

## PROGRAM PROGRESS PERFORMANCE REPORT

**Awarding Federal Agency:** US Department of Transportation, Research and Innovative Technology Administration

**Federal Grant Number:** DTRT12-G-UTC16

**Project Title:** Center for Advanced Infrastructure and Transportation (CAIT) Tier I UTC Consortium Led by Rutgers, The State University of New Jersey

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**Recipient Organization (Name and Address):** Rutgers, The State University of New Jersey, Center for Advanced Infrastructure and Transportation, 100 Brett Road, Piscataway, NJ 08854-8058

**Recipient Identifying Number or Account Number, if any:** Rutgers' account #434310

**Project/Grant Period:** January 1, 2012 through January 31, 2014

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**Report Term or Frequency:** Semiannual (7/1/12-12/31/12)

**Signature of Submitting Official:**



## 1. **ACCOMPLISHMENTS: What was done? What was learned?**

### **What are the major goals of the program?**

The major goal of the CAIT Tier I UTC Consortium is to build a program that will: 1) have a sharp focus on maintaining state of good repair of the nation's infrastructure and the interrelated activities of the Secretary of Transportation's strategic goals where the consortium can make significant impacts, and 2) foster intelligent, effective, and meaningful leveraging between institutions and stakeholders to achieve program goals and objectives.

State of Good Repair (SGR) has been identified as the consortium's **primary area of research** and Safety and Economic Competitiveness as secondary areas in which we believe our team's capabilities, resources, past experience, and track record qualify us to make significant impacts toward reaching the goals of the USDOT. To help fulfill these goals and objectives we will:

- **Sharply focus our research portfolio** to make significant and meaningful impacts during the lifetime of the grant. The UTC designation will be a catalyst for generating relevant and sustainable operations that can aid USDOT in fulfilling the objectives of its strategic plan.
- **Develop effective leveraging** with centers of critical mass and establish networks of researchers, laboratories, test-beds, proving grounds, and all other resources necessary to address the objectives of the strategic plan. Through intelligent leveraging, we will minimize potential duplication of effort and promote and encourage meaningful team work and collaboration.
- **Develop and enhance meaningful relationships with local, regional, national, and international stakeholders** to stay abreast of new problems and best practices; work together to address local challenges and needs; and partner in implementing research results and products.

The consortium will cultivate interest in the transportation industry through a comprehensive **education and workforce development program**. The education and workforce goals are to:

- Develop an educational program that will prepare current and future transportation professionals and researchers to be responsive to changes in the transportation field.
- Develop a strong multidisciplinary component that reflects changes in the organizational, intermodal, and global character of transportation, as well as the use of advanced materials and technologies relative to infrastructure.
- Develop a program that informs high school students about transportation studies and encourages undergraduates to pursue advanced transportation studies.

The consortium supports knowledge sharing and is committed to move research results into practice through its **technology transfer initiatives**. The technology transfer goals are to:

- Ensure all research proposals include feasible implementation plans.
- Provide a forum to discuss the state of practice and innovative new technologies that support State of Good Repair, through conferences and symposiums.
- Continuously post reports and research findings in multiple online repositories and clearinghouses, such as the USDOT Research Clusters and CAIT website.

**What was accomplished under these goals?**

<b>Major Goal Area</b>	<b>Major Activities</b>	<b>Specific Objectives</b>	<b>Significant Results</b>	<b>Key Outcomes</b>
<b>Research</b>	Research Selection	Select projects that make significant and meaningful impacts during the lifetime of the grant.	Several new projects have cleared the pre-proposal stage and are now being developed by the PI's for full submission and review.	The Research Advisory Board has already reviewed and approved <b>eight new research projects</b>
<b>Education and Workforce Development</b>	National Summer Transportation Institute-Next Generation Engineers (NextGen) (Summer 2012)	Generate knowledge and skills to foster a world class workforce for the transportation sector.	CAIT worked with the Office of Student Development at Rutgers's School of Engineering to promote and support engineering education activities and research skill development for under-represented students, as well as to promote careers in transportation industries.	Middle and high school students (56) learned about the transportation industry and its various modes and how they might pursue post-secondary education concentrating on some aspect of transportation.
	Intersection Safety Webinar (July 25, 2012)	Generate knowledge and skills to foster a world class workforce for the transportation sector.	FHWA Resource Center safety and design engineer John McFadden, Ph.D., P.E., P.T.O.E. discussed intersection-related roadway management.	Attendees gained federal perspectives on intersection safety issues as McFadden defined and explored effective crash reduction options for engineers and planners who want to use federally-approved crash reduction applications to improve intersection safety.
	The 14 <sup>th</sup> Annual NJDOT Research Showcase (October 18, 2012)	Generate knowledge and skills to foster a world class workforce for the transportation sector.	The showcase provided an opportunity for NJDOT customers to experience the broad scope of ongoing research initiatives, technology transfer activities and	Over 200 researchers and NJDOT stakeholders gathered for a full-day demonstration of statewide transportation research efforts.

