

## 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, 2016

**Reporting Period End Date:** June 30, 2013

**Report Term or Frequency:** Semiannual (1/1/13-06/30/13)

**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>seventeen research projects</b>
<b>Education and Workforce Development</b>	Planning for T.A.R.G.E.T	Generate knowledge and skills to foster a world class workforce for the transportation sector	CAIT brought young women interested in the field of engineering with professional female engineers currently working in the industry.	High school girls were educated on the abilities, roles, successes, and challenges of being a woman in the field of engineering through firsthand accounts.
	Sponsored assistantship at UTEP	Generate knowledge and skills to foster a world class workforce for the transportation sector	Five graduate students have been hired at UTEP	Graduate students are working on advanced research projects and learning about transportation related issues and how to solve them.
	Sponsored fellow at UD	Generate knowledge and skills to foster a world workforce for the transportation sector	Diane Wurst was awarded a fellowship at CAIT at UD. She is expected to complete her MS thesis this summer.	Ms. Wurst is working on redundancy in bridges with Professor McConnell and gaining valuable skills related to the transportation field.
	Sponsored summer State DOT internship program (June-August 2013)	Generate knowledge and skills to foster a world workforce for the transportation sector	Two civil engineering undergraduates are interning with Delaware Department of Transportation for the summer.	Interns are evaluating each asset identified by DelDOT as potentially impacted by sea level rise, to determine the feasibility of each of three basic treatments – elevate, armor, or abandon – and to assign a cost estimate based upon unit costs for road surface, fill

				dirt, or bridge construction.
	Planning for Governor's School	Generate knowledge and skills to foster a world class workforce for the transportation sector	CAIT developed and presented a 12 module elective for the state's top math and engineering students.	High school seniors were exposed and educated on the differing civil engineering and transportation issues.
	Planning for National Summer Transportation Institute NextGen	Generate knowledge and skills to foster a world class workforce for the transportation sector	CAIT partnered with the Office of Student Development in Rutgers' School of Engineering to promote and support engineering education activities and research skill development.	Middle and high school students learned about the transportation industry and multiple modes of transportation; students learned about post-secondary school careers in transportation.
	Use of Geosynthetic Reinforced Soil Integrated Bridge System Workshop (January 26)	Generate knowledge and skills to foster a world class workforce for the transportation sector	Promoted FHWA Every Day Counts initiative	Showcased technology advantages, such as reduced construction time and cost, flexible and easily modified design, and hassle-free construction.
	Planning for LPA Boot Camp	Generate knowledge and skills to foster a world class workforce for the transportation sector	Promotes FHWA Every Day Counts initiative and federal aid compliance	Pilot training for new compliance personnel will serve as a best practice for others
	Traveling Lecture Series: Risk-Informed Management of Bridge Infrastructure (February 7)	Generate knowledge and skills to foster a world class workforce for the transportation sector	Dr. Daniel Zonta from the Department of Transportation of the Autonomous Province of Trenton, Italy, spoke about bridge structural health monitoring.	Exposes researchers, students, and professionals in the transportation industry to subject matter experts.
	Traveling Lecture Series: Design Code Calibration for Concrete Structures (February 27)	Generate knowledge and skills to foster a world class workforce for the transportation sector	Dr. Andy Nowak of the University of Nebraska spoke about critical design procedures that impact long-term structural performance.	Exposes researchers, students, and professionals in the transportation industry to subject matter experts.
	Annual Rutgers	Generate	350 professionals	Attendees learned

