another city is proportional to the destination city's population as a percentage of the total population of all the cities in the network.
- Terminal capacities and fixed costs are proportional to the population of the nearest large city. The amount of demands may change and the variation is assumed to be Gaussian random variable with variance being one tenth of the mean value.
- With the use of existing four terminals, three configurations were tested: no additional terminals added, one added near Chattanooga, and one added near Meridian, Some of the costs and capacities of studied terminals are shown in Table 1.
- The results show that the proposed Chattanooga terminal absorbs much of the demand that is normally routed unimodally from Nashville, so the cost is noticeably lower. The proposed Meridian terminal, however, is not well placed and its utility to the network is minimal.

Terminal	Capacity (tons)	Fixed Cost (\$)
Memphis	168,370	159,280
Huntsville	47,219	44,671
Birmingham	54,491	51,552
Atlanta	114,050	107,890
Chattanooga	96,349	96,800
Meridian	37,187	37,361

**Implementation Statement:** It can be concluded that the Bayesian inference method with MCMC could provide a unified methodology for solving various operational optimization problems in intermodal transportation systems. Compared with other case-by-case heuristic methods. This proposed work has an advantage to guide the “random walk” in the multi-dimensional decision space based on the samples’ contribution to a well-mapped stationary probability distribution. As a result, a better final solution can be approached, with a short time period.

This project has broader impact. Since the probabilistic features are inherent in transportation, the design model based on Bayesian inference with MCMC has the potential to provide a unified framework not only for the location planning but also for many other optimization problems in intermodal transportation systems.

**Students Supported on Project:** 1 PhD, 1 M.S.

**Graduate M.S. Report/Thesis and PhD Dissertation:** None

## Published Papers and Presentations

Henderson, W. and P. Goggans, “Parallelizing nested sampling,” *Proceedings of the 33rd International Workshop on Bayesian Inference and Maximum Entropy Methods in Science and Engineering (MAXENT 2013)*, Canberra, Australia, December 15-20, 2014.

Goggans, P., W. Henderson and L. Cao, “Design-as-inference: probability-based design of intermodal transportation networks,” *Proceedings of the 33rd International Workshop on Bayesian Inference and Maximum Entropy Methods in Science and Engineering (MAXENT 2013)*, Canberra, Australia, December 15-20, 2014.

*Key Words:* Bayesian, intermodal, terminal, Markov Chain, Monte Carlo, transportation

For further information about this project and other research reports, please contact: Dr. John Usher [www.ncitec.msstate.edu/](http://www.ncitec.msstate.edu/)  
 Dr. Waheed Uddin, Director CAIT, Department of Civil Engineering, University of Mississippi, MS 38677-1848, USA  
<http://www.olemiss.edu/projects/cait/> Tel 1-662-915-5363 [cvuddin@olemiss.edu](mailto:cvuddin@olemiss.edu) [cvuddin@gmail.com](mailto:cvuddin@gmail.com)



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## University of Mississippi Research Project 2012-27

### Integrated Intermodal Transportation Corridors for Economically Viable and Safe Global Supply Chain

**PI:** Dr. Waheed Uddin University of Mississippi (UM), Civil Engineering/CAIT

Dr. Jody Holland, UM Public Policy; Consultants: Dr. Rob Smith and Dr. Victor Torres-Verdin

Collaboration With: Dr. Patrick Sherry, University of Denver (DU), DU PI

Dr. Burak Eksioglu, Clemson University (CU), CU PI

Dr. Ned Mitchell, Army ERDC Hydraulics Laboratory, Vicksburg, MS, Advisor

Mr. Karl Y. Metrow, Maritime Information Systems Inc., Warren, RI

**Project Period:** July 1, 2012 – December 31, 2014

### Background

Freight transportation of consumer goods and commercial/industrial products is critical for sustainable and efficient supply chain. The motivation and goals include:

- Development of geospatial visualization maps of freight corridors and commodity flow.
- Improvement of supply chain delivery efficiency and cost-effectiveness by integrating four transportation modes (shipping port, aviation, rail, and highway) being operated by different entities in the U.S.
- Exploration of innovative financing mechanisms for preserving and upgrading intermodal infrastructure
- Formulation of safer operations and disaster resiliency of the global supply chain infrastructure.

The economic competitiveness, safety, security and disaster resilience of freight transport and supply chain can be significantly enhanced if owners, operators, and users of all transportation modes understand the importance of operational integration of these modes.

### Objective

The primary objectives of this project are to:

- Identify major transportation corridors involving shipping ports (marine and inland river system) highway network and rail infrastructure
- Evaluate the economic viability, safety, disaster resiliency, and revenue/funding aspects of integrating selected segments of the candidate corridors.



The scope of this project is limited to NAFTA trading partner countries of the United States, Canada, and Mexico.

The project objective was accomplished by using airborne and spaceborne remote sensing and geospatial technologies for mapping and visualization of freight corridors and connecting major city hubs.

### Synopsis

The project investigated the aspects of multi-modal freight related to congestion, intermodal integration, and impacts of fuel savings and Carbon Dioxide (CO<sub>2</sub>) emissions. Key features of the study include:

- The research contributes to:
  - Improved understating of loading based pavement friction and skid resistance assessment
  - Historical perspectives of state and NAFTA freight data, new opportunity of rail-truck intermodal integration.
  - A value engineering methodology of life cycle costs and benefits.
- The project developed an analyzed three different intermodal integration scenarios, as follows:
  - Colorado study of freight transport intermodal integration of highway truck and rail
  - NAFTA Highway truck freight intermodal integration and optimization with freight rail from Laredo to Detroit
  - Freight transport by highway truck freight and Mississippi River barge integration (Figure 1)
  - Impacts of intermodal integration on economic competitiveness, travel time and cost reduction, and emission reduction. The intermodal freight corridor case studies were developed to provide a “best practice guide” example.
- The research studies analyzed impacts of intermodal integration of freight truck transport with rail and waterway barges for reductions in shipping costs and CO<sub>2</sub> emissions (Table 1).
- An intermodal infrastructure bank proposal was developed for consideration by government transportation agencies, private transport operators, and all other stakeholders.
- Highway safety was studied using tire-loading theory and field tests that provided insight into the effect of pavement texture on skid resistance.



## Key Results

Key outcomes or other achievements follow:

- This project developed geospatial maps, optimization models, benefit/cost results of proposed modal integration simulation studies, life cycle economic model results of economic and environmental impacts, and intermodal infrastructure bank proposal.
- Theoretical consideration and associated field studies improved understanding of transportation professionals for tire/pavement interaction during braking and crash incidents. Guidelines are recommended to improve road safety.
- Computer simulations of selected port(s) and freight corridor(s) with economic and sustainability analysis are used to show the importance of the intermodal integration approach for enhancing the economic competitiveness, safety, security and disaster resilience of freight transport.
- The intermodal freight corridor case studies are used to develop a “best practice guide” examples.
- The studies demonstrate the assessment of other societal benefits, which include reduction of wastage of hours of travel time by reducing traffic congestion, cost avoidance of fuel wastage on congested highway corridors, and decrease in transportation related emissions of carbon dioxide and other harmful pollutants.

**Implementation Statement:** It is recommended that the developed approach of freight corridor integration studies be applied by transportation agencies to assess other societal benefits, which include reduction of wastage of hours of travel time by reducing traffic congestion, cost avoidance of fuel

wastage on congested highway corridors, and decrease in transportation related emissions of carbon dioxide and other harmful pollutants. The innovative revenue mechanisms and infrastructure bank policy paper are recommended for consideration by transportation infrastructure agencies.

**Students Supported on Project:** 5 PhD, 3 M.S., 14 UG

## Graduate M.S. Report/Thesis and PhD Dissertation

Ahlan, Muhammad. (2015). Geospatial Applications for Mobility, Travel Demand, Transport Infrastructure, and Associated Impacts on the Environment. M.S. Graduate Report, University of Mississippi, Dec 2014. (Advisor: Dr. W. Uddin)  
Cobb, Seth. (2015). Economic Viability and Societal Benefits of Integrated Multimodal Freight Corridors and Sustainable Passenger Transportation. M.S. Thesis, University of Mississippi, August 2015. (Advisor: Dr. W. Uddin)

## Published Papers and Presentations

Uddin, W., Cobb, S., Sherry, P. and Eksioglu, B. (2015). Economically Viable Intermodal Integration of Surface and Waterway Freight Transport for Sustainable Supply Chain. *University Transportation Center (UTC) Conference for the Southeastern Region*, University of Alabama at Birmingham, March 26-27, 2015, Birmingham, Alabama.  
Uddin, W., S. Cobb, T. McCarty, and J. Sharma. (2015). Environmental and Energy Concerns for Life Cycle Analysis of Transportation Systems. *ASCE Special Publication International Symposium on Systematic Approaches to Environmental Sustainability in Transportation*, Center for Environmentally Sustainable Transportation in Cold Climates (CESTiCC), Fairbanks, Alaska, August 2-5, 2015.  
Uddin, W. (2013). Value Engineering Applications for Managing Sustainable Intermodal Transportation Infrastructure Assets. *Management and Production Engineering Review*, MPER, Vol. 4, No. 1, March 2013, pp. 74–84.

