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

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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

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Report Term or Frequency: Semiannual (1/1/15-6/30/15)

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?

Major Goal Area	Major Activities	Specific Objectives	Significant Results	Key Outcomes
Research	Research Selection	Select projects that make significant and meaningful impacts during the lifetime of the grant.	Several projects have cleared the pre-proposal stage and are now being developed by the PI's for full submission and review.	10 new projects were approved this period.
Education and Workforce Development	Transportation and Dance Program	Generate knowledge and skills to foster a world class workforce for the transportation sector.	CAIT at Delaware taught engineering concepts through interdisciplinary lesson plans that unite the engineering principles with dance.	Fifth grade students were introduced to engineering concepts in a manner that is fun and engaging.
	Future Cities Competition	Generate knowledge and skills to foster a world class workforce for the transportation sector.	CAIT provides mentorship to student teams at Keyport Central Middle School.	6th, 7th, and 8th grade students were exposed to the process and practices of engineering with the aim of building the cities of the future.
	2015 Outstanding AAA School Safety Patrols of the Year (April 24, 2015)	Generate knowledge and skills to foster a world class workforce for the transportation sector.	CAIT staff member Dave Maruca was a guest presenter at the 2015 Outstanding AAA School Safety Patrols of the Year Awards.	CAIT encourages and celebrates the development of leadership skills in elementary school students.
	Challenge Project WTS Transportation YOU Summit 2015 (June 2015)	Generate knowledge and skills to foster a world class workforce for the transportation sector.	CAIT aided in the development of the 2015 Summit, helped organize the comprehensive Summit activities, and led the effort of producing the Challenge Project.	CAIT aided in the exposure of 20-23 high school girls to transportation and engineering practices, and encouraged their career development through this program.
Technology Transfer	CUTC Summer Meeting (June 2015)	Support research projects that have significant and	This event, hosted by CAIT, will facilitate	Nearly 175 UTC researchers and administrators will

		meaningful impacts	communication between UTC administrators nationwide, generate cross-country research collaborations, and create new policies and products founded on UTC research	attend the conference to network with other university researchers, learn how to maintain research collectives that align with USDOT goals, and produce meaningful research projects that have national applications
	FHWA EDC2/SHRP 2 Traffic Incident Management Responder Training	Support research products that can make significant and meaningful impacts	CAIT help two additional training 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.
	16th Annual Work Zone Safety Conference (April 2015)	Support research projects that have significant and meaningful impacts	Provides a forum for public and private sector, multi-disciplinary attendees, to learn best processes and best practices.	250+ contractor personnel, NJDOT employees, NJ Turnpike employees, law enforcement, engineers, consultants, and local public agencies attended this event coordinated by CAIT.

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 OSTR. 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.
- **TECHNOLOGY TRANSFER ACTIVITIES:**
  - Continue to host EDC Exchange Webinars (March)

2. <u>PRODUCTS</u>: What has the program produced?

Research projects awarded

10 new projects were awarded during this period.

Publications, conference papers, and presentations.

Journal publications

- Shariati, A., Schumacher, T., and Ramanna, N. (2015). Eulerian-Based Virtual Visual Sensors to Detect Natural Frequencies of Structures. Journal of Civil Structural Health Monitoring. Available online first as of June 23. DOI: 10.1007/s13349-015-0128-5.
- A paper titled, "Behavior of 48-Year old, Double-Tee Girders, made with Lightweight Concrete" was submitted for publication in the Journal of Bridge Engineering.
- Sigurdardottir D.H, Glisic B. (2015). On-site validation of fiber-optic methods for structural health monitoring: Streicker Bridge, Journal of Civil Structural Health Monitoring, DOI 10.1007/s13349-015-0123-x (21pp, online first).
- "A Multi-Objective Asset Management Approach to Evaluate Maintenance Strategies for Funding Allocation". Ninth International Conference on Managing Pavement Assets. Blacksburg, Virginia, June, 2015.
- "A Framework to Integrate On-Street Bikeway Maintenance into Pavement Management Practices". Transportation Research Record 2015. Washington D.C., U.S. January 2015.
- "Environmental-Related Performance Measures Framework for Sustainable Asset Management Practices' presented at 3rd International Conference on Transportation Infrastructures (ICTI) in April 2014, Italy.