	Asphalt Paving Conference (March 5-6, 2013)	knowledge and skills to foster a world class workforce for the transportation sector	from NJ and surrounding states attended the conference	about the most recent advancements in design, construction, and maintenance.
	Pedestrian Engineering Symposium (March 21)	Generate knowledge and skills to foster a world class workforce for the transportation sector	200 professionals from the tri-state region attended this first-time conference.	Speakers from FHWA and county and local government, as well as MPOs, provided case studies and best practices for improving pedestrian safety through engineering countermeasures.
	Annual Work Zone Safety Conference hosted by NJ LTAP in cooperation with NJ Work Zone Safety Partnership (April 23, 2013)	Generate knowledge and skills to foster a world class workforce for the transportation sector	300 professionals with multidisciplinary backgrounds attended this annual conference.	Attendees learned about work zone issues such as speed, personal protection, proper work zone set up, and operations
	Rutgers Day Event-Infrastructure: Improving the Quality of Life (April 27)	Generate knowledge and skills to foster a world class workforce for the transportation sector	Prospective students and their families, as well as community members were able to interact with researchers.	Attendees learned about how infrastructure impacts their daily lives and how research is critical to quality of life.
	Participated in Women's Transportation Seminar Annual Conference (May 15-17)	Generate knowledge and skills to foster a world class workforce for the transportation sector	The consortium provided registration and travel support for 12 young women to attend the conference in Philadelphia, PA.	The consortium provided the means for 12 students to attend this conference, to encourage interest in the transportation field.
	ITS NJ June 2013 Technical Meeting	Generate knowledge and skills to foster a world class workforce for the transportation sector	CAIT developed and coordinated the annual June Technical meeting for the ITS Chapter of New Jersey.	Almost 200 professionals were exposed to the state's primary ITS needs and issues.
<b>Technology Transfer</b>	Pavement Resource Program and Transportation Safety Resource Program Information Exchange with China (January 24 and March 5)	Support research products that can make significant and meaningful impacts	CAIT coordinated the information exchange between Chinese government officials.	Best Practices on pavements, pavement management systems, and engineering were traded between Chinese and CAIT.

	UTC Spotlight: Superstorm Sandy LiDAR Damage Assessment Tools Change Disaster Recovery (February)	Support research products that can make significant and meaningful impacts	CAIT produced a Spotlight piece on the timely use of LiDAR tools for assessing damage by Superstorm Sandy for UTC Spotlight publication	The UTC Spotlight was published and read by many interested parties.
	State of Good Repair Summit (March 27)	Support research products that can make significant and meaningful impacts	A CAIT hallmark, the SGR Summit brought together some of the nation's infrastructure experts to create an informative and productive Summit	Almost 200 like minded people addressed and delved into the fundamental SGC issues and needs.
	UTC Spotlight: Evaluation of Accelerated Bridge Construction- A Forensic Analysis (April)	Support research products that can make significant and meaningful impacts	CAIT produced a Spotlight piece on the examination of a bridge constructed using the ABC method for UTC Spotlight publication	The UTC Spotlight was published and read by many interested parties.
	LiDAR Capabilities Demonstration to NJDOT (April 3)	Support research products that can make significant and meaningful impacts	CAIT demonstrated the capabilities of LiDAR equipment to different sections of the NJDOT for new and innovative uses.	The NJDOT will be using the technology on new and innovative areas to examine sight lines, investigate accidents, and supplement the aviation section.
	ITE Northeast District Meeting (May 22-24) Presentation on Crash Data	Support research products that can make significant and meaningful impacts	Presented on meeting traffic safety data needs in a data intensive world	Highlighted a practical approach in identifying many of the issues surrounding successful implementation of crash analysis software.
	EDC Exchange: Traffic Incident Manager Responder Training (June 19)	Support research products that can make significant and meaningful impacts	Supports FHWA's Every Day Counts 2 initiatives	Promotes unified incident response strategies across disciplines

**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?**

- **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:**
  - Continue to work with partner schools in delivering **Traveling Distinguished Lecture Series** presentations.
  - Deliver the NextGen, T.A.R.G.E.T and Governor’s School, among other **K-12 programs** to cultivate interest in engineering and transportation programs, supporting STEM and workforce development goals for the consortium.
  - Conduct kick-off meeting for **Transit Virtual Career Network** recently contracted by the Federal Transit Administration. This project is developing a dynamic online resource to support the public transportation workforce recruit, retain, and retrain employees.
  - Conduct annual **Research Showcase** for the New Jersey Department of Transportation.
  - Conduct annual **Safety Forum** for the transportation community.
  - Conduct an **Intersection Symposium** for the transportation community.
  - Conduct a **Local Public Agency Federal Aid Compliance Boot Camp** for new oversight personnel.
- **TECHNOLOGY TRANSFER ACTIVITIES:**
  - Continue to support the **FHWA Every Day Counts** program by hosting two more EDC Exchange Webinars (September and December 2013).