**Key Words:** congestion, freight, multimodal, intermodal, transportation, emission, supply chain

Gulfport, MS to St. Louis, MO Base Scenario, I-55



Figure 1. Highway-Waterway freight corridors

Table 1. Summary of Benefits Calculated for Three Case Studies of Freight Integration

Freight Intermodal Integration Study	Corridor Length, miles	Annual Truck Freight Diverted	Travel Time Reduction	Ton-Mile Cost Savings	CO <sub>2</sub> Reduction	Fuel Cost Saving
Colorado-California	Truck 1,201 Rail 1,353	30%	98.9%	87.0%	57.7%	\$3,737,349
NAFTA Laredo-Detroit	Truck 1,594 Rail 1,777	20%	98.8%	87.2%	58.2%	\$84,798,828
Gulfport, MS - St. Louis, MO	Truck 695 Mississippi River 984	30%	19.0%	18.0%	11.7%	\$ 113,088

For further information about this project and other research reports, please contact: Dr. John Usher [www.ncitc.msstate.edu/](http://www.ncitc.msstate.edu/)  
Dr. Waheed Uddin, Director CAIT, Department of Civil Engineering, University of Mississippi, MS 38677-1848, USA  
<http://www.olemiss.edu/projects/cait/> Tel 1-662-915-5363 [cvuddin@olemiss.edu](mailto:cvuddin@olemiss.edu) [cvuddin@gmail.com](mailto:cvuddin@gmail.com)



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## University of Mississippi Research Project 2013-25

### Predicting Erosion Impact on Highway and Railway Bridge Substructures

**PI:** Charles T. Swann University of Mississippi, Mississippi Mineral Resources Institute (MMRI)

Collaboration With: Dr. Christopher Mullen University of Mississippi (UM), Civil Engineering

**Project Period:** July 1, 2013 – May 31, 2016

#### Background

The National Bridge Inventory (NBI) includes 58,495 structurally deficient bridges in the United States. Of the 17,057 bridges in the highway database located in the state of Mississippi, 2184 bridges are defined as “structurally deficient”. This places Mississippi as 8<sup>th</sup> nationally for total number with that designation and 12<sup>th</sup> nationally as a percentage of the state’s inventory. A subset of these bridges spans surface water. These bridges have a unique set of stability concerns relating to the surface environment on which the bridge is founded. Understanding this surface water system (fluvial system) allows the engineer to not only understand on-going processes likely to impact the structure, but to also better plan and site bridges where future problems (and maintenance expenses) can be minimized.

Extensive erosion has been noted along several key transportation routes. The erosion is the cause for major concern about the deterioration of the United States infrastructure. While there are some minor attempts to control the erosion, the controlling agencies sometimes do not have the required funds to implement erosion protocols that will increase the lifespan of these structures. The lack of funds shows that there needs to be a method, that is both accurate and cost effective, that will predict key areas of erosion. It should be useful to better define geographic areas of increased erosion rates that bridge engineers can incorporate into future bridge design, aid in formulating a strategy for protection from this natural hazard, and evaluate the need for enhanced bridge inspection practices.

#### Objective

The primary objectives of this project are to:

- Identify railroad/highway bridges in field area; Completion of scour / geological analysis; identification / acquisition of background data; identify students for project; identify bridges to model, begin collection of technical drawings; begin development of network of interested professionals and organizations.
- Modeling of selected bridges.
- Formulation of best practices for erosion control

The scope of this project can be applied to any bridge system that has been exposed to the elements.

The project objective is accomplished by the selection and modeling of bridges. Ground surveys allowed for the evaluation of the bridges and scour conditions to be determined. These bridge ground surveys test the accuracy of the National Bridge Database information for the study area.

#### Synopsis

The NBI database has been utilized to guide the field work. An observation from this bridge verification is that the NBI database is in need of an update. A significant number of bridges have been replaced with box culverts, and so there are fewer bridges in the study area than originally thought. Most of the bridges have had rip rap added to soil surface below the bridges and often across the stream bed as well. It is assumed that this additional rip rap was added to mitigate under-bridge stream erosion.

The bridge selected for the initial detailed work is B-002 in Union, County (Figure 1).

- This bridge dates from 1936 and has evidence of significant erosion.

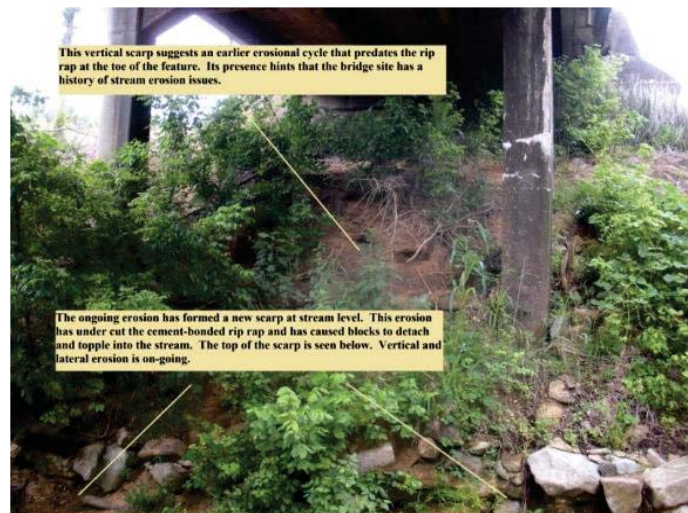


Figure 1. Photograph of Erosion Conditions at a Bridge in Union County, Mississippi

- Preliminary results suggest that there has been 12.6 feet of erosion since the bridge was built (estimates based from MDOT bridge drawings).
- If averaged over the 78 years since the bridge was built, the stream has down cut at an average rate of 2.9 inches per year.
- Extensive erosion has also been observed at other railway and road bridges across America. One such bridge is the Burlington Northern and Santa Fe Railroad (BNSF).



Figure 2. Fixed Base FE Model for US 178 B-002 Highway Bridge Superstructure

## Key Results

Key outcomes or other achievements follow:

- The National Bridge Inventory database was utilized to guide the field work. An observation from this bridge verification is that the NBI database is in need of an update. A significant number of bridges have been replaced with box culverts, and so there are fewer bridges in the study area than originally thought.
- The bridge selected for the initial detailed work is B-002 in Union, County. This bridge dates from 1936 and has evidence of significant erosion of about 12.6 feet since the bridge was built. An average rate of 2.9 inches per year is an unusually high rate of down cutting.
- Using the MDOT drawings and field survey measurements, a preliminary FE model was constructed of the three-span B-002 highway bridge using the CAE processor of the ABAQUS version 6-12 software. Figure 2 shows the model that was used to establish the fixed-base model of the superstructure and intermediate bents. The piles, abutments, and soil were added to establish the soil-foundation-structure (SSI) model.
- An earthquake scenario of the type used in emergency management plans for the study region was used to assess the effect of scour on vulnerability to ground motion.
- Simulated time history response was computed for the flexible system with and without scour. Acceleration response time histories were presented that show a significant increase in the transverse acceleration which tends to increase the instability of the system.

**Implementation Statement:** The supporting erosion/scour studies identified substantial erosion resulting from the negative consequences of channelization, easily erodable geologic materials, and inadequate erosion mitigation measures. Past practices have ignored the “under-bridge” stream which is the primary agent of erosion. Stream geometry should be recorded on design plans and monitored as part of standard bridge inspection practices.

**Students Supported on Project:** 1 PhD, 1 M.S.

**Graduate M.S. Report/Thesis and PhD Dissertation:** None

## Published Papers and Presentations

Mullen, C., Tanner, K. (2015). Effects of Scour on Structural Integrity of Highway and Railway Bridges in the Blue Springs, Mississippi Region. *2015 American society for Civil Engineers (ASCE) Structural Engineer Institute (SEI) Structures Congress*, Portland, Oregon, April 23-25, 2015

*Key Words:* bridge, erosion, highway, rail, substructures, scour, transportation

For further information about this project and other research reports, please contact: Dr. John Usher [www.ncittec.msstate.edu/](http://www.ncittec.msstate.edu/)  
Dr. Waheed Uddin, Director CAIT, Department of Civil Engineering, University of Mississippi, MS 38677-1848, USA  
<http://www.olemiss.edu/projects/cait/> Tel 1-662-915-5363 [cvuddin@olemiss.edu](mailto:cvuddin@olemiss.edu) [cvuddin@gmail.com](mailto:cvuddin@gmail.com)





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## University of Mississippi Research Project 2013-26

### Detecting Weakened Highway and Railroad Bridge Substructures at Deck Level

**PI:** Dr. Chris L. Mullen      University of Mississippi (UM), Civil Engineering

Collaborated With: Dr. Elizabeth K. Ervin, University of Mississippi (UM), Civil Engineering

**Project Period:** July 1, 2013 – May 30, 2016

#### Background

The project focuses on developing soil-structure interaction capability of the 3D finite element (FE) models of select bridges in the study area of north Mississippi and performing static and eigenvalue analysis to establish baseline model data for the evaluation of modal characteristics. The selected bridges are characteristic of many in the state and national inventory and offer a range of soil, foundation, and superstructure conditions as well as states of deterioration. Detailed soil-structure interaction (SSI) finite element (FE) models have been constructed for two of the bridges having pile foundations and one that is supported by spread footings lying directly on a friable rock formation.

