

## PROGRAM PROGRESS PERFORMANCE REPORT

**Awarding Federal Agency:** US Department of Transportation, Office of the Assistant Secretary for Research and Technology

**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

**Program Director (PD) Name,** Dr. Ali Maher, CAIT Director. **E-mail address:** mmaher@rci.rutgers.edu  
**Phone number:** 848-445-2951

**Name of Submitting Official, Title, and Contact Information (e-mail address and phone number), if other than PD:** Dr. Patrick Szary, CAIT Associate Director. **E-mail address:** [szary@rci.rutgers.edu](mailto:szary@rci.rutgers.edu) **Phone number:** 848-445-2999

**Submission Date:** July 31, 2014

**DUNS Number:** 001912864000

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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, 2014

**Report Term or Frequency:** Semiannual (1/1/14-6/30/14)

**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 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.	Reviewed and approved <b>eight research projects</b>
<b>Education and Workforce Development</b>	Concrete for Kids (June 2014)	Generate knowledge and skills to foster a world class workforce for the transportation sector.	CAIT at Virginia Tech encourages young women to succeed in engineering careers.	The camp provided 50 rising senior high school girls a two-week introduction to a wide variety of engineering disciplines.
	Planning for Imagination Camps	Generate knowledge and skills to foster a world class workforce for the transportation sector.	CAIT at Virginia Tech encourages young men and women to succeed in engineering careers.	The camp provided 40 middle school boys and girls a week-long introduction to a wide variety of engineering disciplines.
	Participated in Women's Transportation Seminar Annual Conference (May 2014)	Generate knowledge and skills to foster a world class workforce for the transportation sector.	The consortium provided registration and transport for students to attend the conference in Portland, OR.	The consortium provided registration and transport for 9 young women to attend the conference in Portland, OR.
	Transportation Project (Spring 2014)	Generate knowledge and skills to foster a world class workforce for the transportation sector.	CAIT at Delaware teaches elementary school children on the various creative aspects of transportation and engineering.	A series of lessons were presented to 40 elementary school children that integrated arts with transportation and engineering concepts.
	Council for University Transportation	Generate knowledge and skills to foster a	Administrative Leadership Award	Dr. Patrick Szary was awarded the Administrative

	Centers Banquet (January 11, 2014)	world class workforce for the transportation sector.		Leadership Award.
	Planning for Governor's School Program	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.	Teach graduating HS seniors about the transportation industry and multiple modes of transportation; students learned about post-secondary school careers in transportation.
	Planning for Garrett Morgan Academy	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.	Teach incoming Garrett Morgan Academy freshmen about the transportation industry and multiple modes of transportation; students learned about post-secondary school careers in transportation.
	Planning for The Academy at Rutgers for Girls in Engineering (TARGET)	Generate knowledge and skills to foster a world class workforce for the transportation sector.	CAIT encourages young women to succeed in engineering careers	CAIT will facilitate "lunch and learn" roundtables so female middle and HS students could receive professional guidance from established female engineers.

	I-95 Corridor Coalition Freight Academy (April 27 - May 2)	Generate knowledge and skills to foster a world class workforce for the transportation sector.	CAIT hosted the 2014 class of the Freight Academy at Rutgers.	35 public agency employees were trained to better understand their professional roles and how their positions impact goods movement decisions, investments and interactions.
	2014 Transportation YOU Summit (June 2014)	Generate knowledge and skills to foster a world class workforce for the transportation sector.	CAIT partnered with WTS International and NITC to promote and encourage young women to pursue transportation careers	21 young women learned about the significance of transportation in connecting people to jobs and economic opportunities.
	15th Annual Work Zone Safety Conference (June 2014)	Generate knowledge and skills to foster a world class workforce for the transportation sector.	CAIT hosted the 15th Annual Work Zone Safety Conference with this year's theme being "Work Zone Speed: A Costly Mistake". This event is designed to promote work zone safety awareness for a multi-disciplinary audience.	Professionals in the areas of construction, maintenance and operations, engineering and public safety personnel attended the conference and learned about work zone safety practices and products.
	ITS Resource Program Training	Generate knowledge and skills to foster a world class workforce for the transportation sector.	CAIT partnered with NJIT to provide professionals with training opportunities in intelligent transportation systems.	Professionals engaged in training seminars to receive the necessary knowledge and skills with ITS resources.
	Annual NJ Public Works Expo	Generate knowledge and skills to foster a world class workforce for the	CAIT partnered with the American Public Works Association, NJ Chapter to conduct workshops	Professionals in the public works field were trained in basic work zone safety for routine