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

**Research projects awarded**

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

- “Highly efficient model updating for structural condition assessment of large-scale bridges” (University of Texas at El Paso)
- “Performance Determination of Precast Concrete Slabs used for the Repair of Rigid Pavements” (University of Texas at El Paso)
- “Warehouse Location and Freight Attraction in the Greater El Paso Region” (University of Texas at El Paso)
- “Correlation between Hurricane Sandy Damages along NJ Coast with Land Use, Demographic and Other Local Characteristics” (Rutgers University)
- “Elevated Temperature Properties of Weathering Steel (Princeton University)
- “The Effects of Network Characteristics on Traffic Flows and Emission” (Rutgers University)
- “Quantifying Impact of Port Truck Traffic on Highway Operations Using GPS-Based Speed Data” (New Jersey Institute of Technology)

- 3D Laser Scanning for Quality Control and Assurance in Bridge Deck Construction (Rutgers University)
- "Development of A Real-Time Vibrator Tracking System for Intelligent Concrete Consolidation" (Rutgers University)
- "Mixing and Compaction Recommendations for Warm Mix Asphalt (WMA) with Recycled Asphalt Shingles (RAS)" (Rutgers University)
- "COLLABORATIVE PROPOSAL: Analysis of Interactions between the Marine Terminal and Highway Operations" (Rutgers University and New Jersey Institute of Technology)
- "COLLABORATIVE PROPOSAL: Feasibility of Bridge Structural Health Monitoring Using Short Term, Data Acquisition System" (Utah State University, Virginia Polytechnic Institute and Columbia University)
- "COLLABORATIVE PROPOSAL: Multi-Sensor Sheets Based on Large-Area Electronics for Advanced Structural Health Monitoring of Civil Infrastructure" (Princeton University, University of Delaware and Columbia University)
- "COLLABORATIVE PROPOSAL: Numerical Simulation of Intelligent Compaction Technology for Construction Quality Control"( University of Texas at El Paso and Rutgers University)
- "COLLABORATIVE PROPOSAL: Big Data: Opportunities and Challenges in Asset Management" (Rutgers University, University of Delaware and Utah State University)
- "COLLABORATIVE PROPOSAL: Analyzing Asset Management Data Using Data and Text Mining" (Rutgers University and Utah State University)
- "COLLABORATIVE PROPOSAL: Evaluation of Biotechnologies for Flexible Pavement Applications" (Rutgers University, University of Delaware and University of Texas at El Paso)

**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.**

- "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
- *“Structural Identification And Uncertainty Quantification In Operational Modal Analysis With Minimal Instrumentation”* by Suparno Mukhopadhyay, Raimondo Betti, Hilmi Lus. Paper presented in the 11<sup>th</sup> International Conference on Structural Safety and Reliability, held in Columbia University, New York, NY, from June 16 – 20, 2013
- *“Modal Parameter Based Damage Detection In Operational Modal Analysis: A Statistical Pattern Recognition Approach”* by Luciana Balsamo, Suparno Mukhopadhyay, Raimondo Betti, Hilmi Lus. Paper presented in the 11<sup>th</sup> International Conference on Structural Safety and Reliability, held in Columbia University, New York, NY, from June 16 – 20, 2013
- Y. Yao, E. Tung, N. Verma and B. Glisic. “Towards sensing sheets based on large area electronics,” *The 9th International Workshop on Structural Health Monitoring*, Stanford University, USA, September 2013.
- Y. Yao, E. Tung, N. Verma and B. Glisic. “High-resolution sensing sheet for damage detection based on large area electronics,” *The 6th International Conference on Structural Health Monitoring of Intelligent Infrastructure*, Hong Kong, China, December 2013.
- B. Glisic, Y. Yao and D. Sigurdardottir. “Two probabilistic damage detection approaches,” *The 6th International Conference on Structural Health Monitoring of Intelligent Infrastructure*, Hong Kong, China, December 2013.
- Mhamdi, L.; Schumacher, T.; Righman-McConnell, J.; Quantitative Acoustic Emission Monitoring of Fatigue Cracks in Fracture Critical Steel Bridges; Poster presented at the Delaware Center for Transportation PI/PM Showcase; Dover, DE; May 9, 2013.
- McNeil, Sue, Farzana Atique, Yaw Adu-Gyamfi, and Hong Yin, Better State of Good Repair Indicators for the Transportation Performance Index, Poster presented at the Delaware Center for Transportation PI/PM Showcase; Dover, DE; May 9, 2013.

- Yaw Adu-Gyamfi, Yaw, Nii Attoh-Okine, Performance Assessment of Flexible Pavements Using Active Contour Models. 2013 Airfield and Highway Pavement Conference, June 8-12, Low Angeles, California
- Glassman, Paige, Transportation and Dance, Poster at the Colonial Academic Alliance Conference, Newark, Delaware, April 2013.