#### Objective

The primary objectives of this project are to:

- Identify highway/railroad bridges accessible to the project team; characterize bridge substructures for purposes of selecting representative cases for FE analysis; identify students for project; identify bridges to model, begin collection of technical drawings; identify lessons learned in a predecessor NCITEC project for further development.
- Modeling of select bridges for purposes of applying proposed damage detection methodology
- Experimental testing of subset of selected bridges
- Evaluation of feasibility or limitations of the methodology in field maintenance operations based on results of tasks in Goals 2 and 3; final report preparation; formulation of best practices

The scope of this project can be directed toward detecting weakened highway and railroad bridge substructures at the deck level.

#### Synopsis

The project has four major goals having the objective of assessing potential of deck-level vibration monitoring in detecting structural and foundation damage in aging infrastructure in a study region comprising most of north Mississippi which is a microcosm of semi-urban and rural economic development. The bridges selected are characteristic of others throughout the nation serving in a similar capacity whose deterioration threatens economic competitiveness and emergency response to disasters.

- Identify highway/railroad bridges accessible to the project team; characterize bridge substructures for purposes of selecting representative cases for FE analysis; identify students for project; identify bridges to model, begin collection of technical drawings; identify lessons learned in a predecessor NCITEC project for further development.
- Modeling of select bridges for purposes of applying proposed damage detection methodology.
- Experimental testing of subset of selected bridges.
- Evaluation of feasibility or limitations of the methodology in field maintenance operations based on results of tasks in Goals 2 and 3; final report preparation; formulation of best practices.

The following activities were completed:

- Tests were conducted on a shake table to assess variations in frequency and temporal dynamic response characteristics for the different configurations, and frequencies were compared with those obtained by simplified finite element analysis of the subsystems.
- Detailed finite element analysis was then performed to characterize the dynamic characteristics of two full scale three-span highway bridges accessible to the project team (Figure 1). The two bridges have similar superstructures consisting of composite steel girder decks but lie in different geologic formations such that one was designed with a deep foundation system and the other with a shallow one. Fixed base models highlight the significant difference in fundamental frequencies for the two structural systems even when the different foundations are not considered.

- Soil-structure interaction models were developed to incorporate the soil and foundation elements and account for scour conditions.
- Damage scenarios were considered that consist of material deterioration in the form of softening modeled as reductions of the elastic modulus in various substructure elements of one of two central piers.

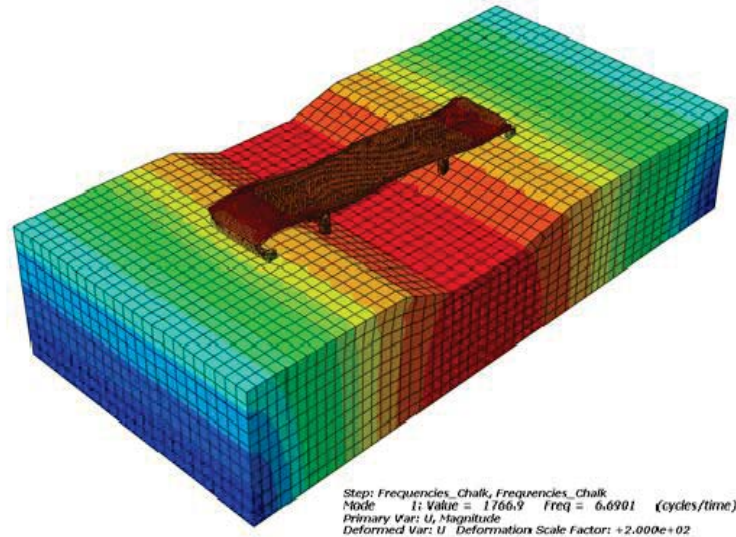


Figure 1. 3D FE SSI Model of B005 Bridge

## Key Results

Key outcomes or other achievements follow:

- A refinement of the bridges selected for detailed study was made to maximize benefits of the study to the goals and objectives. All bridges have a composite steel girder deck superstructure and concrete pier/abutment substructures. The bridges on piles nominally differ only by virtue of the skewness of the roadway alignment.
- Modeling of selected bridges advanced during the reporting period. Figure 1 shows fundamental mode shape involving longitudinal vibration of as-built structure. Effect of chalk foundation and top soil layer is primarily to lower fixed base frequency slightly. Footings are fully embedded and piers/abutments are partially embedded.
- The material deterioration scenarios do not produce noticeable changes in the modal frequencies of the flexible system whereas the scour scenario produces changes in modes involving horizontal movement of the deck mass that are potentially significant enough to be detectable by measurements made at deck level.

**Implementation Statement:** The models developed for this project to study deterioration and vibrational characteristics are improving the state of the deterioration and vibrational characteristics. They are able to account for a far greater amount of detail than any previous model has been able to develop since the time of his dissertation on seismic response of highway bridges using motion arrays from a recorded earthquake event and in studies of earthquake hazard mitigation and risk assessment he has performed during his time as a faculty researcher at UM.

**Students Supported on Project:** 1 PhD, 3 M.S.

**Graduate M.S. Report/Thesis and PhD Dissertation:** 1 PhD, 1 M.S.

Miah, Md. Mamun, “Development of a Dynamic Coupled Hydro-Geomechanical Code and its Application to Induced Seismicity.” PhD dissertation, The University of Mississippi, August 2016. (Advisor Dr. Mullen)

Tanner, Kimberly Ann, “Computational Finite Element Analysis of Extreme Loading Response of Structural Insulated Panel (SIP) Building Subsystems.” M.S. Thesis, December 2015. (Advisor Dr. Mullen)

## Published Papers and Presentations

Mullen, Chris, Kim Tanner, and Amir Irhayyim, “3D FE simulation of aging bridges on soil and rock foundations,” *Simulia South Regional Users Meeting*, Houston, TX, October 15, 2015. (Presenter: Mullen)

*Key Words:* transportation, bridge, Finite Element, foundation, structure

For further information about this project and other research reports, please contact: Dr. John Usher [www.ncitc.msstate.edu/](http://www.ncitc.msstate.edu/)  
Dr. Waheed Uddin, Director CAIT, Department of Civil Engineering, University of Mississippi, MS 38677-1848, USA  
<http://www.olemiss.edu/projects/cait/> Tel 1-662-915-5363 [cvuddin@olemiss.edu](mailto:cvuddin@olemiss.edu) [cvuddin@gmail.com](mailto:cvuddin@gmail.com)



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## University of Mississippi Research Project 2013-27

### Rapid Noncontact Measurement using Multiple Point Laser Doppler Vibrometry for Health Evaluation of Rail and Road Bridges

**PI:** Elizabeth K. Ervin University of Mississippi (UM), Civil Engineering

Collaboration With: Dr. Vyacheslav Aranchuk University of Mississippi (UM), NCPA

Dr. James P. Chambers University of Mississippi (UM), Mechanical Engineering

**Project Period:** January 1, 2014 – December 31, 2014

#### Background

Measurement of dynamic responses to ambient stimuli can be used to evaluate as-built structural characteristics. These parameters can be used to determine the overall “health” of the structure; that is, the damage level and location can provide reliability information that aids infrastructure managers in maintenance decision-making. In contrast to traditional vibration measurement systems, laser technology provides for rapid remote inspection. Laser Doppler vibrometers (LDV) have recently been used to capture noncontact vibration of bridges and are being used in an associated NCITEC project. Civil infrastructure has an entirely different frequency range; massive structures with such low frequencies present a unique challenge. In this project, a new method for structural vibration measurements on bridges was implemented.

#### Objective

The primary objectives of this project are to:

- Construct instrumentation systems.
- Conduct experiments on a scale model bridge.
- Develop and test damage detection scale.

The technical scope is also limited to overall health (and global modes), so subsequent local inspection may be indicated. Locating of potential damage is still extremely valuable for more pointed inspection and maintenance.

The project objective is accomplished by implementing a new method for structural vibration measurements on bridges. The overarching idea is that parallel vibration measurements at multiple points will enhance noncontact bridge inspection technology. The technique will eventually advance to implementation on a bridge at a distance on the order of hundreds of meters.

#### Synopsis

The project sought to improve damage detection in bridge inspections via parallel noncontact vibration measurements. In contrast to traditional contact measurements, laser technology provides for rapid remote inspection.