			academic research conducted by university research partners and their associates. Keynote speaker: Bernie Arseneau, deputy commissioner and chief engineer of the Minnesota DOT, who outlined case studies where research findings could be applied to transportation improvement projects.	
	NJ Safety Forum	Generate knowledge and skills to foster a world class workforce for the transportation sector.	The Transportation Safety Resource Center (TSRC) hosted its Annual New Jersey. This year's focus was intersection and pedestrian safety, covering topics such as statewide educational initiatives, low-cost engineering improvements and demystifying the red light running automated enforcement pilot program.	Ernie Blais, administrator of the FHWA-NJ Division, gave an overview of safety aspects contained in MAP-21, stressing infrastructure investments for sustainable and safe communities to an audience of 190 educators, engineers, emergency responders and enforcement professionals.
	New Graduate Programs	Generate knowledge and skills to foster a world class workforce for the transportation sector.	CAIT will be engaging in the creation of a new pavement graduate education program.	Dr. Carrasco and Nazarian from UTEP developed a new course entitled Dynamic Loads on Infrastructure where the structural dynamics and dynamics of soil structure interaction were combined into one course. Seven MS and PhD students attended that class.
	New Jersey Roundtable of the	Generate knowledge and skills	A career workshop for supply chain	Attendees received career advice from

	Council of Supply Chain Management Professionals (CSCMPNJ) (December 13, 2012)	to foster a world class workforce for the transportation sector.	professionals in transition and graduating supply chain and freight students was held at CAIT. This event was led by Tom Bacola, Sector Expert-Transportation, Distribution & Logistics for Raritan Community College.	representatives from several leading supply chain companies.
	Student of the Year	Generate knowledge and skills to foster a world class workforce for the transportation sector.	Selection of Student of the Year	Christopher Mazzotta has been selected SOY. Mazzotta is currently a master's student in civil and environmental engineering and will pursue his Ph.D. next. His primary focus is structural engineering, though he also has a keen interest in geotechnical engineering and water systems.
	Fellowships and Internships Program	Generate knowledge and skills to foster a world class workforce for the transportation sector.	UTC fellowships and internships were granted.	<ul style="list-style-type: none"> <li>• The Dean of Graduate School at UTEP has dedicated an NSF fellowship to Mr. Daniel Rodriguez as part of the UTC.</li> <li>• USU worked with UDOT to start a UTC sponsored intern program. Kailey Jackson was selected as the UTC/UDOT Intern and worked in Region 1.</li> </ul>
<b>Technology Transfer</b>	Meet with LTAP Directors (August 2012)	Create workforce training opportunities for local government.	The CAIT UTC Local Technical Assistance Programs (Delaware, New Jersey, Utah, Virginia) met at the summer National	Ideas for collaboration and instructor-sharing across programs.

			Local Technical Assistance Program conference as part of their ongoing discussion about technology transfer opportunities for their local government constituents.	
	Coordination and Logistics for the State of Good Repair Summit	Support research products that can make significant and meaningful impacts during the lifetime of the grant	CAIT convened a planning committee of its consortium partners to plan and determine the featured speakers for the conference. The consortium looked to leverage its regional prominence to attract both significant players and major participants.	All logistics for hosting the event to take place in March 2013 were handled; including location reservations, advertising, promotion, and speaker recruitment efforts.
	Robot Demo	Support research products that can make significant and meaningful impacts during the lifetime of the grant	CAIT and FHWA have developed a robotic system for condition assessment of concrete bridge decks. This robot automates data collection using multiple NDE technologies.	Application for a joint Rutgers-FHWA patent is in process. This technology is easily portable to state DOTs and offers a means of sophisticated, consistent information that can be collected without needing a large field team to perform individual tests.
	Supporting FHWA's Every Day Counts 2	Support research products that can make significant and meaningful impacts during the lifetime of the grant	In supporting FHWA's Every Day Counts 2 and stewardship of the federal aid program, CAIT has developed Local Public Agency Training as part of a qualification program.	Topics such as Federal Aid Requirements, GRS-IBS, Adaptive Signal Control, and innovative contracting have reached hundreds of federal grantees.
	LiDAR Scan – Post Superstorm Sandy Recovery Effort	Support research products that can make significant and meaningful impacts	Immediately following one of the worst natural disasters in U.S.	The high-resolution 3-D output will help municipalities, FEMA, and others

		during the lifetime of the grant	history the center encouraged one of its newest junior faculty members, Dr. Jie Gong, to deploy LiDAR technology to scan storm-ravaged neighborhoods, including Seaside Heights and Mantoloking, NJ and areas of Staten Island and Queens, NY.	develop better response strategies and prepare critical infrastructure to withstand the effects of disaster events.
<b>Management and Collaboration Activities</b>	Partner Meeting (September 25, 2012)	Foster research collaboration among consortium partners.	Heads of each consortium institution and some of their researchers gathered at CAIT for an intensive full-day session to share information, present research results and identify research topics.	Research topic areas were defined for several collaborative projects to be conducted in 2013.

**What opportunities for training and professional development has the program provided?**

This information has been integrated into the table above for the “what was accomplished under these goals?” section. Please see table above.

**How have the results been disseminated?**

This information has been integrated into the table above for the “what was accomplished under these goals?” section. Please see table above.