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

"Nothing to Report"

Other publications, conference papers and presentations.

- Tian, J., Yi, S., Imhoff, P., Chiu, P., Guo, M., Maresca, J., Beneski, V., and Cooksey, S. (2014) Biochar-Amended Media for Enhanced Nutrient Removal in Stormwater Facilities. 2014 World Environmental and Water Resources Congress, pp. 197-208. doi: 10.1061/9780784413548.022.
- Shariati, A. and Schumacher, T. (2015). Oversampling in Virtual Visual Sensors as a Means to Recover Higher Modes of Vibration. AIP Conference Proceedings (Proceedings of QNDE. Boise, ID. July 20-25, 2014). Vol. 1650, pp. 1717-1724. DOI: 10.1063/1.4914793.

- Delaware Center for Transportation Research Showcase, Dover, DE. Poster presentation. "Pilot Demonstration of Enhanced Nitrate Removal through Incorporation of ZVI and Biochar into a Stormwater Bioretention Cell."
- Shariati, A. and Schumacher, T. (2015). Structural Health Monitoring Using Digital Videos: an Approach Based on Virtual Visual Sensors. SEI-ASCE Structures Congress. Portland, OR. April 23-25.
- Shariati, A. and Schumacher, T. (2015). Video-Based SHM: Research Update. Technical communication during the AFF40(1) committee meeting at the Transportation Research Board (TRB) 94th Annual Meeting. Washington, D.C. January 11-15.
- Department of Civil and Environmental Engineering, Penn State University, University Park, PA. "Microbial Nitrate Reduction Promoted by Zero-Valent Iron and Biochar."
- Schumacher, T. (2015). Novel Distributed Sensing Methodologies for NDT and SHM of Bridges. Construction Material Seminar. University of Illinois at Urbana-Champaign, Champaign, IL. March 4. (invited).
- Department of Civil and Environmental Engineering, University of Virginia, Charlottesville, VA. "Microbial Nitrate Reduction Promoted by Zero-Valent Iron and Biochar."
- Wells, Z.G., Barr, P.J., James, P.J. and Halling, M.W. "Performance of Transverse Joints of Precast Decks using Post Tensioned, Curved-Strand Connections." Miami, Fl. 2014 Accelerated Bridge Construction Conference. Dec. 2014.
- Laurendeau, M., Barr, P.J., Higgs, A. and Halling, M.W. "Live-Load Testing of a Steel Cantilevered Deck Arched Preatt Truss Bridge." Portland, OR, ASCE Structures Congress. May 2015.
- Sigurdardottir, D., Flanigan, K., Glisic, B. (2015). In-service monitoring of US202/NJ23 highway overpass: four-year overview, 7th International Conference on Structural Health Monitoring of Intelligent Infrastructure (SHMII-7), Turin, Italy, paper on conference CD002E
- "Innovative Work Zone Management in Regional Highway Projects", presentation and panel discussion, Wasif Mirza , Director, Division of Mobility and Systems Engineering, NJ DOT, April 2015.

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 "Numerical Simulation of Intelligent Compaction Technology for Construction Quality Control", the researchers developed a numerical model of soil response due to roller compaction and light weight deflectometer testing that incorporates the MEPDG constitutive model for base and subgrade. This model advances towards a better representation of the compaction process as it considers contact models and provides a step further by considering the material nonlinearity.
- Under research project entitled "Improving Connection Details for Adjacent Prestressed Bridge Beams", the connection detail for adjacent box beams was modified and used as a retrofit technique on the Buffalo Branch Bridge near Staunton, VA. The repair was performed in the last week of June 2015.
- Under the research project entitled "Enhancing Nitrogen Removal in Stormwater Treatment Facilities for Transportation", the study produced the knowledge that is necessary to guide future design and implementation of field-scale stormwater treatment systems. The proposed biochar/ZVI technology presents a promising and sustainable approach to stormwater management. It could

reduce the footprint required for stormwater treatment and potentially provide significant savings for state DOTs.