		transportation sector.	on construction inspection and work zone safety during the annual expo.	and short term maintenance projects and basic construction inspection for municipal projects.
	NJ Association of Counties Conference	Generate knowledge and skills to foster a world class workforce for the transportation sector.	CAIT partnered with the NJ Association of Counties to provide a workshop on pavement management for local officials.	Local officials in county government learned about pavement management techniques and financial considerations from CAIT pavement expert.
<b>Technology Transfer</b>	FHWA Sustainable Pavements Technical Working Group	Support research products that can make significant and meaningful impacts	CAIT faculty was invited to present research project results at an FHWA Pavements event.	Information on the sustainability of pavement was exchanged by infrastructure experts at a FHWA-sponsored event.
	ASCE Opal Awards Gala (March, 2014)	Support research products that can make significant and meaningful impacts	Charles Pankow Award for Innovation	The RABIT bridge deck inspection tool was awarded the Pankow Award for Innovation, which honors innovation and collaboration in the design and construction industry.
	ASCE New Jersey Section's 40th Annual Awards Dinner (May 9, 2014)	Support research products that can make significant and meaningful impacts	Project of the Year	CAIT'S RABIT was named the Project of the Year by the ASCE New Jersey Section.
	Long Term Bridge Performance Program Information Exchange with Japan (June 19, 2014)	Support research products that can make significant and meaningful impacts	CAIT coordinated the exchange of information with Japanese bridge engineers.	Information on LTBP practices, and the function and projects of each program were exchanged

				between Japanese and CAIT bridge engineers.
	FHWA EDC2/SHRP 2 Traffic Incident Management Responder Training	Support research products that can make significant and meaningful impacts	CAIT coordinated two Train the Trainer programs for the SHRP 2 product.	As part of FHWA Every Day Counts 2, participated in and hosted the Train the Trainer program in partnership with NJDOT and its partners, to produce 100+ trainers.

**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.
- Execute the plans for the 2014 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.

- **TECHNOLOGY TRANSFER ACTIVITIES:**

- Continue to host EDC Exchange Webinars (March)

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

**Research projects awarded**

Reviewed and approved eight new research projects:

- “Utilization of a Pneumatic Tube Mixing Technique for Processing and Stabilization of Contaminated Dredge Material” (Rutgers University)

- “Addressing the issue of insufficient information in data-based bridge health monitoring” (Columbia University)
- “Cloud-based Federation and Fusion of Distributed Geospatial Data Sources for Supporting Hurricane Response: Requirements, Challenges and Opportunities” (Rutgers University)
- “Evaluation of Uncertainty in Determination of Neutral Axis and Deformed Shape of Beam Structures” (Princeton University)
- “Performance Life of HMA Mixes” (University of Texas at El Paso)
- “Effects of Temperature on Bridge Dynamic Properties” (Utah State University)
- “Evaluating the Effectiveness of Traffic Diversion and Managed Lanes on Highway Work Zones ” (New Jersey Institute of Technology)
- “Environmental Assessment of Airport Pavement Design and Construction Alternatives” (Rutgers University)

### **Publications, conference papers, and presentations.**

#### **Journal publications**

- Y. Yao and B. Glisic (2014). “Sensing sheets: optimal arrangement of dense array of sensors for an improved probability of damage detection”. (Submitted to Structural Health Monitoring, under review)
- S-T. Tung, Y. Yao and B. Glisic, 2014. “The sensitivity of thin-film full-bridge strain sensors for crack detection and characterization”, *Measurement Science and Technology*, 25(7), art. no. 075602 (14pp).
- Y. Yao, S-T. Tung and B. Glisic, 2013. “Crack detection and characterization techniques – an overview”, *Structural Control and Health Monitoring*. (published online first, in press)
- Higgs, A., Barr, P.J. and Halling M.W. “Comparison of Residual Prestress Forces, Shear and Flexural Capacity of High Strength, Prestressed Concrete Bridge Girders.” Accepted to the *ASCE Journal of Bridge Engineering*. December 2013.
- Structural Health Monitoring with Small Size Samples, L. Balsamo, and R. Betti.
- H. Wang, R. Gangaram, P. Szary (2014) “Life Cycle Assessment of Pavement Preservation at Construction and Usage Stages Corresponding,” *Transportation Research Part D: Transport and Environment*