**What do you plan to do during the next reporting period to accomplish the goals?**

- **MANAGEMENT AND COLLABORATION ACTIVITIES:**
  - **Assist in Post Superstorm Sandy recovery efforts:** The majority of catastrophic damage occurred within 50 miles of Rutgers, putting university researchers in a unique position to study the disastrous effects of major storms.
- **RESEARCH ACTIVITIES:**
  - **Ongoing Review of Research projects by the Research Advisory Board:** As previously described.
  - **Modify Agreements to Approve expenditure of Research Funds:** No research activities can start until the projects have been reviewed and approved as outlined in the prime proposal submitted to RITA. CAIT has and will continue to issue modifications to the master agreements with each partner as research projects are approved.
  - **Ongoing Research:** Each of the consortium members will continue to perform SGR oriented research.
- **EDUCATION AND WORKFORCE DEVELOPMENT ACTIVITIES:**

- **Schedule with the Partner Schools the Spring “Traveling Distinguished Lecture Series”:** This will include scheduling facilities at each school and coordinating the logistics of broadcasting the webinar at each location. A promotional poster will be developed and broadly distributed within the consortium.
  - **WTS Annual Meeting:** Partnering with the Women’s Transportation Seminar (WTS), which promotes and supports female participation in the transportation field, the Consortium will hold an annual competition for students to attend the WTS Conference. Each consortium member plans to send at least one female student to attend the conference. Students who show potential for making significant contributions in the transportation field will be selected based on their academic/extracurricular merit.
  - **Transit Virtual Career Network:** The Consortium was recently awarded the Transit Virtual Career Network. Funded by FTA, this project’s main objective is to develop a dynamic online resource that helps public transportation operators to recruit a wide range of workers—including veterans, women, and minorities. The network will provide unprecedented access to new recruitment and training tools such as labor market conditions, training available nearby, and identifying jobs or advancement opportunities in their region or across the country.
  - **K-12 Programs:** The Consortium is engaged in many K-12 programs. An example includes the Governor’s School, a month long intensive summer program that targets top math and science high-school students. The Consortium offers a course on “Engineering the Nation’s Infrastructure” focused on pavement engineering and construction issues with the intent of encouraging them to pursue careers in transportation.
- **TECHNOLOGY TRANSFER ACTIVITIES:**
- SGR summit -- For the end of March, we will host and administer the first ever State of Good Repair Summit where some of the nation and region's premiere experts will address over 100 infrastructure experts on the needs and methods for maintaining a State of Good Repair on our roadways, bridges, rails, and ports.
  - Support RITA Spotlight -- To support the valuable RITA Spotlight newsletter, CAIT is preparing a timely and informative piece on the reconstruction efforts of the post Sandy ravaged New Jersey coastline through the efforts of one our aggressive young faculty members who will be using mobile LiDAR.

## 2. **PRODUCTS: What has the program produced?**

### **Research projects awarded**

The Research Advisory Board has reviewed and approved eight new research projects:

- “Quantitative Acoustic Emission Monitoring of Fatigue Cracks in Fracture Critical Steel Bridges” (University of Delaware)
- “Better State-of-Good-Repair Indicators for the Transportation Performance Index” (University of Delaware)
- “Multi-Resolution Information Mining and a Computer Vision Approach to Pavement Condition Distresses” (University of Delaware)
- “Mathematical Modeling and Experimental Responses of Polymer Modified Asphalt” (University of Delaware)
- “Fiber optic monitoring methods for composite steel-concrete structures based on determination of neutral axis and deformed shape” (Princeton University)
- “Life Cycle Assessment of Asphalt Pavement Maintenance” (Rutgers University)
- “Railroad Operations Research and Training” (Rutgers University)



- “Combining Model Based and Data Based Techniques in a Robust Bridge Health Monitoring Algorithm” (Columbia University)

**Publications, conference papers, and presentations**

**Journal publications.**

“Nothing to Report”

**Books or other non-periodical, one-time publications.**

“Nothing to Report”

**Other publications, conference papers and presentations.**

- A paper on the sign retroreflectivity project has been submitted to the TRB Conference in January of 2013.
- A paper has been submitted to the ASCE Journal of Bridge Engineering for the ABC Deck Project.
- “Why Ground Tire Rubber?” Workshop #100 Transportation Research Board
- “Systemic Safety Programs in Practice: Identifying Risk Factors & Prioritization – Salem County New Jersey” Workshop #113 Transportation Research Board
- “Field Validation of Materials and Concepts” Workshop #154 Transportation Research Board
- “Automation of Multiple Nondestructive Evaluation Technologies for Assessment and Condition Rating of Concrete Bridge Decks” Workshop #167 Transportation Research Board
- “Evaluation of Gate Strategies at Marine Container Terminals” Session #217 Transportation Research Board
- “Correlation of Non-Destructive Testing Results to Improve Assessment of Corrosion and Corrosion Damage of a Reinforced Concrete Deck” Corrosion Committee Transportation Research Board
- “Development of Estimating Tool for Transportation Project Design” Session #248 Transportation Research Board
- “Analysis of Impacts of Specimen Type on Dynamic Modulus and Predicted Pavement Performance” Session #239 Transportation Research Board
- “Nondestructive Evaluation-Based Assessment of Deterioration Progression in Concrete Bridge Decks” Session #269 Transportation Research Board
- “Nanoscale Evaluation of Effect of RAP on Virgin Asphalt Binder Properties” Session #307 Transportation Research Board
- “Safety Risk Analysis of Maritime Transportation: A Review” Session #307 Transportation Research Board
- “Analytical Model for Vehicle Emissions at Signalized Intersection: Integrating Traffic and Microscopic Emissions Models” Session #557 Transportation Research Board
- “Forensic Study on Cracking Distress of New Jersey’s LTPP SPS-5 Sections: 30% RAP Versus Virgin Hot-Mix Asphalt” Session #656 Transportation Research Board” Session #656 Transportation Research Board
- “Three-Dimensional Finite Element Modeling of Instrumented Airport Runway Pavement Responses” Session #737 Transportation Research Board
- “Green Asphalt Paving Technologies” Session #743 Transportation Research Board

- “Development of Transportation Skill Assessment Tool for Individuals on the Autism Spectrum to Aid in Finding Safe and Accessible Paratransit Services”  
Session #767 Transportation Research Board