#### **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**

- Developed new email announcement templates to highlight projects, events, or personnel achievements
- Under research project entitled “Highly efficient model updating for structural condition assessment of large-scale bridges,” UTEP developed a new technique to perform model updating for large-scale bridges, which is faster and more accurate than traditional approaches. This approach is to apply the response surface (RS) method based on radial basis functions to generate a surrogate model of the complicated finite element model of the structure, and then perform a genetic algorithm on the surrogate model to update parameters of the structure. As a result, the computational amount is significantly reduced, making the model updating more quickly. The implementation of the RS method makes model updating promising in being applied to large-scale real-world structures.

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

“Nothing to Report”

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

- UD outreach effort involving teachers and elementary and middle school students to introduce them to transportation through dance and creative movement is continuing. Resources are being compiled for current and future scholars and classroom teachers and a website is being developed with lessons and other resources.
- CAIT at USU was involved with Engineering State in June, 2013. The faculty from the center sponsored a challenge session involving bridge design. Five challenge sessions were performed in all with over 100 high school kids in attendance.
- CAIT at VTech has completed the planning and will soon be presenting the Concrete for Kids (C4K) program to three summer camps at Virginia Tech. The C-Tech<sup>2</sup> camp provides rising senior high school girls a two week introduction to a wide variety of engineering disciplines. The C4K program will be presented to the 50 girls in this program. The program will also be presented to middle school boys and girls in two separate “Imagination” camps. These camps are also geared toward introducing students to engineering. The program will be presented to 40 children in each of the two camps.

### **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
Parsons Transportation Group		Financial support; Collaborative research; Personnel exchanges
Virginia DOT	Richmond, VA	Financial support; Collaborative research; Personnel exchanges
Oregon DOT	Salem, OR	Project customers/managers
Delaware Department of Transportation	Dover, DE	Project customers/managers
Cambridge Systematics, Inc.	Cambridge, MA	Project customers/managers
TA Instruments-Waters LLC	New Castle, DE	Project customers/managers
TxDOT	Austin, TX	Financial support; Collaborative research; Personnel exchanges
California DOT	Sacramento, CA	Project customers/managers
El Paso MPO	El Paso, TX	Financial support; Collaborative research; Personnel exchanges
Applied Research Associates Inc	Panama City, FL	Financial support; Collaborative research; Personnel exchanges
Cambridge Systematics	Topeka, Kansas	Project customers/managers

**Have other collaborators or contacts been involved?**

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

- **Partner Meeting/Communication:** ongoing communications and virtual meetings through the year.

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

- Karl Zipf, from Delaware Department of Transportation has been involved in the experimental setup to understand the properties needed for modeling of asphalt/asphalt with polymer/wax binder properties.
- Dr. Steven Lovejoy, Senior Bridge Engineer from the Oregon DOT and external project manager for project entitled “Quantitative Acoustic Emission Monitoring of Fatigue Cracks in Fracture Critical Steel Bridges” led by UDEL, has been consulted on the fabrication of the specimens and to determine initial stress ranges for fatigue loading.
- Federal Highway Administration Office of Policy has collaborated with UDEL team members to provide updated HPMS data.
- Due in large part to the initial studies performed with the first year UTC funding, VTech has received a grant (\$144,000) from the Virginia Center for Transportation Innovation and Research (VCTIR) to expand the scope of the adjacent member connection project to perform additional test of the connections between adjacent box girders and voided slabs.

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

- Dr. Lindsay Linzer, Geophysical Engineer from Johannesburg, South Africa, is the author of the MTI toolbox which is being used to perform research at CAIT at UDEL.
- Dr. Yan from UTEP has been collaborating with Professor Jinping Ou from Dalian University of Technology. They plan to conduct experimental tests on a cable-stayed bridge model in his lab to validate the proposed approach experimentally. They plan to perform dynamic tests on the bridge model, collect acceleration responses and implement the proposed model updating technique.