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

“Nothing to Report”

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

- S-T. Tung, Y. Yao and B. Glisic. “Crack identification based on thin-film full-bridge strain sensors,” *SPIE Smart Structures/NDE*, San Diego, USA, March 2014.
- Y. Yao and B. Glisic. “Probabilistic Damage Detection Based on Large Area Electronics Sensing Sheets,” *The 7th European Workshop on Structural Health Monitoring*, Nantes, France, July 2014.
- Y. Yao, S-T. Tung and B. Glisic. “High-resolution sensing sheet for damage detection based on large area electronics,” *The 7th International Conference on Bridge Maintenance, Safety and Management*, Shanghai, China, July 2014.
- Cook, W., Barr, P.J. and Halling, M.W. “Segregation of Bridge Failure Causes and Consequences.” *Proceedings, Annual Transportation Research Board*, Washington, D.C., January 2014.
- Foust, N.R., Halling, M.W. and Barr, P.J. “Statistical Models of a Concrete Bridge: Changes in Modal Parameters due to Temperature.” Boston, MA, *ASCE Structures Congress*. April, 2014.



- Higgs, A., Maguire, M., Halling, M.W. and Barr, P.J. "Shear and Flexural Capacity of Salvaged High-Strength, Self-Consolidating Prestressed Concrete Bridge Girders." Washington DC, PCI-NBC Conference. Sept. 2014.
- Damage detection using large-scale covariance matrix, L. Balsamo, R. Betti, H. Beigi, Proceedings of the 32nd 2014. International Modal Analysis Conference, Orlando, FL, USA,
- Halbe, K., Field, C., Joyce, P. Roberts-Wollmann, C.L., and Cousins, T., "Spliced Connections for Adjacent Precast Member Bridges using Ultra- and Very- High Performance Concrete", paper accepted to 2014 PCI Convention.
- Zolghadri, N. Halling, M.W. and Barr, P.J. "Comparison of Wireless and Wired Structural System Identification." Boston, MA, *ASCE Structures Congress*. April, 2014.
- Zeng, Yun, "Stochastic modeling and simulations of transient networks: Soft materials, gels and concentrated surfactants," mini symposium talk at the Society of Rheology meeting in Pasadena Feb. 2014.
- Greer, Alex, "Understanding the Relationships between Household Decisions and Infrastructure Investment in Disaster Recovery: Cases from Superstorm Sandy" Presented at the IRCD/Natural Hazard Center Researchers Meeting, Colorado, June 2014.
- Greer, Alex, and Israt Jahan, (2014). "Understanding the Relationships between Household Decisions and Infrastructure Investment in Disaster Recovery: Cases from Superstorm Sandy." Delaware Center for Transportation PI/PM Research Showcase. Dover, DE. May 7
- Shariati, A., Schumacher, T., and Ramanna, N. (2014). Video-Based Structural Health Monitoring. Delaware Center for Transportation PI/PM Showcase. Dover, DE. May 7.
- Ramanna, N. (2014). Innovative NSM-CFRP Retrofitting of Concrete Beams and Slabs under Static and Impact Loads. Delaware Center for Transportation PI/PM Research Showcase. Dover, DE. May 7
- Imhoff, P. and P. Chu, "Integrating Zero-Valent Iron and Biochar Amendments in Green Stormwater Management Systems for Enhanced Treatment of Roadway Runoff" Delaware Center for Transportation PI/PM Research Showcase. Dover, DE. May 7.
- Greer, Alex, "Understanding the Relationships between Household Decisions and Infrastructure Investment in Disaster Recovery: Cases from Superstorm Sandy" Poster Natural Hazards Workshop, Colorado, June 2014.
- McNeil, Sue, Farzana Atique, Ryan Burke and Susanne Trimbath, "Using the Transportation Performance Index to Understand the Impact of Regional Plans," Proceedings of the ASCE TD&I Congress, Orlando, June 2014.
- Tian, J., Yi, S., Imhoff, P.T., Chiu, P., Guo, M., Maresca, J.A., Beneski, V., and S.H. Cooskey "Biochar-Amended Media for Enhanced Nutrient Removal in Stormwater Facilities," Conference paper for the ASCE EWRI World Environmental & Water Resources Congress 2014, Portland, Oregon June 1-5, 2014.
- Halbe, K., Field, C., Cousins, T., and Roberts-Wollmann, C., "Splice Lengths for No. 4 and No. 6 bars in UHPC and VHPC".