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

CAIT has established two internet sites:

- <http://cait.rutgers.edu/cait/research> to disseminate research results
- <http://cait.rutgers.edu/cait/program-sites> to inform about consortium program activities

#### **Technologies or techniques**

- The FHWA Expert Task Group (ETG) on Superpave Mixtures and Aggregates Technology recently appointed PRP Director Dr. Thomas Bennert to advise on hot mix asphalt technologies. ETG appointments are an honorable and very exclusive distinction within the pavement industry— only five state engineers, five private sector highway representatives, and two academic researchers from around the nation serve on the committee at any given time.
- On September 19, 2012, CAIT Director Ali Maher was honored to speak to a national audience of researchers and federal officials as part of the ongoing USDOT-RITA Transportation Innovation Series, a monthly event that is webcast to transportation professionals across the country. Maher presented an update on progress of the FHWA Long-Term Bridge Performance (LTBP) Program.
- On August 15, 2012, the Institute of Transportation Engineers (ITE) awarded Rutgers’ CAIT with three outstanding achievement awards at the ITE 2012 Annual Meeting in Atlanta:
  - Edmund R. Ricker Transportation Safety Award for the Transportation Safety Resource Center
  - ITE Transportation Education Council 2012 Innovation in Education Award for CAIT’s K–12 educational programs
  - ITE Transportation Achievement Award for Safety for Plan4Safety crash data analysis tool

#### **Inventions, patent applications, and/or licenses**

“Nothing to Report”

#### **Other products: outreach activities, courses and workshops**

- University of Delaware hosted one of the CAIT Traveling Lecture Series: "Nondestructive Evaluation using Air-coupled Impact-Echo Scanning for Bridge Decks." John Popovics, Ph.D., presented an effective nondestructive evaluation (NDE) approach to assess large areas of concrete bridge decks using a contactless acoustic impact-echo (IE) scanning system.
- Consortium partner Utah State University hosted a seminar featuring Utah DOT program manager Blaine Leonard. The presentation focused on the high costs of repairing largely ignored infrastructure issues. Leonard explored case scenarios that support SGR initiatives, quality of life, and economic vitality
- During this reporting period, Dr. Ali Maher, CAIT director, and Dr. Sue McNeil, professor at the Department of Civil and Environmental Engineering of the University of Delaware and project director for the CAIT Tier I Consortium led by Rutgers, were honored to speak to a national audience of researchers and federal officials as part of the ongoing UDOT-RITA Transportation Innovation Series, a monthly event that is webcast to transportation professionals across the country. Dr. Maher presented an update on progress of the FHWA Long-Term Bridge Performance (LTBP) Program. Dr. McNeil’s

presentation “Why Measure Transportation Infrastructure Performance” focused on the relationship between transportation infrastructure and economic competitiveness and quality of life.

- UTEP has integrated the lectures delivered so far in its Graduate Seminar Class. We are currently in the process of inviting an eminent scholar to provide such a webinar in February/March 2013 time frame.
- In the Fall 2012 semester, UDEL continued to offer CIEG 650 Urban Transportation Systems to provide an advance introduction to Transportation to engineers and non-engineers including both seniors and graduate students.
- UDEL also continued our outreach program introducing transportation to elementary school students through dance.

### **3. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS:**

#### **What individuals have worked on the program?**

**Program Director:** Dr. Ali Maher

**Project Directors:** Dr. Sue McNeil (University of Delaware), Dr. Paul J. Barr (Utah State University), Dr. Raimondo Betti (Columbia University), Dr. Lazar N. Spasovic (NJIT), Dr. Branko Glisic (Princeton University), Dr. Soheil Nazarian (University of Texas at El Paso), Dr. Steven B. Chase (University of Virginia), Dr. Carin Roberts-Wollmann (Virginia Polytechnic Institute)

#### **Consortium Universities Involved:**

**Rutgers, The State University of New Jersey (Lead)**

**University of Delaware, Newark, DE**

**Utah State University, Logan, UT**

**Columbia University, New York, NY**

**New Jersey Institute of Technology, Newark, NJ**

**Princeton University, Princeton, NJ**

**University of Texas, El Paso, TX**

**University of Virginia, Charlottesville, VA**

**Virginia Polytechnic Institute, Blacksburg, VA**

#### **What other organizations have been involved as partners?**

<b>Organization Name</b>	<b>Location of Organization</b>	<b>Partner’s contribution to the project</b>
New Jersey Department of Transportation	1035 Parkway Ave., Trenton, NJ 08625	Financial support; Collaborative research; Personnel exchanges
WTS International	1701 K Street, NW, Suite 800, Washington DC 20006	Female participation in the transportation field
Utah Department of Transportation	4501 South 2700 West, Salt Lake City, UT 84114	Financial support; Collaborative research; Personnel exchanges; Facilities
Virginia Center for Transportation Innovation and Research (VCTIR)	530 Edgemont Road, Charlottesville, VA 22903	Financial support; Collaborative research; Personnel exchanges
New Jersey Asphalt Pavement Association	520 Horizon Drive, Trenton, NJ 08691-1907	In-kind support; Facilities; and Personnel exchanges
American Automobile Association of New Jersey (AAA-NJ)	1 Hanover Road, Florham Park, NJ 07932	In-kind support (provided safety related activity books that cover from K-6th grade)