- Three single point LDVs were simultaneously employed. Their base isolation was essential to obtain absolute measurements on the bridge.
- A floor-mounted frame was designed to reduce measurement noise caused by ambient vibration.
- At the onset of testing, the scale model bridge was in place for one year.
- Figure 1 shows a schematic diagram of the instrumentation.

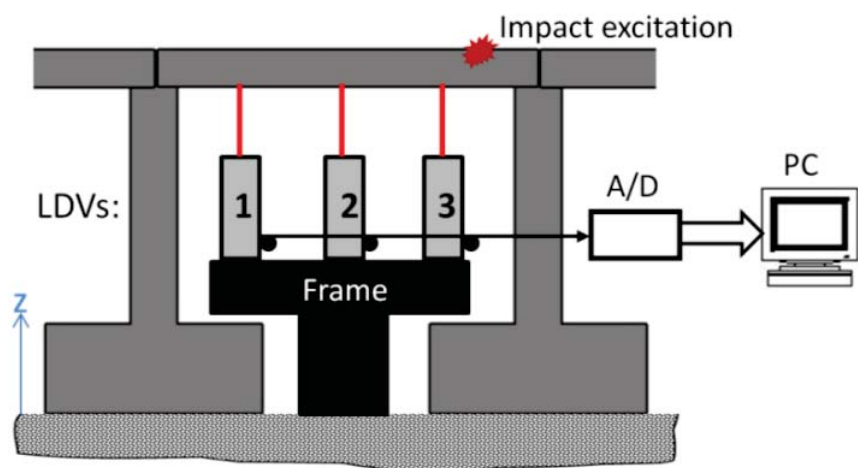


Figure 1. Schematic Diagram of Vertical Instrumentation

- New multi-beam baseline data was captured and compared to previously captured single point data.
- Production runs included multiple series of experiments using multiple beams. Settings were examined for their effects on noise levels.
- Vibratory velocity was captured and used to evaluate dynamic characteristics of the scale model bridge.

## Key Results

Key outcomes or other achievements follow.

- Laser measurements were made for each case at forty-five points, omitting boundary points. Three Laser Doppler Vibrometers made simultaneous noncontact velocity measurements from underneath the bridge. As a hammer strikes the bridge (Figure 2) inducing three-dimensional excitation, the LDVs measure the simultaneous vibration response in real-time for three points at a time.
- The LDV data sets produced 64 unique peaks for the baseline and 55 for the damaged case. The LDV signals provided nearly twice the potential modes due to the increased sensitivity and noise.
- The cumulative frequency response functions (FRFs) for the damaged trace's peaks have lesser magnitude and are "softer," demonstrating that more damping has been introduced into the system.
- The average difference is -4.32% with a standard deviation of 0.045, and all but three natural frequencies decreased, demonstrating softening.
- Baseline Peaks 44 and 50 are outliers showing the most damage at -12.57% and -17.87%, respectively. Thus, large frequency shifts are shown in the mid-range 110 Hz to 190 Hz.
- Examination of the FRFs also reveals those peaks dropped markedly in amplitude and increased in breadth. Baseline Peak 7 increased by 3.08%, which is within a reasonable range for variable contact behavior.



Figure 2. Impact Test in Progress

**Implementation Statement:** This project has increased the base of knowledge for low frequency structures. However, much more work is needed before an inspection tool is developed. The developed method will apply to broad classifications of structures and will significantly improve current infrastructure management. This methodology will apply to both railroad and highway bridges (both passenger and freight) as well as potentially extending to dams, levees, buildings, etc. The eventual goal is to provide condition-based maintenance via a cost-effective product that will transverse any structure and identify an overall change in its stiffness, indicating that localized inspection is required before a bridge collapse, for instance.

**Students Supported on Project:** 2 PhD, 2 M.S.

## Graduate M.S. Report/Thesis and PhD Dissertation

Worley, Steven, "Development and Validation of the Structural Health Evaluation (SHE<sup>TM</sup>) Program," M.S. Thesis, University of Mississippi, May 2014.

## Published Papers and Presentations

Elizabeth K. Ervin, "Three Experimental Applications of Health Algorithms to Improve Infrastructure Inspection," *European Workshop on Structural Health Monitoring*, July 2014. (Refereed paper accepted and presented)

*Key Words:* bridge, Doppler vibrometry, laser, noncontact, rail, road, transportation

For further information about this project and other research reports, please contact: Dr. John Usher [www.ncitec.msstate.edu/](http://www.ncitec.msstate.edu/)  
Dr. Waheed Uddin, Director CAIT, Department of Civil Engineering, University of Mississippi, MS 38677-1848, USA  
<http://www.olemiss.edu/projects/cait/> Tel 1-662-915-5363 [cvuddin@olemiss.edu](mailto:cvuddin@olemiss.edu) [cvuddin@gmail.com](mailto:cvuddin@gmail.com)





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## **University of Mississippi Research Project 2013-29 and Project 2016-08**

### **2013-29 Risk Framing of U.S. Intermodal Transportation Toxic Spills in News and Social Media 2016-08 Toxic Transportation Spills: Invisible or Ignored?**

**PI:** Dr. Kristen Alley Swain University of Mississippi (UM), Meek School of Journalism

**Project Period:** August 26, 2013 – August 31, 2016

#### **Background**

Between 2003 and 2012, 161,079 toxic spills in the U.S. involving highway, air, rail and waterways exceeded \$701 billion in cleanup and mitigation. 5,555 transportation hazmat (toxic spill) accident reports between Jan. 1, 2003 and Dec. 31, 2012 that U.S. DOT had classified as “serious” in the federal Pipeline and Hazardous Materials Safety Administration database were examined according to social media presence and news coverage data per accident, for the 2,782 transportation companies involved in these spills.

#### **Objective**

The primary objectives of this project are to:

- Test and expand an original risk-framing model, to identify ways to reduce outrage and misinformation in public risk messages following intermodal transportation hazmat incidents.
- Determine how and why transportation companies and agencies do – or do not – communicate directly (via social media) and/or indirectly (via news media), with public audiences about transportation toxic spill accidents.
- Provide recommendations for improved crisis communications about transportation-related toxic spills.

The scope of this project is limited to major intermodal transportation hazmat incidents that had social media attention.

The project objective is accomplished by measuring brand strength/social media presence through the Klout, TweetReach, and HowSocial scores. The Klout score reflects a company’s overall social media influence based on its presence on Twitter, Facebook, Wikipedia, LinkedIn, and YouTube (score<25 = little or no presence). The TweetReach exposure score reflects the number of company tweets, follower counts, and retweets. The How Sociable magnitude score is a company’s level of social media activity, on a scale of 1 to 10 (0 = no activity).

#### **Synopsis**

The project investigated the public response of transportation companies related to serious toxic spills (Figure 1). This was done by demining the amount of coverage from media and social media outlets. Swain’s news media analysis found that 99.48% of the 5,555 most serious spills during transportation of hazardous materials received no news coverage.

- Key features of the study include:
  - Establishing a baseline of social media presence and online influences of the public transportation companies.
  - Identifying all newspaper coverage appearing in the U.S. Media for all 5,555 spills.
  - Analyzing all the news stories about the toxic spills between 2001 and 2011.
  - Conducting a survey of news agency reports and public agency officials for their perceptions of reporting effectiveness.

#### **Key Results**

Key outcomes or other achievements follow:

- After the data analysis phase and a survey of news media and transportation agencies, the project provided practical implications for future risk message design, not only for the corporate and governmental communications representatives who must talk to the media in the aftermath of transportation accidents but also for journalists who cover these events.
- Most journalists who track police, fire and other emergency reports said they do so by receiving daily emails from law enforcement (69.2%), getting tips from readers emailed or posted on social media (69.2%), or following social media accounts of law enforcement agencies (61.5%), listening to a police scanner (53.9%), calling police or fire stations daily (38.5%) or collecting paper reports from police or other departments (38.5%). Other methods (30.8%) included tracking Pipeline and Hazardous Materials Safety Administration news releases, receiving emails about spills from state emergency services, or receiving daily fax reports from state police.

- The project reviewed the news routines and reporting strategies used in coverage of serious transportation incidents.
- Transportation officials viewed media coverage of spills in a much more favorable light than the journalists did. When asked to rate past media coverage of hazardous transportation spills, 44.5% of journalists rated the overall coverage as good or excellent, compared with 76.9% of the officials.
- The project developed a framework for improved news coverage of these incidents (Figure 2). Ultimately, a better understanding of corporate crisis communication and reputation management could minimize the economic and environmental impact of future toxic spills in intermodal transportation.
- The explanatory content is believed to mitigate these responses, even when content that promotes high uncertainty is also disseminated. Outrage-provoking content includes speculation, off-record news sourcing, conflicting reports, vague advice for avoiding exposure to hazards, or false alarms.
- The project will identify implications for changing practices in crisis communications about future transportation accidents, to improve crisis communications practice, increase public understanding, and minimize the economic and environmental impact of future accidents. The recommendations developed from these implications will be disseminated to public information officers from corporate and agency representatives through a presentation at the annual National Public Health Information Coalition convention in Atlanta, which includes many agency PIOs involved in crisis communications and/or a transportation-related convention such as a University Transportation Center conference.