#### **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**

- Under research project entitled "Quantitative Acoustic Emission Monitoring of Fatigue Cracks in Fracture Critical Steel Bridges", a seismology-based technique has been implemented and

evaluated to monitor and quantitatively describe acoustic emissions caused by steel fatigue cracking.

- Under research project entitled “Exploration of Video-Based Structural Health Monitoring Techniques”, a technique to monitor structural vibrations is being developed based on variations in the intensity of pixels with fixed, or Eulerian specified, coordinates in digital videos. The idea differs from traditionally used approaches that are tracking features in space and time (Lagrangian-based). The advantage is that our proposed approach is simpler and computationally much more inexpensive.
- Under research project entitled “Bridge Response Due to Temperature Variations”, empirical relationships of ambient temperature and average bridge temperature were developed.

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

- Schumacher, T. and Shariati, A. (2014). Monitoring of Structures and Mechanical Systems Using Digital Videos. United States Provisional Patent. Application # 61941667. Receipt Date: February 19.

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

- Schumacher, T. and Shariati, A. (2014). Video-Based Structural Health Monitoring. Technical communication during the AFF40(1) committee meeting at the Transportation Research Board (TRB) 93rd Annual Meeting. Washington, D.C. January 12-16.
- Schumacher, T. and Shariati, A. (2014). Video-Based Structural Health Monitoring. University of Delaware University Transportation Center (UD-UTC) Brown Bag Discussion. Newark, DE. March 4.
- Greer, Alex, Joseph Trainor and Sue McNeil, (2014). “Understanding the Relationships between Household Decisions and Infrastructure Investment in Disaster Recovery: Cases from Superstorm Sandy,” CAIT at UD Brown Bag, March.
- Tian, Jing, “Enhancing Nitrogen Removal in Stormwater Facilities for Transportation”, UTC Brown Bag seminar, 3/11/14;
- DeCoursey, BJ, and Jeremy Rothwell, “Defining and Quantifying State of Good Repair (SGR) for the Pedestrian Network,” Brown Bag Discussion, 4/22/2014.
- Ramanna, Nakul, “Guidelines for embedment length of carbon fiber reinforced polymer (CFRP) strips in near surface mount (NSM) retrofitted concrete structures,” Brown Bag Discussion, 5/6/2014
- Attoh-Okine, Nii and Pam Cook, “Asphalt: Rheology and strengthening through polymer binders” Brown Bag Discussion, May, 2014.

### **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
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
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

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

- **collaborations with others within the lead or partner universities; especially interdepartmental or interdisciplinary collaborations**
  - **Partner Meeting/Communication:** the partners have plenty of communications and virtual meetings through the year.
- **collaborations or contact with others outside the UTC**
  - Dr. Ed Zhou, the head of Infrastructure and Bridge Division at URS Corporation, gave a presentation about activities at URS to an audience at CAIT.
- **collaborations or contacts with others outside the United States or with an international organization (country(ies) of collaborations or contacts).**
  - Kenji Yoshitake and Dr. Wakahara of the Cross-Ministerial Strategic Innovation Promotion have engaged in exchanging information with CAIT regarding long term bridge performance programs and practices.