I-95 Corridor Coalition	1390 Piccard Drive, Suite 200, Rockville, MD, 20850	Support of Freight Academy Immersion Program
Parsons Transportation Group		Financial support; Collaborative research; Personnel exchanges
Virginia DOT	Richmond, VA	Financial support; Collaborative research; Personnel exchanges
TA Instruments - Waters LLC	Newcastle, DE	Project customers/managers
Oregon DOT	Salem, OR	Project customers/managers
Cambridge Systematics	Topeka, Kansas	Project customers/managers
U.S. Chamber of Commerce	Washington D.C.	Personnel exchanges
Jersey Precast	853 Nottingham Way, Hamilton Township, NJ 08638	Financial support; Collaborative research; Personnel exchanges

### Have other collaborators or contacts been involved?

- **collaborations with others within the lead or partner universities; especially interdepartmental or interdisciplinary collaborations**

- **Partner Meeting:** Though the partners had plenty of communications and virtual meetings through the year, the first in-person consortium meeting was held September 25, 2012. Heads of each consortium institution and some of their key researcher gathered at CAIT for an intensive full-day day session to share information and present research results. The group also identified topics for further collaborative research projects to start January 2013.
- Rutgers University has collaborated with research project being conducted by Princeton University. The bridge scale-model and the artificial damages were designed and placed by researchers from Rutgers University. Rutgers also provided all material for the damages and the bridge scale-model itself. The bridge scale-model is currently located on the Rutgers Campus.

- **collaborations or contact with others outside the UTC**

- ExxonMobil representatives visited Rutgers in September to discuss asphalt trends, sustainability, and life-cycle analysis.
- VCTIR is sponsoring a very similar project on connection details for adjacent inverted-T beams. Virginia Polytechnic students collaborate on all aspects of both projects and exchange information and experience both in the lab and on the analytical aspects of their work. In addition, technical advice from research engineers at VCTIR and from bridge design engineers at VDOT has been provided to ensure that the details developed and tested in the projects are practical, constructible and have a considerable potential to be durable over the long term. Although details have not been finalized, VCTIR will be providing funding to purchase specimens for the next phase of laboratory testing. In addition, the inverted-T project has a materials testing component whose results will be used in the box-beam project as well. A source of tensile stresses in the topping concrete of adjacent box-beams and inverted-T beams is differential shrinkage of the topping concrete relative to the older, precast pieces. Work is underway to develop low shrinkage topping mixtures, and also to better understand the mechanism of tensile creep to relieve the restraint stresses which develop with time. Both projects will utilize the resulting topping mixture recommendations.
- Discussions about detail constructability have been ongoing with engineers from precasters in Virginia.

• **collaborations or contacts with others outside the United States or with an international organization (country(ies) of collaborations or contacts).**

- CAIT faculty traveled to China to give lectures and discuss potential academic and research collaborations with Harbin Institute of Technology (HIT).
- ExxonMobil representatives visited Rutgers in May to exchange information on various energy issues and again in September to discuss asphalt trends, sustainability, and life-cycle analysis. Both visits were full-day meetings that included lab tours and presentations by Rutgers.

**4. IMPACT: What is the impact of the program? How has it contributed to transportation education, research and technology transfer?**

**What is the impact on the development of the principal discipline(s) of the program?**

**SELECTED PROJECTS SELECTED DURING CURRENT REPORTING PERIOD**

<b>Outputs</b>	<b>Expected Outcomes</b>	<b>Impacts</b>
“Quantitative Acoustic Emission Monitoring of Fatigue Cracks in Fracture Critical Steel Bridges” (University of Delaware)	The objective is to evaluate quantitative AE methods for monitoring of fatigue crack detection, propagation, and retrofitting in steel bridges. Anticipated outcomes include recommendations on sensor locations, effective analysis methods to be used, and how to interpret the obtained data to ensure informed decisions can be made by bridge owners.	The proposed quantitative monitoring tool may provide owners of fracture critical bridges and bridges with fracture-prone details with a novel tool to make (1) objective informed decisions on when to intervene and repair, (2) enable safe operation during service, (3) verify that implemented repair methods are effective, and (4) ensure repairs are made only if necessary which increases economic competitiveness.
“Better State-of-Good-Repair Indicators for the Transportation Performance Index” (University of Delaware)	The goal of this project is to revise the Transportation Performance Index to better capture the role state of good repair and safety play in transportation infrastructure performance.	The end result of the project is a revised TPI that can be used to assess the economic impact of maintaining the physical infrastructure in a state of good repair and safety improvements. In turn, the TPI can be used to evaluate alternative infrastructure repair and improvement policies.
“Multi-Resolution Information Mining and a Computer Vision Approach to Pavement Condition Distresses” (University of Delaware)	The research will provide a new and effective method in addressing pavement monitoring data as well as a new platform for training graduate students in advanced data processing-including image and signal processing, a new hybrid method – the use of GIS, signal analysis and computer vision application in asset management applications.	The successful completion of the project will address important issues within an advanced infrastructure monitoring framework and thus provide a well-improved evaluation mechanism for pavement performance and deterioration.
“Mathematical Modeling and Experimental Responses of Polymer Modified Asphalt” (University of Delaware)	The goal of this project is to work cross-discipline (pavement engineering and mathematical science) to carry out experiments	The successful completion of the project will have direct impact on the SGR focus, especially in the area Advance/Innovative Materials and a