**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?**

**PROJECTS SELECTED DURING CURRENT REPORTING PERIOD**

<b>Outputs</b>	<b>Expected Outcomes</b>	<b>Impacts</b>
“Highly efficient model updating for structural condition assessment of large-scale bridges” (University of Texas at El Paso)	The objective is to propose a high-speed, highly efficient model updating technique for structural condition assessment of large-scale bridges.	Reliable condition assessment is important to make decisions on timely maintenance or repair, which ensures the integrity of bridges and improves the safety for the public, and significantly reduces the life-cycle costs of bridges.
“Performance Determination of Precast Concrete Slabs used for the Repair of Rigid Pavements” (University of Texas at El Paso)	The goal is to provide a better understanding of the mechanical behavior of the precast concrete panels considering the temperature variation in the field.	Rapid repair of damaged rigid pavements is important for the safety of users of transportation facilities. Proper characterization and construction of precast panels is

		in line with the sustainable repair objective identified by the USDOT.
“Warehouse Location and Freight Attraction in the Greater El Paso Region” (University of Texas at El Paso)	The objectives of this project are to develop a methodological approach to analyze current and future warehouse/distribution center locations along border regions. It is expected that research results can provide greater accessibility and mobility for increasing bi-national freight flows that are safer and economically feasible.	It is anticipated that the to-be-developed decision support methodology will be readily used by metropolitan planning organizations, state and city departments of transportation for their land-use planning purposes.
“Correlation between Hurricane Sandy Damages along NJ Coast with Land Use, Demographic and Other Local Characteristics” (Rutgers University)	This study builds on the “FEMA Flood Mitigation Research and Modeling” project conducted by Rutgers Bloustein School of Planning and Public Policy. The goal is to understand the correlation between Hurricane Sandy damages along NJ Coast with land use, demographic and other local characteristics and to evaluate whether modifying or adding additional sea wall and sand dune infrastructure would have reduced the surge related damages that occurred from Sandy.	The modeling results will help determine the most feasible flood reduction strategy to be adopted by areas undergoing extensive rebuilding.
“Elevated Temperature Properties of Weathering Steel (Princeton University)	Bridge fires, which result in extended congested detours for damage assessment and repair, affect the welfare of our transportation system. The goal of this work is to develop a database of mechanical properties of weathering steel that has been exposed to high temperatures.	The information generated by this study will aid in reducing the assessing and repair time and, possibly, bridge replacement.
“The Effects of Network Characteristics on Traffic Flows and Emission” (Rutgers University)	The objective of this research is to use state-of-the-art macroscopic traffic models to relate the characteristics of a street network and the level of travel demand to aggregated properties of the traffic demand. This relationship will provide the inputs to greenhouse gas emissions models as developed through EPA MOVES.	These results will be useful for developing insights about the environmental performance of urban street networks in general, and provide a foundation for studying specific networks and improvement plans on real street networks.
“Quantifying Impact of Port Truck Traffic on Highway Operations Using GPS-Based Speed Data” (New Jersey Institute of Technology)	The goal of this study is to develop an analytical model that can be used to quantify effects of the port-related truck traffic on prevailing vehicle operating speed and level of	The findings will help determine critical truck volume (or demand), which is defined as a truck volume that deteriorates the highway infrastructure performance below

	service on surrounding highway system.	the acceptable minimum level of service.
3D Laser Scanning for Quality Control and Assurance in Bridge Deck Construction (Rutgers University)	The study will develop new quality control and assurance tools for bridge deck construction.	The tools will assist state DOTs to discover and proactively mitigate quality problems in bridge deck construction, in particular those related to rebar installation and concrete placement. This project hopes to provide best practices for bridge deck construction and rehabilitation.
“Development of A Real-Time Vibrator Tracking System for Intelligent Concrete Consolidation” (Rutgers University)	The purpose of this research is to develop a real-time vibrator tracking based intelligent concrete consolidation system. The expected outcome of the study is a new intelligent concrete consolidation tool.	This new tool can significantly benefit concrete bridge construction and retrofitting by allowing contractors to pro-actively address concrete consolidation issues.
“Mixing and Compaction Recommendations for Warm Mix Asphalt (WMA) with Recycled Asphalt Shingles (RAS)” (Rutgers University)	The anticipated outcome of the research is a set of general guidelines that could be used when producing warm mix asphalt (WMA) with recycled asphalt shingles (RAS). It is envisioned that the results of the research would be adopted in a best practices for handling RAS with WMA technologies.	The Best Practices document would provide general procedures and recommendations on the proper mixing and compaction temperatures to ensure proper coating of the aggregate and field density is achievable when incorporating RAS in WMA.
“COLLABORATIVE PROPOSAL: Analysis of Interactions between the Marine Terminal and Highway Operations” (Rutgers University and New Jersey Institute of Technology)	The goal of the study is to develop a simulation model that will be capable of ascertaining the interactions between the marine terminal operations and a highway system that provides access to the port. In addition, a set of operational and policy improvements will be defined to address the deficiencies of the highway system in handling the growing port-related truck demand.	It is expected that the type of analysis provided by this modeling framework will find application in regional strategic planning.
“COLLABORATIVE PROPOSAL: Feasibility of Bridge Structural Health Monitoring Using Short Term, Data Acquisition System” (Utah State University, Virginia Polytechnic Institute and Columbia University)	The goal of the research is to develop a self contained, structural health monitoring system that tracks critical bridge behavior over a period of four to six weeks. This tool will be used for making decisions related to bridge maintenance or replacement.	In the long term, results from this research could aid DOTs in making better quantified decisions in terms of maintenance strategies or bridge replacement. Currently the data to make these decisions is not sufficient or available.
“COLLABORATIVE PROPOSAL: Multi-Sensor Sheets Based on Large-Area	The research team will develop and evaluate a prototype of a novel	Potential future implementations of this sensing approach include: an