**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>
“Utilization of a Pneumatic Tube Mixing Technique for Processing and Stabilization of Contaminated Dredge Material” (Rutgers University)	The primary goal of this proposal is to demonstrate the viability of a pneumatic tube mixing method for the processing and handling of contaminated navigational dredged materials from the NY/NJ harbor system.	The results should demonstrate 1) that pneumatic tube mixing is a cost effective, repeatable, and more consistent method for the amendment of dredged materials and 2) to document how the process is best conducted in the field.
“Cloud-based Federation and Fusion of Distributed Geospatial Data Sources for Supporting Hurricane Response: Requirements, Challenges and Opportunities” (Rutgers University)	The objective of this project is to explore the potential of cloud-based federation and fusion of distributed geospatial data sources to support hurricane response.	The outcome of this research will contribute to improving the security and resilience of the critical infrastructures.
“Environmental Assessment of Airport Pavement Design and Construction Alternatives” (Rutgers University)	The proposed research is to develop an environmental assessment tool to quantify the emission during the construction and maintenance phases of airport pavement.	This environmental assessment tool can help airport authorities incorporate environmental sustainability into their decision-making process.
“Addressing the Issue of Insufficient Information in Data-Based Bridge Health Monitoring” (Columbia University)	The goal is to develop, investigate and validate, through numerical and experimental test data, techniques to address the issues and consequent limitations related to scarcity of measured data in data-based bridge health monitoring.	Through this new approach, bridge engineers will be able to create more reliable data-based models using the same amount of recorded data.
“Evaluation of Uncertainty in Determination of Neutral Axis and Deformed Shape of Beam Structures” (Princeton University)	The overall objective is to research and develop universal SHM methods based on strain monitoring using series of parallel long-gauge fiber-optic sensors.	The creation of robust data analysis algorithms for damage identification and structural identification will be useful to (1) owners or managers of structures that implement and benefit from SHM system (e.g., FHWA, DOTs); (2) providers of SHM solutions (e.g. companies that provide instrumentation and data analysis solutions for SHM) and (3) researchers in the area of SHM.
“Performance Life of HMA Mixes”	This project focuses on evaluating	The product of this research will

(University of Texas at El Paso)	and validating the performance lives of common mixes.	provide a comprehensive tool relating the HMA mix to performance by means of linking the mix type, design and construction information, and pavement management information data.
“Effects of Temperature on Bridge Dynamic Properties” (Utah State University)	The goal of this study is to rigorously determine the effect that changes in temperatures throughout a bridge have on the dynamic properties of the bridge.	The data provided by all these bridges will make it possible to advance toward a true smart bridge by providing a methodology for detecting changes in the bridge condition.
“Evaluating the Effectiveness of Traffic Diversion and Managed Lanes on Highway Work Zones” (NJIT)	The objective of the proposed study is to develop an analytical model that can be used to quantify effects of the planned traffic diversion and managed lanes (i.e., the use of road shoulders) for work zones on multi-lane highways.	The findings of this research will help determine a guideline on selecting strategies to mitigate traffic congestion and GHG emission as well as accidents that deteriorates the highway infrastructure performance.

#### ONGOING RESEARCH PROJECTS

<b>Outputs</b>	<b>Expected Outcomes</b>	<b>Impacts</b>
“Forensic Testing of Post Tensioned Concrete Girders” (Utah State University)	The goal of this project is to obtain better estimations of the condition of a state's bridge inventory by studying the behavior of in service prestressed concrete bridges.	It is expected that the research findings will result in design recommendations that will directly impact operation and maintenance practices as well as new construction planning.
“Bridge Response Due to Temperature Variations” (Utah State University)	The goal of this research is to quantify the effects of daily temperature variations on the behavior of concrete bridges.	Analysis of data on the effects of temperature variations will have direct implications for operation and maintenance practices as well as new design procedures.
“Evaluation of Repair Techniques for Impact Damaged Prestressed Beams” (Virginia Polytechnic Institute)	The objectives of this research are to evaluate existing methods of repair of impact damaged precast, prestressed bridge beams, and develop guidelines for best methods for evaluation and repair.	It is envisioned that the policy developed will be adopted by VDOT for their use in evaluating and repairing impact damaged prestressed concrete bridge beams.
“Guidelines for Embedment Length of Carbon Fiber Reinforced Polymer (CFRP) Strips in Near Surface Mount (NSM) Retrofitted Concrete Structures” (University of Delaware)	Research outcome includes new technical guidelines for the use of NSM-CFRP strips and MATLAB code to capture experimental bond behavior of strengthened member.	NSM-CFRP strengthening technique has a huge potential for considerably increasing the service life of structures.