	and couple those results with mathematical modeling to better understand the properties of polymer modified asphalts. In the process we will be cross training graduate students in understanding. The project will lead to the development a) mathematical models, b) laboratory studies to support the mathematical/theoretical models, c) field validation techniques.	major influence on the modeling and evaluation of innovative asphalt material. This will ultimately improve the understanding of flexible pavement deterioration performance modeling. It will also improve decision-making in asset management.
“Fiber optic monitoring methods for composite steel-concrete structures based on determination of neutral axis and deformed shape” (Princeton University)	The objective is to research and develop Structural Health Monitoring methods (SHM), including structural identification and damage detection, based on strain monitoring using long-gauge fiber-optic sensors. The main outcomes are the developed SHM methods for determination of these parameters including number and position of sensors, monitoring schedule, and data analysis algorithms.	This research will allow comparison between laboratory results and data from a real structure under true service conditions. The research is therefore directly linked to real world application and knowledge gained from this data can be applied to other construction and preservation projects.
“Life Cycle Assessment of Asphalt Pavement Maintenance” (Rutgers University)	The main research objective is to develop a Life Cycle Assessment (LCA) methodology to consider the energy and environmental impacts of pavement maintenance at its construction and usage stage.	The methodology developed under this study from will aid state transportation agencies in selecting the most efficient maintenance and preservation treatments.
“Railroad Operations Research and Training” (Rutgers University)	The goal of this research is to explore the possibilities for railroad education leading to the implementation of short courses for professionals and ultimately to develop courses for undergraduate Civil Engineering curriculums.	Training courses will provide ideas for better maintenance techniques for rail and mass transit system employees while college level courses will expose Civil Engineering students to topics such as railroad design and management.
“Combining Model Based and Data Based Techniques in a Robust Bridge Health Monitoring Algorithm” (Columbia University)	The primary objective of this proposed research is to develop a continuous heal monitoring strategy applicable to real life bridges.	The robustness of the final unified scheme will be in its ability to address the practical constraints of incomplete instrumentation, unobserved/weakly excited vibration modes, unknown scaling in output-only situations, and effect of model uncertainty induced by environmental variations of the structural parameters.

#### ONGOING RESEARCH PROJECTS

Outputs	Expected Outcomes	Impacts
“Development of a Bridge Resource	The support from the UTC will help	The USDOT Strategic Goal of State

<p>Program for the New Jersey Department of Transportation” (Rutgers University)</p>	<p>establish a program that is intended to become an integral component of the NJDOT’s bridge research activities. The products of this project will be a report on the state’s structural asset management activities as well as a pilot plan to provide enhanced nondestructive evaluation and inspection on a sample of the State bridges.</p>	<p>of Good Repair will be directly addressed with this research. Through improving asset management strategies and incorporating nondestructive evaluation strategies, the Bridge Resource Program will provide NJDOT with advanced tools to manage the state's structural assets. In addition, the Bridge Resource Program will incorporate advanced load rating analyses to evaluate ten bridges. The advanced investigation will provide NJDOT with a new tool that will enable engineers to determine precise load carrying capacities of bridges. While this clearly supports state of good repair, the tool also provides a means to maintain economic competitiveness for state routes for trucking by preventing overload truck permits being re-routed due to load carrying capacity limits resulting from “standard” structural ratings. New tools will determine if additional load carrying capacity exists in the selected bridges and to demonstrate the value of such advanced analytical approaches.</p>
<p>“Development of a Comprehensive Hot Mix Asphalt Pavement Specification” (Rutgers University)</p>	<p>The major goal of this study is to search and critically evaluate the literature to determine how the HMA quality characteristics can best be incorporated into the existing NJDOT HMA pavement specification to produce a comprehensive and effective multi-characteristic acceptance specification that can be easily understood and implemented. Particular attention will be paid to methods to develop a simple but scientifically-based performance-related pay adjustment methodology to produce a new specification that is practical and effective, fair to both the highway agency and the construction industry, and legally defensible. It is expected that successful completion of this project will significantly advance the asphalt</p>	<p>Improve the state-of-good repair of multimodal transportation infrastructure systems</p>

	technology development in NJ and extend the service life of flexible pavements.	
“Improved Connection Details for Adjacent Prestressed Bridge Beams” (Virginia Polytechnic Institute)	The primary outcome of the project will be recommendations for improved connection details for adjacent precast/prestressed member bridges.	Bridges constructed with the new details are expected to have longer service lives with reduced maintenance costs. Safety is also addressed, because with the new detail the shear transfer between members will not break down and compromise the redundancy of the system. Collapses, such as that seen in Pennsylvania, will not occur with the new detail. Finally, Economic Competitiveness is also addressed because adjacent member bridges can be constructed rapidly and inexpensively.
“Development for Transportation Asset Management Inventory & Management Tools” (Utah State University)	Major expected outcomes are increased technology in the maintenance processes; data availability for decision makers; training workshops for LTAP customers and algorithms for optimization of maintenance investments.	This project strongly supports the USDOT goal of State of Good Repair by providing added value to the maintenance funding that is being expended by UDOT and other state DOTs. Also, this research will contribute to the goals of safety by providing roadways with better signage which will contribute to less driver confusion and less crashes on the roadways.
“ABC Deck Panel Testing” (Utah State University)	The research findings will result in design recommendations that can be used by state agencies for precast concrete deck panel connections.	Accelerated Bridge Construction techniques are a promising way of reducing the overall cost of bridge replacements. Specifically, the efficient use of precast concrete deck panels have been used by many states as a viable alternative. By providing a better method to post tension the precast deck panels, the potential benefit of these systems can be a nice tool for DOTs to have available.
“Forensic Testing of Prestress Concrete Girders after Forty Years of Service” (Utah State University)	It is anticipated that the research findings will result in design recommendations that will aid state agencies in better estimate the behavior of in-service bridges.	This project has direct implications for operation and maintenance practices as well as new construction planning.
“Virginia Bridge Information Systems Laboratory” (University of Virginia)	The support from the UTC will help establish this laboratory which is intended to become an integral component of the VDOT’s bridge research activities. The products of this project will be	This research supports the US DOT’s State of Good Repair Strategic Goal by utilizing data from the Long Term Performance Bridge program as one of the ancillary data sources for the proposed laboratory; by helping to