<p>Electronics for Advanced Structural Health Monitoring of Civil Infrastructure” (Princeton University, University of Delaware and Columbia University)</p>	<p>multi-sensor sheet that is inexpensive, can be equipped with a variety of different sensors, easy to fabricate and deploy, and which provides densely spaced quantitative measurements from large areas of a structure. As these sensing sheets will not be structure-specific, they can be used to assess a large variety of structures (bridges, pipelines, tunnels, wind turbines, etc.) made of different materials.</p>	<p>integrated monitoring system for bridges and other structures with similar problems; a research tool for better understanding the damage mechanisms leading to catastrophic failure; and a method for estimating remaining service-life of structures. Professional development opportunities and training include seminars on the benefits of monitoring techniques for informed decision making.</p>
<p>“COLLABORATIVE PROPOSAL: Numerical Simulation of Intelligent Compaction Technology for Construction Quality Control”( University of Texas at El Paso and Rutgers University)</p>	<p>The primary goal of this project is to better understand the process of accepting compacted materials to ensure quality, performance and durability using IC technology. Innovative numerical models will be developed to document and understand the theoretical limitations and sensitivity of this technology in order to generate more rigorous specifications.</p>	<p>The deliverable of this project will be recommendations to implementation of IC based on numerical model results that can be used with confidence to evaluate the effectiveness of the existing and future instrumented rollers. The almost continuous quality control of the final product will improve the productivity of the contractors, improve the longevity of the highway and airport infrastructure, thus minimizing the delay to user of the transportation facilities.</p>
<p>“COLLABORATIVE PROPOSAL: Big Data: Opportunities and Challenges in Asset Management” (Rutgers University, University of Delaware and Utah State University)</p>	<p>The overall objectives of this project are to define "big data" for asset management purposes and to identify opportunities for data integration, data mining, visualization, meta data and other techniques for data aggregation and summarization.</p>	<p>The product of this research will be a catalog of tools and techniques to support asset management.</p>
<p>“COLLABORATIVE PROPOSAL: Analyzing Asset Management Data Using Data and Text Mining” (Rutgers University and Utah State University)</p>	<p>The objective of the study is to produce models that are useful for identifying infrastructure deficiencies. In addition, the researchers will explore how the use of data mining can be used to reduce costs by more quickly identifying problems before more costly interventions are needed.</p>	<p>The research will provide information on how data mining can be used to provide better information to decision makers to keep infrastructure assets in a state of good repair.</p>
<p>“COLLABORATIVE PROPOSAL: Evaluation of Biotechnologies for Flexible Pavement Applications” (Rutgers University, University of Delaware and University of Texas at El Paso)</p>	<p>The main goal of the project is to conduct an evaluation/approval of bio-based materials that will enhance the performance of flexible pavements or used in substitution of current materials at a considerable cost reduction that is environmentally beneficial.</p>	<p>A Best Practices document describing the benefit of bio-based materials in the construction of flexible pavements and a Technical Brief, presenting the mathematical model development and its potential use/application will be generated for distribution.</p>