Inventions, patent applications, and/or licenses

Nothing to report.

Other products: outreach activities, courses and workshops

Nothing to report.

3. <u>PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS</u>:

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?

Organization Name	Location of Organization	Partner's contribution to the project
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
Bridge Diagnostics Inc.	Boulder, CO	Collaborative research
The Biochar Company	Berwyn, PA	Collaborative research
Ramaiah Institute of Technology	Bengaluru, Karnataka, India	Personnel exchange
Old Dominion University	Norfolk, VA	Collaborative research
ArtsBridge		Personnel exchange, Collaborative educational projects
Metropolitan Transportation Commission	San Francisco Bay Area, CA	Collaborative research
Applied Research Associates Inc.	Panama City, FL	Collaborative research
Western Transportation Institute at Montana State University	Bozeman, MT	Collaborative research
reGenesis Consulting Services, LLC	Columbia, SC	Collaborative research
Technologies for Safe and Efficient Transportation	Pittsburgh, PA	Collaborative educational projects

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.
- Delaware Environmental Institute, University of Delaware
- ArtsBridge, University of Delaware: The transportation and dance program integrates transportation knowledge with dance. The information is transformed into classroom lessons for 5th grade students, and allows the students to gain knowledge from two disciplines simultaneously.

• collaborations or contact with others outside the UTC

- Dr. Toni Nanni, University of Miami: Collaborated with Virginia Tech on the VCTIR repair project.
- Vanessa Pino, University of Miami: Collaborated with Virginia Tech on the VCTIR repair project.
- Charles H. Hegberg, reGenesis Consulting Services
- Dr. Marianne Walch, Environmental Scientist of the Delaware Department of Transportation: Dr. Walch has collaborated on the project entitled “Enhancing Nitrogen Removal in Stormwater Treatment Facilities for Transportation”.
- Applied Research Associates Inc.: On the project entitled “Performance Determination of Precast Concrete Slabs Used for the Repair of Rigid Pavements”, ARA collaborated in data collation and through the sharing of historical data.
- Metropolitan Transportation Commission: On the project titled “Multi-objective Sustainable Model for Transportation Asset Management Practices”, MTC allowed access to the pavement management system and shared historical data.

- Dr. Zia Razzaq, Professor, Civil Engineering, Old Dominion University
- Jason Arndt, Bridge Maintenance Engineer, Delaware Department of Transportation
- Ioannis Koutromanos has served as a Co-PI from the VCTIR matching project for the UTC project "Evaluation of Repair Techniques for Imact Damaged Prestressed Beams", and has served in an advisory role to students performing finite element analysis on this project.
- Jeevanjot Singh, New Jersey Department of Transportation: He has collaborated with the NJIT research team on the project titled "Work Zone Mobility Monitoring Program".

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

- Dr. Ramappa Prabhakara, Professor and Department Head, Civil Engineering, Ramaiah Institute of Technology, Bangalore, India: Dr. Prabhakara has collaborated on the project titled "Guidelines for Embedment Length of Carbon Fiber Reinforced Polymer (CFRP) Strips in Near Surface Mount (NSM) Retrofitted Concrete Structures".
- Rutgers CAIT is a partner in the project entitled "Sustainable Design and Management of Industrial Assets through Total Value and Cost Ownership" awarded to Politecnico di Milano in collaboration with the University of Cambridge and the Universidad de Sevilla by the MARIE SKŁODOWSKA-CURIE ACTIONS Research and Innovation Staff Exchange (RISE). Rutgers is part of the project academic partnership which includes other institutions of higher education such as the University of Pretoria, South Africa, India Institute of Technology, Pontificia Universidad Catolica de Valparaiso, Chile and Pontificia Universidad Catolica del Peru as well as experts from industrial companies. The involvement will be achieved through the hosting of interviews and workshops related to how life cycle management is possible thanks to total value and cost of ownership with the goal of providing the asset owner with the capability of developing a sustainable factory according to economic and environmental requirements of the local industry.