Figure 1. River Spill Incident (Photo Credit: CBS News, August 10, 2015) <http://www.cbsnews.com/news/residents-frustrated-after-animas-river-spill-may-have-contaminated-drinking-water/>

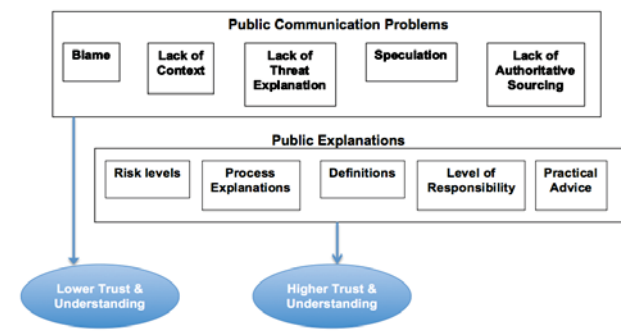


Figure 2: Communication Factors and Framework in Public Understanding of Hazardous Spills

**Implementation Statement:** This project highlights systemic opportunities for improving public communications about spills. The risk of toxic transportation spills increases the challenges and potential costs of operating the intermodal network of highways, rails, waterways, airports, and shipping terminals. Examining how these accidents are presented to the public could help corporate leaders and governmental policymakers more effectively determine the levels of transportation-related risk that are acceptable and affordable. Examining public risk messages about these incidents also may mitigate potential public outrage after accidents and help transportation leaders identify priorities for response and preparedness.

**Students Supported on Project:** 2 M.S.

**Graduate M.S. Report/Thesis and PhD Dissertation**

2 M.S. degrees completed

**Published Papers and Presentations**

Swain, K.A. (2016). Toxic Transportation Spills: Invisible or Ignored? *Presentation to the University Transportation Center Conference for the Southeastern Region*, Knoxville, Tennessee.

Swain, K. (2015). News Blackout and Social Media Invisibility after Toxic Transportation Spills. *National Public Health Information Coalition's National Conference on Health Communication, Marketing and Media*, Atlanta, Georgia, August 2015.

Swain, K.A. and Jordan, L.A. (2015). BP's Reputation Repair Strategies during the Gulf Oil Spill. *Journal of Risk Analysis and Crisis Response* 5 (1), p. 2-15.

*Key Words:* transportation, news, social media, risk, toxic spills

For further information about this project and other research reports, please contact: Dr. John Usher [www.ncitec.msstate.edu/](http://www.ncitec.msstate.edu/) Dr. Waheed Uddin, Director CAIT, Department of Civil Engineering, University of Mississippi, MS 38677-1848, USA <http://www.olemiss.edu/projects/cait/> Tel 1-662-915-5363 [cvuddin@olemiss.edu](mailto:cvuddin@olemiss.edu) [cvuddin@gmail.com](mailto:cvuddin@gmail.com)



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## University of Mississippi Research Project 2013-31

### Harvesting Vibrational Energy Due to Intermodal Transport Systems via Nano Coated Piezo Electric Devices

**PI:** Dr. Tyrus A. McCarty      University of Mississippi (UM), Mechanical Engineering

**Co-PI:** Dr. Jagdish P. Sharma      University of Mississippi (UM), Mechanical Engineering

**Collaboration With:** Dinesh Palikhel      University of Mississippi (UM), Mechanical Engineering

**Project Period:** May 15, 2013 – December 31, 2015

#### Background

Lead (Pb) Zirconium Titanate (PZT) is a piezoceramic material with proficient piezoelectric effect and it is one of the most widely researched piezoelectric materials in the area of vibrational energy harvesting. There is a great opportunity to tap into an existing source of energy being lost to the environment in the form of vibrations. These vibrations result from intermodal transport systems such as passenger cars and freight trucks moving on streets and highways, trains moving on railway tracks, and planes moving on airport runways. Energy harvesting systems consisting of PZT as the primary energy harvesting component can be incorporated into the intermodal transport systems to recover vibrational energy. Recovering energy from these lost vibrations will have considerable economic impact when used for street and highway lighting in high traffic areas for safety concerns. The broader impacts of this research include reducing the load demands on the existing power grid. Other benefits of this system could involve enhancing traffic weigh-in-motion sensing, and monitoring of pavement conditions of roads and structural response of bridges for timely maintenance.

#### Objective

The primary objectives of this project are to:

- Design and construction of the special nano-coated piezo electric energy harvester.
- Test and enhance the newly designed and constructed system in the lab.
- Implement the energy harvesting system to power a lighting system.

The scope of this project is limited to laboratory experimentation.

The objectives of the project was achieved by performing three tasks; design and construction of the special nano-coated piezo electric energy harvester, testing and enhancement of the newly designed and constructed system in the lab and implementation of the energy harvesting system to power a lighting system. Nano-coated PZT energy harvesting system showed substantial and explicit improvement as compared to non-coated PZT energy harvesting system.

#### Synopsis

Vibrational energy resulting from intermodal transport systems can be recovered through the use of energy harvesting system consisting of PZT piezo electric material as the primary energy harvesting component. The ability of traditional PZT piezo electric materials can be enhanced to generate substantially more power by using special coatings made of nano-coating mixtures. The project highlights are summarized, as follows:

- It was demonstrated that the enhanced system can be utilized to power intermodal transport safety lighting systems from roadway vibrations.
- To incorporate this power harvesting system for the application to power LED bulbs, more number of PZTs was integrated into the system.
- The new multi nano-coated PZT composite cantilever system with six PZT composites was designed and constructed. Figure 1 shows a diagram of this

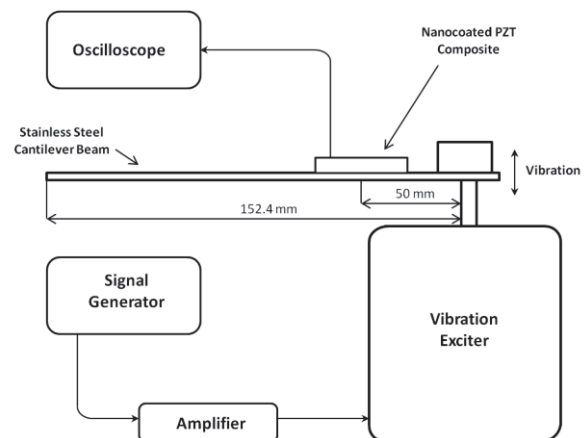


Figure 1. Schematic of Experimental Laboratory Setup



experimental cantilever system. The schematic of the nano-coated PZT Composite and laboratory experiment set up is shown in Figure 2.

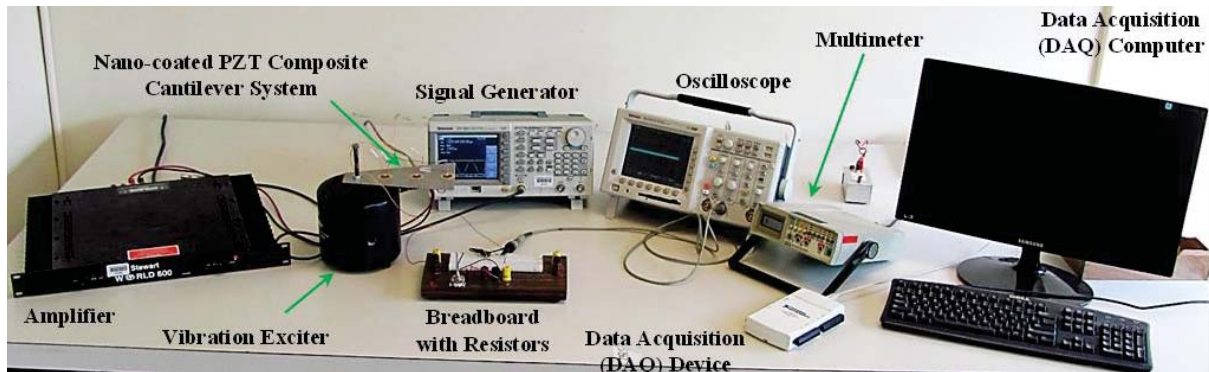


Figure 2. Experimental Laboratory Setup

## Key Results

Key outcomes and other achievements follow:

- The conventional non-coated PZT composite was enhanced in terms of power harvesting capability by coating it with special nanoparticle mixture. This special nanoparticle mixture consisted of 40 % ZnO, 58 % ferrofluid and 2 % epoxy binder.
- Theoretical consideration and associated field studies improved understanding of transportation professionals for tire/pavement interaction during braking and crash incidents. Guidelines are recommended for implementation to improve road safety.
- Rectangular system demonstrated to be more proficient selection as compared to trapezoidal and triangular systems in terms of power harvesting capability.
- The circuit designed and constructed to charge the battery consisted of full wave rectifiers, capacitors and a 240 mAh/3.6 volts NiMH battery. The completely discharged battery was charged with the help of the energy harvested from the multi nano-coated PZT composite cantilever system for 120 minutes. Battery charging process couldn't be achieved beyond this time frame because of breakage of soldering between wire and PZT substrate. This is due to the higher current flow in the energy harvesting circuit at the optimum power output condition than the capacity of the PZT substrate. This power output charged totally discharged 3.6 Volts NiMH Battery to 3.054 Volts in two hours. The charged battery was examined if it could light a LED bulb. It was found that the charged battery had sufficient power to light the LED bulb.