**ONGOING RESEARCH PROJECTS**

<b>Outputs</b>	<b>Expected Outcomes</b>	<b>Impacts</b>
<p>“Development of a Bridge Resource Program for the New Jersey Department of Transportation” (Rutgers University)</p>	<p>The support from the UTC will help 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>The USDOT Strategic Goal of State 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.</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.</p>	<p>Improve the state-of-good repair of multimodal transportation infrastructure systems</p>
<p>“Improved Connection Details for Adjacent Prestressed Bridge Beams” (Virginia Polytechnic Institute)</p>	<p>The primary outcome of the project will be recommendations for improved connection details for adjacent precast/prestressed member bridges.</p>	<p>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.</p>
<p>“Development for Transportation Asset Management Inventory &amp; Management Tools” (Utah State University)</p>	<p>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.</p>	<p>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</p>



		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)	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 1. An annual report summarizing the activities and accomplishments of the laboratory. 2. Special reports produced in response to requests for VDOT and VCTIR. 3. Papers submitted and published in archival quality journals. 4. Conference papers and presentations.	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 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.
“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 and couple those results with mathematical modeling to better understand the properties of polymer modified asphalts.	The successful completion of the project will have direct impact on the SGR focus, especially in the area Advance/Innovative Materials and a 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 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.

<p>“Combining Model Based and Data Based Techniques in a Robust Bridge Health Monitoring Algorithm” (Columbia University)</p>	<p>The primary objective of this proposed research is to develop a continuous heal monitoring strategy applicable to real life bridges.</p>	<p>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.</p>
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**NOTABLE RESEARCH PROJECT STATUS UPDATE**

**“Combining Model Based and Data Based Techniques in a Robust Bridge Health Monitoring Algorithm”** (Columbia University): Some preliminary results from the research being currently conducted under this project have been presented in the 11th International Conference on Structural Safety and Reliability, held in Columbia University, New York, NY, from June 16 – 20, 2013

**“Fiber optic monitoring methods for composite steel-concrete structures based on determination of neutral axis and deformed shape”** (Princeton University): The main outcomes are structural health monitoring methods and data analysis algorithms that can be used to assess bridge condition over time and facilitate maintenance scheduling and management through structural identification and damage detection. The results obtained during this reporting period are very promising. They show that the distribution of the location of the neutral axis is sensitive to damage and display the potential of this parameter. On-site testing in conjunction with laboratory testing creates a strong connection between a controlled environmental setting and the real structure and assists in addressing the environmental challenges faced on-site. The results show similar behavior between the real structure and the test model. The benefit of this research will be to compare laboratory results with 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. Results from this project were included in the Short Course on Structural Health Monitoring held at Princeton University on March 17, 2013.

**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
<b>Municipal Engineering Construction Inspection Program</b>	Comprehensive 6 day program for new municipal engineering construction inspection program develops technical and professional development skills
<b>LPA training to support Federal Aid Compliance</b>	Multi-topic training program developed with NJDOT and the FHWA NJ Division to bolster grant compliance for federal aid projects
<b>Traveling Distinguished Lecture Series</b>	Exposure to transportation issues for students, researchers, and professionals with experts in the industry from other parts of the world
<b>EDC Exchange Webinar: Traffic</b>	Supports implementation of FHWA and SHRP 2 initiatives

<b>Incident Manager Responder</b>	
<b>Student participation in Women's Transportation Seminar Conference</b>	Provided a unique and meaningful experience for consortium students to network with peers and mentors
<b>Annual Work Zone Safety Conference</b>	Brings together multidisciplinary audience of public safety, highway construction, engineers, planners, and regulatory agencies to address work zone safety
<b>Annual Rutgers Paving Conference</b>	Brings together multidisciplinary audience of lab technicians, highway construction, researchers, engineers, and labor representatives to address paving technologies, materials, best practices, and specifications
<b>Bridge Resource Program Webinar Series</b>	Provides access to multiple technical topics for NJDOT structures personnel

**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?**

- It is anticipated that all projects will lead to the adoption of new practices or inform policy. For example, the project on acoustic emission monitoring led by UDEL will impact monitoring of steel fatigue cracks, and knowledge can be gained on the mechanisms of fatigue cracking and how they compare for different steels. The TPI project will explore alternative policies.

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

<b>Outputs</b>	<b>Outcomes/Impacts</b>
Federal Aid compliance training	Ensuring funding recipients are aware of, and trained in, proper federal regulations and procedures.
Results of ongoing research projects	Increased safety of structures and saving of public funds through sustainable preservation and maintenance planning of existing infrastructure made possible by knowledge and understanding of true structural behavior.
Outreach efforts using dance to introduce transportation and infrastructure concepts to elementary and middle schools	This program is raising awareness of infrastructure issues among school children.

**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"