4. <u>IMPACT:</u> 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

Outputs	Expected Outcomes	Impacts
"Impact of Gradation and Moisture Content on Stiffness Parameters of Base Materials" (University of Texas at El Paso)	The goal of this study is to evaluate the behavior of the base materials with different gradations and moisture contents for the construction of pavements.	This research provides a cost-effective solution for selection of sustainable and durable material for construction of a stable pavement foundation, and contributes in the reduction of repair and maintenance work during the operation phase of the pavement.
"Traffic Safety Measures Using Multiple Stream Real Time Data" (Rutgers University)	The main objective of this project is to build advanced analytics to estimate a	The proposed analytics opens up a new frontier for the connected vehicle and smart car

	composite traffic safety risk measure that change temporally and spatially, and take into account driver behavior, roadway quality conditions and historical safety characteristics of roadways.	technologies by creating an environment where drivers and vehicles act in a closed loop in the roadway and externalities and allows for these drivers to respond to traffic risks that may be ahead.
"Laboratory for Energy Smart Systems" (Rutgers University)	This project is the initialization of the development of the newly established Laboratory for Smart Energy Systems at CAIT.	The development of this lab will lead to the creation of partnerships with energy-related industry and public agencies to produce a collaborative research program to identify technology challenges and develop tools and solutions to support the adoption of these technological advances.
"Development of an Online Platform for Streamlining Highway LIDAR Data Collection, Sharing, and Processing" (Rutgers University)	This project aims to develop an online platform for sharing, visualizing, and analyzing lidar data to support typical DOT data needs.	An effective data infrastructure for lidar technology offers potential to drastically improve state DOTs' design, operation, and maintenance practices.
"Aerodynamic Flow Deflector to Increase Large Scale Wind Turbine Power Generation by 10%" (Rutgers University)	A proposed aerodynamic flow deflector has been proposed to increase the power generation of wind turbines.	The results of this project could have greatly impact the energy industry, and could lead to the increased adoption of energy harvesting using wind turbine technology. Thus, this aids in the reduction of society's dependence on fossil fuels and moves us further toward an adoption of cleaner energy practices.
"Nondestructive Evaluation of Four Sister Bridges in Virginia Using Manual NDE Technologies and Robotic Platform RABIT" (Rutgers University)	Four sister bridges will be tested using manual NDE technologies and the robotic platform RABIT to quantify the influence of bridge design and traffic on the performance of concrete bridge decks and to evaluate the performance of the RABIT platform in relation to manual NDE technologies.	The utilization of automated platforms for non-destructive evaluation can streamline to process of bridge condition evaluation, and could lead to the adoption of automated platforms in numerous other applications.
"Research Challenges Toward the Implementation of Smart Cities in the United States" (University of Texas at El Paso)	The objective of this project is to identify technological issues and formulate a research agenda for a smart city research program	It is anticipated the results of this review will propose a definition of smart cities that is suitable for implementation in

	beginning with assessments in the areas of smart bridges, smart mobility, and smart buildings.	U.S. cities. Additionally, research topics will be identified for further investigation.
"Biochar as a Rechargeable Geobattery to Promote Nitrogen Removal in Stormwater from Roadways" (University of Delaware)	The goal of this project is to test the hypothesis that biochar is a rechargeable "geo-battery" that can promote microbial nitrate removal from stormwater.	This research will advance a new and environmentally sustainable stormwater technology that can potentially help the USDOT meet the challenge of achieve regulatory requirements with a smaller footprint at reduced costs.
"Tracking Housing Recovery in Sea Bright, NJ and the Relationship to Infrastructure Renewal" (University of Delaware)	This research project aims to be able to measure the rate of housing recovery in Sea Bright NJ since Hurricane Sandy by assessing the progress of the housing recovery and better understanding the state of the transportation infrastructure influences household housing decisions following a disaster.	This project will quantify the influence on demand for transportation services to connect the household decisions to the infrastructure investment decisions.
"Cookbook for Rheological Models – Asphalt Binders" (University of Delaware)	The goal of this effort is to develop a guidebook that provides guidelines for using appropriate rheological models of asphalt binders.	This guidebook will present the effective practices for using rheological (binder) models in pavement analysis and design, and will identify the key advantages/disadvantages of each model.