**Implementation Statement:** Alternatives to the main piezo electric nano component, ZnO, of the nano-coating mixture of this study, having better piezo electric characteristic in terms of power output should be investigated. Additionally, different base piezo electric materials, other than PZT, should be explored. These two recommendations could lead to sufficient increase in the power output which could immensely impact the economic feasibility of vibrational energy harvesting from traffic on highways and rail lines.

**Students Supported on Project:** 1 PhD, 1 M.S.

**Graduate M.S. Report/Thesis and PhD Dissertation:** None

## Published Papers and Presentations

- McCarty, T. and J. Sharma. "Harvesting Vibrational Energy due to Intermodal Transport Systems Via Nano Coated Piezo Electric Devices." *2015 University Conference for the SE Region*, Birmingham, Alabama, March 26-27, 2015.
- Uddin, W., S. Cobb, T. McCarty, and J. Sharma. "Environmental and Energy Concerns for Life Cycle Analysis of Transportation Systems." ASCE Publication, *International Symposium on Systematic Approaches to Environmental Sustainability in Transportation*, Fairbanks, Alaska, August 2-5, 2015. (Peer Reviewed ASCE Special Publication).
- Sharma, J. Invited keynote speaker. *International Conference on Agile Manufacturing*, Sultanpur, UP, India, December 27-28, 2015.

*Key Words:* energy, highway, piezoelectric, nano-coated, rail, traffic, transportation, vibration

For further information about this project and other research reports, please contact: Dr. John Usher [www.ncitec.msstate.edu/](http://www.ncitec.msstate.edu/) Dr. Waheed Uddin, Director CAIT, Department of Civil Engineering, University of Mississippi, MS 38677-1848, USA <http://www.olemiss.edu/projects/cait/> Tel 1-662-915-5363 [cvuddin@olemiss.edu](mailto:cvuddin@olemiss.edu) [cvuddin@gmail.com](mailto:cvuddin@gmail.com)



Mississippi State University  
University of Mississippi  
University of Denver  
Louisiana State University  
Hampton University  
2012 - 2016



## University of Mississippi Research Project 2013-32

### Intermodal Optimization for Economically Viable Integration of Surface and Waterborne Freight Transport

**PI:** Dr. Waheed Uddin University of Mississippi (UM), Civil Engineering / CAIT

Collaboration With: Dr. Patrick Sherry, University of Denver (DU)

Dr. Burak Eksioglu, Clemson University (Clemson)/MSU

Dr. Kenneth.N.Mitchell, US Army ERDC Hydraulics Laboratory, Vicksburg, MS

Mr. Karl Y. Metrow, Maritime Information Systems Inc., Warren, RI

**Project Period:** January 1, 2014 – May 31, 2016

#### Background

In order to improve the economic competitiveness, safety, security and disaster resilience of freight transport and the supply chain, owners, operators, and users of all transportation modes need to understand the importance of operational integration of these modes. These goals include:

- The enhancement of freight mobility for economically competitive markets using intermodal integration and seamless connectivity among surface transport, inland waterways, and marine ports
- The development of geospatial visualization maps of selected ports, freight corridors, commodity flow

#### Objective

The primary objectives of this project are to:

- Identify major freight transportation corridors involving shipping ports, highway network, and rail infrastructure assets.
- Model transport demand, visualize routing scenarios, and optimize integrated intermodal routes.
- Evaluate the economic competitiveness of highway-rail-waterway intermodal integration case studies.

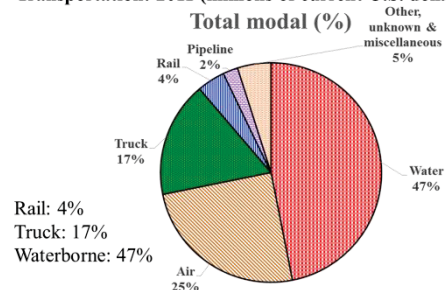
The project objectives are accomplished by using airborne and spaceborne remote sensing and geospatial technologies for mapping and visualization of freight corridors, major ports on the Mississippi River, and selected sea ports/harbors.

#### Synopsis

This project used geospatial mapping to analyze the modes of intermodal integration available along the Mississippi River waterway and analyzed navigation channels or cargo flow through selected ports. Key features of the study include:

- U.S. international trade data were analyzed transportation mode (Figure 1).
- The development of geospatial maps of the Mississippi waterway, inland ports, sea ports, and interconnecting surface transportation network, synthesis of surface and waterborne databases and commodity flow, optimization models, benefit/cost results of proposed modal integration studies, and life cycle economic evaluation and environmental impacts.
- Studies were conducted to calculate travel time and Carbon Dioxide (CO<sub>2</sub>) emissions of Mississippi River barge (Figure 2) traffic integration with highway freight truck traffic.
- Average size of container ship via the Suez Canal is 8,000 TEUs and 5,000 TEUs through the traditional locks of Panama Canal. New Post Panama container ships (Panamex) are estimated to carry 12,000 TEUs through the Panama Canal expansion, which was completed on 23 June 2016.

**Value of U.S International Merchandise Trade by Mode of Transportation: 2011 (millions of current U.S. dollars)**



**Total Merchandise Trade : 3,687,622 million Dollars**

**Figure 1. U.S. International Trade by Transportation Mode, 2011**

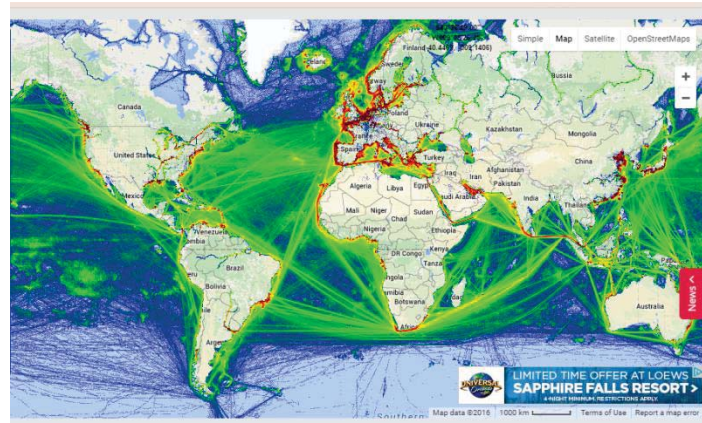
- Global shipping demand and impacts on CO<sub>2</sub> emissions were calculated using publicly available Automated Information System (AIS) data sources (Figure 3) for cargo container ships traveling through global navigation channels including ships from Rotterdam to Port of New York.

The research contributes to:

- Provide the economic benefits of intermodal integration approach for enhancing the efficiency of freight transport and supply chain.
- Assess the societal benefits of freight intermodal corridor including reduction in CO<sub>2</sub> emissions and natural disaster resilience studies.



Figure 2. Spatial Map of Mississippi River Ports



<http://www.marinetraffic.com/en/ais/home/centerx:-51/centery:14/zoom:2>

Figure 3 . Worldwide spatial distribution of cargo ships through major shipping routes based on AIS data portal (screen capture from Marine Traffic web view)

## Key Results

Key outcomes or other achievements follow:

- This project developed geospatial maps of freight corridors (highways, Mississippi River, and freight rail). The commodity data was analyzed for each state and commodity flow data was determined at all Mississippi River ports.
- Geospatial maps of the Mississippi and Ohio Rivers were created along with the 26 adjoining Middle American states. A geospatial map showing the river freight intermodal integration study (Figure 2).
- Spatial maps were produced for cargo shipping channels worldwide using AIS data sources (Figure 3) and CO<sub>2</sub> emissions were calculated. Impacts of extended Panama Canal of U.S. ports and Mississippi trade were evaluated.
- Computer simulations of selected port(s) and freight corridor(s) with economic and sustainability analysis are used to show the importance of the intermodal integration approach for enhancing the economic competitiveness, safety, security, and disaster resilience of ports and intermodal freight transport.
- The intermodal freight corridor case studies recommended as “best practice guide” examples for consideration by government transportation agencies, private transport operators, and other global supply chain stakeholders.