<p>“Understanding the Relationships between Household Decisions and Infrastructure Investment in Disaster Recovery: Cases from Superstorm Sandy” (University of Delaware)</p>	<p>The focus of this exploratory project is to connect the qualitative data provided by adult members of households that sustained substantial damages from Hurricane Sandy to the quantitative data that are used in the planning and infrastructure decision making process.</p>	<p>A workshop with representatives of impacted communities, Federal and state Emergency Management Agencies, the relevant MPOs, and state DOTs will be held to better explore the integration of the qualitative data into the household decision making process.</p>
<p>“ Asphalt : Rheology and Strengthening through Polymer Binders” (University of Delaware)</p>	<p>The goal of this project is to work cross-discipline (pavement engineering and mathematical science) to carry out experiments (laboratory and field studies) and couple those results with mathematical modeling to better understand the properties of polymer modified asphalts.</p>	<p>An attempt will be made to introduce the proposed methodology as part of a mechanistic pavement design approach. A series of numerical and design examples will be provided to guide engineers in selecting the inputs for analysis.</p>
<p>“Defining and Quantifying State of Good Repair (SGR) for the Pedestrian Network” (University of Delaware)</p>	<p>The primary goal of this proposal is to propose guidelines as to what constitutes a SGR for the pedestrian network, with priority placed on the contextual setting more so than the adjacent roadway classification.</p>	<p>The result of the research is expected to provide state and local governments with a better understanding of the concept of SGR and how it may be applied to pedestrian and bicycle infrastructure at the state and local government levels.</p>
<p>“Exploration of Video-Based Structural Health Monitoring Techniques” (University of Delaware)</p>	<p>The objective of this research is to evaluate advanced video-based techniques for SHM of civil infrastructure.</p>	<p>Research products include novel remote monitoring techniques for capturing the dynamic response of structures. Once the algorithm has been implemented and evaluated, it can be deployed to monitor critical structures, e.g. bridges, in the field.</p>
<p>“Forensic Testing of a Double Tee Bridge” (Utah State University)</p>	<p>By studying the behavior of in service prestressed concrete double tee bridges, better estimations of the condition of a state's bridge inventory can be quantified.</p>	<p>This research has direct implications for operation and maintenance practices as well as new construction planning. It is anticipated that the results of this research will be used to help engineers make informed decisions in terms of capacity of in-situ prestressed concrete bridges made with double tee girders.</p>
<p>“A Multi-objective Sustainable Model for Transportation Asset</p>	<p>This research will provide a holistic multi-objective asset management</p>	<p>The multi-objective asset management model will improve</p>

<p>Management Practices” (University of Texas at El Paso)</p>	<p>approach integrating environmental related measures with traditional indicators in order to provide a robust framework for implementation.</p>	<p>the current decision making process of local and state agencies.</p>
<p>“Performance Determination of Precast Concrete Slabs used for the Repair of Rigid Pavements” (University of Texas at El Paso)</p>	<p>The goal is to provide a better understanding of the mechanical behavior of the precast concrete panels considering the temperature variation in the field.</p>	<p>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.</p>
<p>“COLLABORATIVE PROPOSAL: Enhancing Nitrogen Removal in Stormwater Treatment Facilities for Transportation” (University of Delaware and Rutgers University)</p>	<p>The objective of this project is to conduct laboratory-based studies that will enable to elucidate the mechanisms by which biochar mixed with soil is able to reduce nutrients in a pilot-scale system.</p>	<p>New treatment technologies, like the one considered in this project, are needed that significantly reduce the footprint required for stormwater systems treating roadway runoff - which would result in significant cost reductions for State DOTs.</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.</p>	<p>Improve the state-of-good repair of multimodal transportation infrastructure systems.</p>
<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 health 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>
<p>“Highly Efficient Model Updating for Structural Condition Assessment of Large-scale Bridges” (University of Texas at El Paso)</p>	<p>The objective is to propose a high-speed, highly efficient model updating technique for structural condition assessment of large-scale bridges.</p>	<p>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,</p>

		and significantly reduces the life-cycle costs of bridges.
“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)	The research team will develop and evaluate a prototype of a novel 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.	Potential future implementations of this sensing approach include: an 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.
“COLLABORATIVE PROPOSAL: Numerical Simulation of Intelligent Compaction Technology for Construction Quality Control”(University of Texas at El Paso and Rutgers University)	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.	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.
“COLLABORATIVE PROPOSAL: Big Data: Opportunities and Challenges in Asset Management” (Rutgers University, University of Delaware and Utah State University)	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.	The product of this research will be a catalog of tools and techniques to support asset management.
“COLLABORATIVE PROPOSAL: Evaluation of Biotechnologies for Flexible Pavement Applications” (Rutgers University, University of Delaware and University of Texas at El Paso)	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.	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.
“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.	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.