ONGOING RESEARCH PROJECTS

Outputs	**Expected Outcomes**	**Impacts**
"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" (University of Texas at El Paso)	This project focuses on evaluating and validating the performance lives of common mixes.	The product of this research will 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 planed 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.

"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.
"Understanding the Relationships between Household Decisions and Infrastructure Investment in Disaster Recovery: Cases from Superstorm Sandy" (University of Delaware)	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.	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.
" Asphalt : Rheology and Strengthening through Polymer Binders" (University of Delaware)	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.	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.
"Defining and Quantifying State of Good Repair (SGR) for the Pedestrian Network" (University of Delaware)	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.	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.
"A Multi-objective Sustainable Model for Transportation Asset Management Practices" (University of Texas at El Paso)	This research will provide a holistic multi-objective asset management approach integrating environmental related measures with traditional indicators in order to provide a robust framework for implementation.	The multi-objective asset management model will improve the current decision making process of local and state agencies.
"Performance Determination of	The goal is to provide a better	Rapid repair of damaged rigid

Precast Concrete Slabs used for the Repair of Rigid Pavements" (University of Texas at El Paso)	understanding of the mechanical behavior of the precast concrete panels considering the temperature variation in the field.	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.
"Development of a Comprehensive Hot Mix Asphalt Pavement Specification" (Rutgers University)	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.	Improve the state-of-good repair of multimodal transportation infrastructure systems.
"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.

RESEARCH PROJECTS COMPLETED

Outputs	**Expected Outcomes**	**Impacts**
"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: Multi-	The research team will develop and	Potential future implementations of

Sensor Sheets Based on Large-Area Electronics for Advanced Structural Health Monitoring of Civil Infrastructure" (Princeton University, University of Delaware and Columbia University)	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.	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: 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.
"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.
"COLLABORATIVE PROPOSAL: Enhancing Nitrogen Removal in Stormwater Treatment Facilities for Transportation" (University of Delaware and Rutgers University)	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.	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.

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

- "Forensic Testing of Post Tensioned Concrete Girders" (Utah State University)
- "Bridge Responses Due to Temperature Variations" (Utah State University)
- "Combining Model Based and Data Based Techniques in a Robust Bridge Health Monitoring Algorithm" (Columbia University)
- "Exploration of Video-Based Structural Health Monitoring Techniques" (University of Delaware)
- "Forensic Testing of a Double Tee Bridge" (Utah State University)
- "COLLABORATIVE PROPOSAL: Analyzing Asset Management Data Using Data and Text Mining" (Rutgers University and Utah State University)
- "Mixing and Compaction Recommendations for Warm Mix Asphalt (WMA) with Recycled Asphalt Shingles (RAS)" (Rutgers University)

- "Development of a Real-Time Vibrator Tracking System for Intelligent Concrete Consolidation" (Rutgers University)
- "3D Laser Scanning for Quality Control and Assurance in Bridge Deck Construction" (Rutgers University)
- "Quantifying Impact of Port Truck Traffic on Highway Operations Using GPS-Based Speed Data" (NJIT)
- "The Effects of Network Characteristics on Traffic Flows and Emission" (Rutgers University)
- "COLLABORATIVE PROPOSAL: Analysis of Interactions between the Marine Terminal and Highway Operations" (Rutgers University and NJIT)
- "Railroad Operations Research and Training" (Rutgers University)
- "Life Cycle Assessment of Asphalt Pavement Maintenance" (Rutgers University)
- "Mathematical Modeling and Experimental Responses of Polymer Modified Asphalt" (University of Delaware)
- "Multi-Resolution Information Mining and a Computer Vision Approach to Pavement Condition Distresses" (University of Delaware)
- "Better State-of-Good-Repair Indicators for the Transportation Performance Index" (University of Delaware)
- "Virginia Bridge Information Systems Laboratory" (University of Virginia)
- "Development for Transportation Asset Management Inventory & Management Tools" (Utah State University)
- "Improved Connection Details for Adjacent Prestressed Bridge Beams" (Virginia Polytechnic Institute)
- "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?