	<ol style="list-style-type: none"> <li>1. An annual report summarizing the activities and accomplishments of the laboratory.</li> <li>2. Special reports produced in response to requests for VDOT and VCTIR.</li> <li>3. Papers submitted and published in archival quality journals.</li> <li>4. Conference papers and presentations.</li> </ol>	<p>develop, evaluate and explore new system performance indicators for bridges; by examining the trends in permits for weights in excess of legal limits and quantifying bridge damage costs associated with those loads; by studying specific aspects of bridge performance and helping to develop a comprehensive process to regularly document the condition of VDOT's bridge infrastructure; supporting and advancing sound asset management principles for bridges through the deployment of new tools and techniques, the transfer of knowledge, and by providing technical assistance to more effectively manage the system; and by encouraging VDOT to use improved highway design and construction procedures, innovative quality assurance practices, innovative materials, and asset management practices by conducting special studies on the efficacy and cost effectiveness of such practices.</p>
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**NOTABLE RESEARCH PROJECT STATUS UPDATE**

**“Development of a Bridge Resource Program for the New Jersey Department of Transportation”**

(Rutgers University): Just after the morning rush hour on October 3, 2012, a dump truck traveling south on the New Jersey Turnpike crashed and caught fire under the bridge that carries I-195 over the Turnpike. It turned out to be the first “field call” for the recently established NJDOT-CAIT Bridge Resource Program (BRP). The truck crashed into the bridge abutment and started to burn, subjecting steel girders directly above to flames for more than an hour before firefighters could bring the blaze under control. This would have continued to be the case for drivers for at least another six weeks if not for NJDOT calling on CAIT and its partners, Intelligent Infrastructure Systems (IIS) and Princeton University, a CAIT University Transportation Center (UTC) consortium member. It was the first onsite assignment for the BRP team: Perform field testing and provide results to help NJDOT determine if the closed lane could safely remain in service until the replacement overpass opened. Within about 48 hours, CAIT and IIS prepared a plan to install 30 monitoring and measuring instruments—including displacement sensors, strain rosettes, and longitudinal strain gages—to provide quantitative data on the integrity of the span. Second only to safety, the ultimate goal was to alleviate traffic impacts; so the sensor installation and live load testing using two 22,000-pound dump trucks was done overnight on October 11, 2012. The entire onsite effort was completed in less than seven hours. Testing confirmed the girders in the fire-affected area still had substantial reserve capacity and that the span had robust load-sharing mechanisms in the diaphragms and deck. In short, based on the BRP team’s findings, NJDOT was confident all I-195 lanes could be reopened to traffic until construction on the new bridge was finished. Only two weeks after the crash, BRP, its partners, and NJDOT erased the frustrations that might otherwise have plagued drivers for months. This clearly demonstrates that the consortium is

making great progress towards fulfilling one of CAIT's primary objectives as a UTC: to generate products and quick-turnaround results in direct response to the needs of transportation agencies.

**“Improved Connection Details for Adjacent Prestressed Bridge Beams”** (Virginia Polytechnic Institute): In the previous reporting period, several concepts for connection details using mild reinforcing steel projecting from the sides of the box girders and filler material consisting of Ultra-High Performance Concrete (UHPC) were developed. Before finalizing the concepts, the splice length of reinforcing bars in UHPC needed to be determined. Four 12 ft long beams, 8 in. wide and 12 in. deep with a blockout at mid-span, were cast with typical 6000 psi concrete. In the blockout, reinforcing bars extending from the concrete were spliced with drop-in bars, and the blockout was filled with UHPC. The beams were then tested to place the splice location in a region of constant moment. Load was applied until failure occurred either due to bar rupture, or bond failure.

Thus far, four specimens have been tested. Two investigated the splice length of No. 6 bars and two investigated the splice length of No. 4 bars. Preliminary analysis indicates a splice length of 6 to 7 in. was adequate to fully develop the No. 6 bar and 4 to 5 in. was adequate for the No. 4 bar. Work is ongoing to better understand the curvature ductility of the splice location, however. The bars yielded with the short splice lengths, but the section did not achieve the expected level of ductility due to splitting failures following shortly after first yielding of the bars.

**“ABC Deck Panel Testing”** (Utah State University): all testing has been completed. Currently a paper has been submitted to the ASCE Journal of Bridge Engineering for publication.

**“Development for Transportation Asset Management Inventory & Management Tools”** (Utah State University): all data has been collected and is currently being reviewed. A paper has been submitted to the TRB Conference.

**“Fiber optic monitoring methods for composite steel-concrete structures based on determination of neutral axis and deformed shape”** (Princeton University): During the reporting period an extensive structural health monitoring system was designed for the bridge scale-model. The necessary materials and equipment for installation were acquired. The sensor installation took place during the week of Oct. 8-12, 2012. The monitoring system was fully functional on Oct. 12, 2012 (Figure 1). The interaction between the steel girders and the concrete slab during the curing of the concrete was monitored. Data was taken during the first 14 days of the concrete. Major events such as the lifting of the bridge scale-model (and the change in static system) were registered. The bridge scale-model was moved to its final location at Rutgers University on Nov.14, 2012 (Figure 2).