## RESEARCH PROJECTS COMPLETED

Outputs	Expected Outcomes	Impacts
“Improved Connection Details for Adjacent Prestressed Bridge Beams”	The primary outcome of the project will be recommendations for	Bridges constructed with the new details are expected to have longer



(Virginia Polytechnic Institute)	improved connection details for adjacent precast/prestressed member bridges.	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.
“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 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.
“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.	This research supports the US DOT’s SGR Strategic Goal by utilizing data from the LTBP 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.
“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.
“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 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 completion of the project will have direct impact in the area of Advance/Innovative Materials and a major influence on the modeling

	and couple those results with mathematical modeling.	and evaluation of innovative asphalt material.
“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.
“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 capable of ascertaining the interactions between the marine terminal operations and a highway system that provides access to the port.	It is expected that the type of analysis provided by this modeling framework will find application in regional strategic planning.
“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.	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 service on surrounding highway system.	The findings will help determine critical truck volume (or demand), defined as a truck volume that deteriorates the highway infrastructure performance below 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.
“Development of A Real-Time Vibrator Tracking System for Intelligent Concrete Consolidation”	The purpose of this research is to develop a real-time vibrator tracking based intelligent concrete	This new tool can significantly benefit concrete bridge construction and retrofitting by

(Rutgers University)	consolidation system.	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).	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: Analyzing Asset Management Data Using Data and Text Mining” (Rutgers University and Utah State University)	The objective of the study is to produce models that are useful for identifying infrastructure deficiencies.	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 SGR.

Final research reports for projects completed during this reporting period will be posted on Center’s websites and distributed to designated repositories.

#### RESEARCH PROJECTS REPORTED PREVIOUS PERIODS

- “ABC Deck Panel Testing” (Utah State University)
- “Forensic Testing of Prestress Concrete Girders after Forty Years of Service” (Utah State University)
- “Fiber Optic Monitoring Methods for Composite Steel-concrete Structures Based on Determination of Neutral Axis and Deformed Shape” (Princeton University)
- “Correlation between Hurricane Sandy Damages along NJ Coast with Land Use, Demographic and Other Local Characteristics” (Rutgers University)
- “Quantitative Acoustic Emission Monitoring of Fatigue Cracks in Fracture Critical Steel Bridges” (University of Delaware)
- “Elevated Temperature Properties of Weathering Steel (Princeton University)
- “Warehouse Location and Freight Attraction in the Greater El Paso Region” (University of Texas at El Paso)
- “Development of a Bridge Resource Program for the New Jersey Department of Transportation” (Rutgers University)

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

- “Highly Efficient Model Updating for Structural Condition Assessment of Large-scale Bridges” (conducted at UTEP): This project developed a new technique to perform model updating for large-scale bridges, which is faster and more accurate than traditional approaches. This technique can be applied to model structures in other fields, such as mechanical engineering and aerospace engineering.
- “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): Creation of sensing sheets requires collaboration with researchers in the area of electrical engineering, which cross-fertilizes both disciplines. In addition, sensing sheets can be used in applications in materials and mechanical engineering, where they can provide with fine-grained information on damage to materials and machines.

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

<b>Outputs</b>	<b>Outcomes/Impacts</b>
I-95 Corridor Coalition Freight Academy	Educated public agency professionals on transportation issues and their roles on the influence of these professionals on the various aspects of freight transportation.
15th Annual Work Zone Safety Conference	Brought together multidisciplinary audience of public safety, highway construction, engineers, planners, and regulatory agencies to address work zone safety.
ITS Resource Program Training	Educated NJDOT personnel on work zone design.
Educational events for pre-collegiate students	Spreading awareness of opportunities in transportation to students, and encourage their pursuit of transportation as a viable career possibility through engagement in activities and events.

**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.

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

<b>Outputs</b>	<b>Outcomes/Impacts</b>
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.
Educated county governments about pavement preservation/pavement management	Provides decision makers with information to make educated decisions about local government planning and spending.

**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”