- "Effects of Temperature on Bridge Dynamic Properties" (conducted at USU): The aim of this project is to isolate the effects temperature has on the dynamic properties of several bridge types. By determining the correlation between temperature and dynamic properties, the effects due to temperature can essentially be removed from the structural analysis, and the effects of damage to the bridge can be isolated. This analysis can be applied to model structures in other fields, such as mechanical engineering and aerospace engineering.
- "Evaluation of Uncertainty in Determination of Neutral Axis and Deformed Shape of Beam Structures" (Princeton University): This work is likely to make an impact in structural design and construction. Improved knowledge of structural behavior and better understanding of the uncertainties in key parameters could lead to improved designs and safer construction practices. These disciplines can take advantage of the results from this project in two ways. First, by

implementing the technology and directly applying the algorithms and analysis techniques, and second, by exploring the knowledge in this expanding database of real structural behavior and indirectly applying it to the design and construction. Other disciplines that would likely be impacted by the results of this research are mechanical engineering including aerospace engineering, where structural health monitoring is frequently performed.

- "Enhancing Nitrogen Removal in Stormwater Treatment Facilities for Transportation" (conducted at University of Delaware): This study impacts disciplines including environmental engineering and geo-microbiology. It produces empirical evidence to support the underlying hypothesis; i.e. black carbon such as biochar can serve as an electron donor and acceptor to support/enhance microbial transportation reactions. This new finding has important implications for not only stormwater treatment but (bio)remediation of a broad range of contaminants in groundwater and sediment.
- "Aerodynamic Flow Deflector to Increase Large Scale Wind Turbine Power Generation by 10%" (conducted by Rutgers' CAIT): This project develops a new aerodynamic flow deflector that will increase power generation by 10%. This project is mechanical engineering in nature, but the effects will be felt throughout a variety of different fields. This would encourage the implementation of wind turbine generation which would greatly affect the infrastructure, requiring the involvement of civil engineering and systems engineers. Additionally, electrical engineering would be required to restructure to electrical infrastructure to assimilate the developing technology into society.
- "Laboratory for Energy Smart Systems (LESS)" (conducted by Rutgers' CAIT): The foundation of this laboratory is inherently interdisciplinary, and aims to involve all disciplines working in energy and infrastructure to come together to progress the assimilation of new energy technologies into society. At minimum, this would include civil engineers, electrical engineers, mechanical engineers, and systems engineers working together to solve society's energy problems.
- "Research Challenges Toward the Implementation of Smart Cities in the United States" (conducted by UTEP): The adoption of technological advances into the cities would require the collaboration among numerous fields. In addition to civil engineers, this study would require the inclusion of concepts from fields such as computer science, electrical engineering, and systems engineering.

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

Outputs	Outcomes/Impacts
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.
FHWA EDC2/SHRP 2 Traffic Incident Management Responder Training	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.
16th Annual Work Zone Safety Conference (April 2015)	250+ contractor personnel, NJDOT employees, NJ Turnpike employees, law enforcement, engineers, consultants, and local public agencies attended this event coordinated by CAIT, and were provided a forum to learn best processes and best practices.

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?

Outputs	Outcomes/Impacts
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.

5. <u>CHANGES/PROBLEMS</u>

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. <u>SPECIAL REPORTING REQUIREMENTS</u>

"Nothing to Report"