**Implementation Statement:** It is recommended that the developed approach of freight corridor studies be applied by transportation agencies to assess other societal benefits, which include reduction of wastage of hours of travel time by reducing traffic congestion, cost avoidance of fuel wastage on congested highway corridors, and decrease in transportation related emissions of carbon dioxide and other harmful pollutants.

**Students Supported on Project:** 3 PhD, 2 M.S., 7 UG

**Graduate M.S. Report/Thesis and PhD Dissertation:** 1 M.S.

Cobb, Seth. (2015). Economic Viability and Societal Benefits of Integrated Multimodal Freight Corridors and Sustainable Passenger Transportation.” M.S. Thesis, University of Mississippi, August 2015. (Advisor: Dr. W. Uddin)

## Published Papers and Presentations

Uddin, W., Cobb, S., Sherry, P. and Eksioglu, B. (2015). Economically Viable Intermodal Integration of Surface and Waterway Freight Transport for Sustainable Supply Chain. *University Transportation Center (UTC) Conference for the Southeastern Region*, University of Alabama at Birmingham, March 26-27, 2015, Birmingham, Alabama.

**Key Words:** freight, intermodal, ports, shipping, transportation, waterborne

For further information about this project and other research reports, please contact: Dr. John Usher [www.ncitec.msstate.edu/](http://www.ncitec.msstate.edu/)  
Dr. Waheed Uddin, Director CAIT, Department of Civil Engineering, University of Mississippi, MS 38677-1848, USA  
<http://www.olemiss.edu/projects/cait/> Tel 1-662-915-5363 [cvuddin@olemiss.edu](mailto:cvuddin@olemiss.edu) [cvuddin@gmail.com](mailto:cvuddin@gmail.com)





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## University of Mississippi Research Project 2013-33

### Restoration of Gulf Coast Passenger Rail Service for Sustainable and Economically Efficient Intermodal Corridor Integration

**PI:** Dr. Waheed Uddin University of Mississippi (UM) / CAIT

Collaboration With: Dr. Patrick Sherry, University of Denver (DU)  
Dr. Burak Eksioglu, Clemson University (Clemson)

**Project Period:** July 1, 2013 – December 31, 2015

#### Background

The Amtrak sunset service from Miami to Los Angeles through New Orleans served the Mississippi Gulf Coast triweekly during nighttime hours. The Amtrak sunset service was first interrupted in 1993 after the worst rail disaster in Amtrak history. The Amtrak passenger rail service was suspended during the 2005 Hurricane Katrina disaster due to destruction of the rail infrastructure. Currently, Amtrak coastal rail is not operational through Alabama and Mississippi, therefore taking away a valuable public transportation mode for the underserved and/or vacationers to casinos and beaches. The integration of passenger/commuter rail with the auto traffic in major Mississippi Gulf Coast highway and rail corridors can ease auto travel demand on the existing road corridors, offers economically competitive and safer travel, and reduces air pollution.

#### Objective

The primary objective of this project is:

- To conduct technical and economic competitiveness evaluations of selected passenger rail/commuter intercity rail service alternative plans.

The scope of this study is limited to the Mississippi Gulf Coast. However, the results can be extended to the entire Gulf Coast using the historical demographic and economic data of the region, as well as to other rural and urban communities.

#### Synopsis

- This project developed geospatial maps, cost optimization models, life cycle benefit/cost results of simulation studies involving proposed passenger/commuter rail integration with selected highway corridors on the Mississippi Gulf coast.
- Extensive travel data synthesis and a utility function was used to estimate the number of auto commuters who will be willing to divert to alternative transit modes.
- Life Cycle Analysis (LCA) of costs and benefits was used for value engineering studies to show the importance of the intermodal integration approach for enhancing the economic competitiveness, safety, and congestion and emission reduction of passenger transport. Both technical merits and economic evaluation are imperative to select the most economically efficient and safe rail service alternative as a part of the value engineering study.
- The multimodal passenger corridor case studies are used to develop a white paper that can serve as a “best practice guide” for consideration by government transportation agencies, private transport operators, cities, rail transit rail agencies, and other bus transit and rail stakeholders.
- The developed approach is able to assess other societal benefits, which include elimination of wastage of millions of travel time hours by reducing traffic congestion, cost avoidance of billions of gallons of fuel wastage on congested highway corridors, and decrease in transportation related emissions of carbon dioxide (CO<sub>2</sub>) and other harmful pollutants.
- This approach of economic evaluation is valid for enhancement/revival of other passenger rail lines, such as Southwest Chief corridor. The project enhanced intermodal transportation education by supporting graduate and UG students.

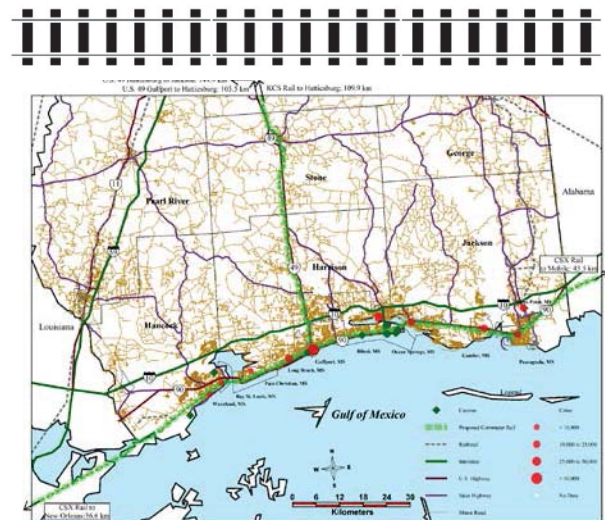


Figure 1. Spatial map of the proposed and “Casino train” E-W and “Beach Train” N-S commuter rail lines on the Mississippi Gulf coast



## Key Results

Key outcomes and other significant achievements follow:

- The project created spatial maps of the existing transportation infrastructure on the Gulf Coast, the proposed “*Casino Train*” in E-W corridor of the existing CSX rail from New Orleans to Mobile and “*Beach Train*” in N-S corridor of the existing KCS rail from Hattiesburg to Gulfport, and a monorail corridor to serve the casino patrons and employees (Figure 1).
- The project student staff also collected most rail cost data and Mississippi gaming and sales tax revenue data for the Gulf Coast counties for a comprehensive life cycle benefit and cost analysis of the proposed rail alternatives using value engineering approach.
- The LCA approach of economic impact analysis is based on life cycle assessment of the rail infrastructure capital and maintenance costs using existing freight rail lines and benefit streams (Figure 2). It is expected that the passenger rail capital investment can be recovered within 6-8 years with almost all annual operating costs coming from passenger fare and other direct revenues.
- The BRT alternative takes 50 years to breakeven considering only direct revenue. It also takes space on existing highways and will lead to congestion and unsafe driving conditions for other motorists. The Monorail will need more than 50 years to breakeven based on direct revenues only because it needs high-cost infrastructure. Both Monorail and Light Rail Transit (LRT) alternatives have been dropped from final recommendation due to very high capital costs that makes them breakeven long after 50 years.
- From an environmental standpoint, less fossil-fuel vehicles on the roads would mean a decrease in harmful air pollutants and CO<sub>2</sub> emissions. It is estimated that 0.86 million metric tons). As a result, the application of commuter rail will decrease the CO<sub>2</sub> emissions by 35 to 68 % (0.44 million metric tons for diesel trains and 0.88 million metric tons for electric train) in Mississippi Gulf Coast counties depending upon the rail power technology.

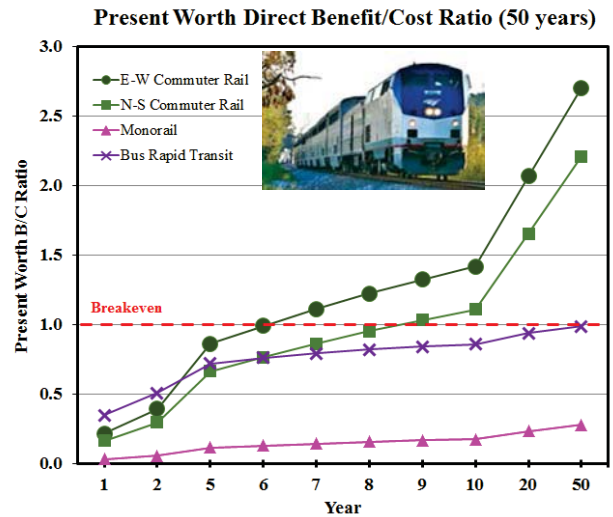


Figure 2. Value Engineering analysis of direct benefit/cost ratio favors commuter rail lines on the Mississippi Gulf coast

**Implementation Statement:** The project viability is evident from the key results of the economic impact study where the commuter rail lines can operate on profit within two years of full operation. Additional benefits include providing safe driving alternatives of “*Casino Train*” to casino patrons on the Mississippi Gulf Coast which accounted for 14.8 million patrons in 2012 and 52% of all gaming associated revenue in Mississippi. The recommended “*Casino Train*” in E-W corridor rail will enhance highway safety by reducing number of automobiles and save lives considering the reduction in alcohol related driving accidents since the rejuvenation of the coast nightlife and casino business. The support of all the cities, public, and employers in the corridor will be essential. There is a strong desire for the restoration of the passenger rail service to show the return on massive rail infrastructure investment, which is important to secure federal and non-federal funding. It is recommended that Mayors association and businesses on the Gulf Coast, transportation infrastructure agencies, passenger rail service, and freight rail stakeholders consider the research products developed in this project and benefits outlined to address the mobility needs, funding deficit and reduction in anthropogenic carbon emissions. The integrated intermodal highway-rail infrastructure networks can be managed as a PPP enterprise.