Figure 1: Installing sensors on concrete rebar



Figure 2: Monitoring during lifting in place

During the reporting period data and research material has been produced both for the bridge scale-model and the highway overpass. In particular for the bridge scale-model, strain and temperature data during the curing of the concrete has been acquired. Analysis of this data will provide insights into the interactive behavior of the steel girders and concrete slab during curing. Preliminary results suggest that artificial delamination was detected during the curing period. Furthermore, data during changes of the static system has been acquired. Analysis of the neutral axis during these changes and deformed shapes will be used to assess the response of the system to the artificial damages.

**“Combining Model Based and Data Based Techniques in a Robust Bridge Health Monitoring Algorithm”** (Columbia University): An extensive literature review has been conducted on the state of the art of the research on what has been named ‘missing modes’ problem. The system identification algorithm ECCA has been studied both theoretically and empirically, by analyzing the performance of the technique in different simulated measurement scenarios. A study has been engaged on the uniqueness problem when a reduced number of sensors is available. This is a realistic scenario that is constantly encountered in real life situations. This study founds the basis for the development of an efficient mode shape expansion method. For the data-based algorithms, a detailed literature review concerning the variety of damage sensitive features customary employed for structural damage detection problems has been performed. The sensitivity to damage of some of the most common structural damage sensitive features has been studied by means of simulations of the response of a very simple system excited with different inputs and modeled under different damage scenarios, i.e. different damage locations and severities have been considered. Pattern recognition is a discipline developed within the machine learning field. For this reason, literature review concerning the features best suited for damage detection purposes has been extended to the work conducted in the field of expertise of computer scientists. Special care has been devoted to the analysis of those applications based on biometrics recognition, as they tackle with problem very similar to those encountered in structural damage detection, e.g. presence of noise in the signals or variability over time of the reference system properties. In addition, since one of the objectives of the work is that of validating the model/data-based algorithm using experimental data, the calibration of the shaking table and accelerometers available in Columbia University laboratory has been completed and some sample experiments have been successfully run.

**What is the impact on other disciplines?**

It is anticipated that the research being conducted under this grant will have an impact on other disciplines such as bridge design and bridge construction. Bridge designers benefit from getting access to databases on true structural behavior and increased understanding on how damage affects the structural system. It will also provide valuable insights into structural element behavior during construction, potentially having an impact on construction practices. In addition, it is expected that improvements will be made in the area of safety.

**What is the impact on the development of transportation workforce development?**

Outputs	Outcomes/Impacts
UCDPER Statewide Conference on Risk & Crisis Communication	Exposure to transportation issues and interaction with researchers and professionals with experts in the transportation industry.
Advances in Infrastructure Asset Management Lecture	Exposure to transportation issues and interaction with researchers and professionals with experts in the transportation industry.
Traveling Distinguished Lecturer Series	Exposure to transportation issues and interaction of graduate and undergraduate students, researchers and professionals with experts in the transportation industry.
Council of Supply Chain Management Professionals Career	Exposure to transportation issues and interaction with researchers and professionals with experts in the transportation industry.

Day	
Annual Safety Forum	Exposure to transportation issues and interaction with researchers and professionals with experts in the transportation industry.
Compliance to the Americans with Disabilities Act	Exposure to transportation issues and interaction with researchers and professionals with experts in the transportation industry.
Federal Aid Requirements and LPA Stewardship	Exposure to transportation issues and interaction with researchers and professionals with experts in the transportation industry.
HSM Lite	Exposure to transportation issues and interaction with researchers and professionals with experts in the transportation industry.
Road Safety 365	Exposure to transportation issues and interaction with researchers and professionals with experts in the transportation industry.
Right of Way EDC Exchange Webinar	Exposure to transportation issues and interaction with researchers and professionals with experts in the transportation industry.
Continuing Professional Competency Day	Exposure to transportation issues and interaction with researchers and professionals with experts in the transportation industry.
NJSACE ADA Compliance	Exposure to transportation issues and interaction with researchers and professionals with experts in the transportation industry.
In Lieu Fees and Mitigation Banking EDC Exchange Webinar	Exposure to transportation issues and interaction with researchers and professionals with experts in the transportation industry.

**What is the impact on physical, institutional, and information resources at the university or other partner institutions?**

“Nothing to Report”

**What is the impact on technology transfer?**

- Research products such as the recently completed “Bridge Deck Robot.” Developed in cooperation with FHWA, the robot provides the high quality information required to make data driven decisions for near-term preservation, rehabilitation, and long-term planning and management. A joint Rutgers-FHWA patent is in process.

**What is the impact on society beyond science and technology?**

Outputs	Outcomes/Impacts
Outreach events to the general community that showcased State of Good Repair related research activities have occurred,	Improving public knowledge
Results of ongoing research projects	Increased safety of structures and saving of public funds through sustainable preservation and maintenance planning of infrastructure made possible by knowledge and understanding of true structural behavior.

**5. CHANGES/PROBLEMS**

**Changes in approach and reasons for change**

“Nothing to Report”

**Actual or anticipated problems or delays and actions or plans to resolve them**

“Nothing to Report”

**Changes that have a significant impact on expenditures**

“Nothing to Report”

**Significant changes in use or care of human subjects, vertebrate animals, and/or biohazards**

“Nothing to Report”

**Change of primary performance site location from that originally proposed**

“Nothing to Report”

**6. SPECIAL REPORTING REQUIREMENTS**

“Nothing to Report”