**Students Supported on Project:** 3 PhD, 2 M.S., 7 UG

**Graduate M.S. Report/Thesis and PhD Dissertation:** 2 M.S. degrees completed

Ahlan, Muhammad. (2014). Geospatial Applications for Mobility, Travel Demand, Transport Infrastructure, and Associated Impacts on the Environment. M.S. Graduate Report, University of Mississippi, Dec 2014. (Advisor: Dr. W. Uddin)  
Cobb, Seth. (2015). Economic Viability and Societal Benefits of Integrated Multimodal Freight Corridors and Sustainable Passenger Transportation. M.S. Thesis, University of Mississippi, August 2015. (Advisor: Dr. W. Uddin)

## Published Papers and Presentations

W. Uddin and T. McCarty. Environmental Sustainability and Energy Considerations for Life-Cycle Analysis of Transportation Infrastructure Systems. Presented at the *International Symposium on Systematic Approaches to Environmental Sustainability in Transportation (ISSAEST)*, University of Alaska Fairbanks, August 2-5, 2015, Fairbanks, Alaska. (Peer reviewed, ASCE Special Publication)

**Key Words:** Gulf Coast, commuter, economic analysis, emissions, highway, infrastructure, rail, transportation

For further information about this project and other research reports, please contact: Dr. John Usher [www.ncitec.msstate.edu/](http://www.ncitec.msstate.edu/)  
Dr. Waheed Uddin, Director CAIT, Department of Civil Engineering, University of Mississippi, MS 38677-1848, USA  
<http://www.olemiss.edu/projects/cait/> Tel 1-662-915-5363 [cvuddin@olemiss.edu](mailto:cvuddin@olemiss.edu) [cvuddin@gmail.com](mailto:cvuddin@gmail.com)



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## UM Engineering Partnership Producing Problem-Solving Research

### National Center for Intermodal Transportation for Economic Competitiveness funds projects

 JUNE 30, 2016 BY EDWIN SMITH

Engineers at the University of Mississippi are at the forefront of a research collaboration that is helping solve infrastructure problems near and far.

UM scientists have partnered with Mississippi State University-led University Consortium for a National Center for Intermodal Transportation for Economic Competitiveness grant of \$6.9 million from the U.S. Department of Transportation's Research and Innovative Technology Administration. Other consortium universities include the University of Denver, Louisiana State University and Hampton University.



Waheed Uddin

"The theme of NCITEC is to promote the development of an integrated, economically competitive, efficient, safe, secure and sustainable national intermodal transportation network by integrating all transportation modes for both freight and passenger mobility," said Waheed Uddin, NCITEC associate director and UM professor of civil engineering. "Between 2012 and 2016, UM researchers conducted 13 research projects using a total grant of \$1.26 million from NCITEC."

Funded topics at UM include the global supply chain, NAFTA freight studies, highway-rail-waterway and intermodal integration, studies of highway bridge structures subject to truck traffic, scouring and floodwater impacts.

UM mechanical engineering professors Tyrus McCarty and Jagdish Sharman are the principal and co-principal investigators of the most innovative NCITEC project, "Energy Harvesting from Traffic Vibrations."

"This project used nanocoated PTZ sensors to enhance energy outputs from traffic vibrations," McCarty said. "The implications are huge, once implemented in the field in rural areas. It can provide energy to illuminate dark areas on highways, including shoulder edges and rail-highway crossings, for increasing safety of auto and rail traffic and reducing carbon dioxide emissions."

## Campus Briefs

 OCTOBER 5, 2016 BY STAFF REPORT

Jordan Samson, the University of Mississippi student who posted a racist comment on social media last month, has issued a public apology, voluntarily withdrawn from classes and given the university permission to share this information. "We as a university condemn the use of language that is threatening or racist, and we are committed to protecting

[Read the story ...](#)

## Thank You To Our Donors

 OCTOBER 22, 2016 BY HANNAH PICKETT

OXFORD, Miss. — To say that Reba McCullough Greer simply has a passion for writing is an understatement. She has devoted her career and life to changing the way students learn to write. With the establishment of the McCullough-Greer Endowment to Advance Writing as a Civic Responsibility, Greer has extended this mission to include University

Uddin and Mustafa Altinakar are co-PIs on another NCITEC project, "Extreme flood simulations and flood impacts on structural integrity of transportation infrastructure assets." Investigators of four other projects on structural assessment of bridges include civil engineering professors Elizabeth Ervin and Chris Mullen, Charles Swann of the Mississippi Mineral Resources Institute and researchers at the university's National Center for Physical Acoustics.

"Dr. Altinakar's computer flood simulations results were the backbone of new discoveries by my two Ph.D. students in civil engineering who advanced the knowledge of flood impacts on infrastructure and communities," Uddin said. "Alper Durmus computed hydrodynamic forces using Dr. Altinakar's computational flood modeling results."

Durmus developed a detailed 3-D finite element computer model of a U.S. 51 concrete bridge subjected to the lateral extreme floodwater force and discovered the vulnerability of bridge superstructure (girders and deck). Uddin's previous research showed that this failure mechanism was observed in the destruction of bridges during 2005 Hurricane Katrina on the Mississippi Gulf Coast and 2011 Hurricane Irene on the East Coast.

"Under my guidance, Alper is developing guidelines using National Bridge Inventory System database to identify such vulnerable bridges crossing over water bodies so that these can be prioritized for hardening to enhance flood resilience," Uddin said.



The U.S. 90 and U.S. 49 at the Port of Gulfport.

studies in Miami and Vietnam," Uddin said. "He further developed a methodology under my guidance to simulate extreme tsunami using 2011 Fukushima tsunami wave surge data to evaluate the extent of submerged coastal land and impacts on affected population."

Kristin Swain of the Meek School of Journalism and New Media conducted her project, "Risk framing of U.S. intermodal transportation toxic spills in news and social media." Her research shows that 161,079 toxic spills in the U.S., reported between 2003 and 2012, involving air, rail and waterways exceeded \$701 billion in cleanup and mitigation costs.

Swain's news media analysis found that 99.48 percent of the 5,555 most serious spills during transportation of hazardous materials received no news coverage.

Uddin is PI for "Intermodal integration of highway-rail and highway-waterway corridors for economically

viable supply chain." Other co-PIs from the University of Denver and Clemson University have their own NCITEC projects on this topic.



This U.S. 51 bridge is one of the study's subjects. Photo courtesy Mississippi DOT

"This project demonstrated the use of geospatial analysis to identify feasible corridors on maps generated from highway and rail map database," Uddin said. "Using mathematical optimization for minimizing shipping costs, the least cost corridors were selected for several intermodal freight integration cases, including NAFTA routes. The research showed substantial reduction in transportation related-carbon dioxide emissions."

The methodology developed in this project is timely because the current USDOT funding authorization of FAST Act recommends calculating carbon emissions as a part of transportation project planning. Uddin has partnered with two different University Transportation Center consortia that submitted new proposed projects on efficient freight mobility.

Two graduate students carried out most of the research tasks. Seth Cobb completed his master's thesis in August 2015. Doctoral student Zul Fahmi conducted comprehensive commodity research and geospatial mapping of carbon emissions on NAFTA corridors.

The white paper on another project, "Gulf Coast Rail Passenger Service Revival," is already being used as a reference in rail studies for connecting Dallas-Fort Worth with Atlanta through Mississippi.

Investigators represent the university's civil, electrical and mechanical engineering departments of the School of Engineering, National Center for Computational Hydrosience and Engineering, Mississippi Minerals Research Institute, National Center for Physical Acoustics, Meek School of Journalism and New Media, and Trent Lott Institute of Public Policy Leadership.

"The primary research accomplishments include brief fact sheets on key research results of each funded project for distribution and web access," Uddin said. "We've seen the development of transportation visualization products based on geospatial analysis and computational modeling."

Research funding has strengthened the workforce and enhanced undergraduate and graduate courses. Ten master's students and two doctoral students have completed their degrees thus far and two doctoral students will complete in 2016. One doctoral student on a CAIT/NCHE project received the 2013 NCITEC Student of the Year award.

Key project investigators presented at regional and national conferences and published papers in journals and conference proceedings. Several YouTube videos and Slide Share posts disseminate the research results of the UM projects to the transportation community and agencies in the state, region and worldwide.