

PROGRAM PROGRESS PERFORMANCE REPORT

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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

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Signature of Submitting Official:

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

What are the major goals of the program?

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

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

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

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

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

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

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

What was accomplished under these goals?

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 new projects have cleared the pre-proposal stage and are now being developed by the PI's for full submission and review.	The Research Advisory Board has already reviewed and approved eleven research projects
Education and Workforce Development	96 th Annual NJ League of Municipalities (November, 2013)	Generate knowledge and skills to foster a world class workforce for the transportation sector	CAIT's research engineers spoke about the benefits of a pavement management system (PMS)	Mayors, local and county engineers, and public works professionals learned how this system can provide them with quantitative information to make the most efficient road maintenance decisions.
	The 15 th Annual NJDOT Research Showcase: Infrastructure and Resiliency: Infrastructure Recovery (October 23, 2013)	Generate knowledge and skills to foster a world class workforce for the transportation sector.	The showcase provided an opportunity for NJDOT customers to experience the broad scope of ongoing research initiatives, technology transfer activities and academic research conducted by university research partners and their associates. Keynote speakers: Jerry DiMaggio, P.E., Second Strategic Highway Research Program (SHRP2) coordinator with the TRB, and Amy Lucero, FHWA technical services director.	Nearly 250 researchers, engineering consultants and NJDOT staff attended the full-day conference and learned about research initiatives and best practices.
	9 th Annual NJ Safety Forum (October 16, 2013)	Generate knowledge and skills to foster a world class workforce for the transportation sector.	The Transportation Safety Resource Center (TSRC) hosted its Annual New Jersey. This year's focus was on local and regional programs that can improve safety	David Kuhn, NJDOT assistant commissioner gave an overview of MAP-21, and its new strategic, performance-based guidelines that encourage

			throughout New Jersey.	organizational partnerships to an audience of 200 transportation professionals, from NJDOT, FHWA, local law enforcement, engineering offices, education systems, and planning organizations.
	Student of the Year	Generate knowledge and skills to foster a world class workforce for the transportation sector.	Selection of Student of the Year	Patricia DiJoseph has been selected SOY. DiJoseph received her doctorate from NJIT in November 2013. In recognition for her achievements, she received the 2013 Doctoral Excellence Award from the Department of Civil and Environmental at NJIT.
	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.
	National Summer Transportation Institute NextGen	Generate knowledge and skills to foster a world class workforce for the transportation sector	CAIT partnered with the Office of Student Development in Rutgers' School of Engineering to promote and support engineering education activities and research skill development.	Middle and high school students learned about the transportation industry and multiple modes of transportation; students learned about post-secondary school careers in transportation.
	Participated in 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 facilitated "lunch and learn" roundtables so female middle and high school students could receive professional

				guidance from established female engineers. These women discussed their professional journeys, successes and obstacles.
	Chapters of ITE and ITS America with the support of NJIT Department of Civil and Environmental Engineering participated in the organization of two seminars	Generate knowledge and skills to foster a world class workforce for the transportation sector.	The seminars geared towards promoting opportunities for research and development in the area of ITS: 1)“Overview of U.S. DOT Connected Vehicle Program,” by Joyoung Lee, Ph.D., Assistant Professor, Department of Civil and Environmental Engineering, NJIT (September 16, 2013) 2)“Transportation Systems Management and Operations,” by Dhanesh Motiani, Assistant Commissioner, New Jersey DOT (Monday, September 30, 2013)	These seminars provided a forum to entice a larger group of graduate students to get involved in transportation research and technology transfer activities.
Technology Transfer	EDC Exchange: Adaptive Signal Control (ASC) Technologies (August 23)	Support research products that can make significant and meaningful impacts	Supports FHWA’s Every Day Counts 2 initiatives	Promotes unified incident response strategies across disciplines.
	EDC Exchange: Intersection and Interchange Geometrics: Safer, Faster, Cheaper! (December 13)	Support research products that can make significant and meaningful impacts	Supports FHWA’s Every Day Counts 2 initiatives	Promotes the benefits of Adaptive Signal Control which include congestion reduction and effectiveness of traffic signal timing.

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.
- Plan 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

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

- "Forensic Testing of Post Tensioned Concrete Girders" (Utah State University)
- "Bridge Response Due to Temperature Variations" (Utah State University)
- "Evaluation of Repair Techniques for Impact Damaged Prestressed Beams" (Virginia Polytechnic Institute)
- "Guidelines for Embedment Length of Carbon Fiber Reinforced Polymer (CFRP) Strips in Near Surface Mount (NSM) Retrofitted Concrete Structures" (University of Delaware)
- "Understanding the Relationships between Household Decisions and Infrastructure Investment in Disaster Recovery: Cases from Superstorm Sandy" (University of Delaware)
- "Exploration of Video-Based Structural Health Monitoring Techniques" (University of Delaware)
- "Asphalt : Rheology and Strengthening through Polymer Binders" (University of Delaware)
- "Defining and Quantifying State of Good Repair (SGR) for the Pedestrian Network" (University of Delaware)
- "Forensic Testing of a Double Tee Bridge" (Utah State University)
- "A Multi-objective Sustainable Model for Transportation Asset Management Practices" (University of Texas at El Paso)
- "COLLABORATIVE PROPOSAL: Enhancing Nitrogen Removal in Stormwater Treatment Facilities for Transportation" (University of Delaware and Rutgers University)

Publications, conference papers, and presentations

Journal publications.

- Schumacher T, Shariati A. (2013). Monitoring of Structures and Mechanical Systems Using Virtual Visual Sensors for Video Analysis: Fundamental Concept

and Proof of Feasibility. *Sensors*. 13(12): 16551-16564. DOI: 10.3390/s131216551.

- Linren Zhou, Guirong Yan and Jinping Ou (2013), "Response Surface Method based on Radial Basis Functions for Modeling large-scale structures in model updating," *Computer-Aided Civil and Infrastructure Engineering*. 28(3): 210-226.
- Cecilia Surace, Guirong Yan, Richard Archibald, Rishu Saxena, and Ruoqiang Feng (2013), "Structural Damage Detection using the Polynomial Annihilation Edge Detection Method", *Australian Journal of Structural Engineering*. 15 (1).
- S-T. Tung, Y. Yao and B. Glisic, 2014. "The sensitivity of thin-film full-bridge strain sensors for crack detection and characterization". (submitted to *Measurement Science and Technology*, under review).
- Y. Yao, S-T. Tung and B. Glisic, 2013. "Crack detection and characterization techniques – an overview". (Submitted to *Structural Control and Health Monitoring*, under review).
- 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." (Submitted to the ASCE Journal of Bridge Engineering. December 2013).

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

"Nothing to Report"

Other publications, conference papers and presentations.

- Modal parameter based damage detection in operational modal analysis: A statistical pattern recognition approach, L. Balsamo, S. Mukhopadhyay, R. Betti, H. Lus, Proceedings of the 11th International Conference on Structural Safety & Reliability, New York, NY, USA, 2013.
- Structural identification and uncertainty quantification in operational modal analysis with minimal instrumentation, S. Mukhopadhyay, R. Betti, H. Lus, Proceedings of the 11th International Conference on Structural Safety & Reliability, New York, NY, USA, 2013.
- Damage detection using large-scale covariance matrix, L. Balsamo, R. Betti, H. Beigi, Proceedings of the 32nd International Modal Analysis Conference, Orlando, FL, USA, 2014.
- Structural identification using response measurements under base excitation, S. Mukhopadhyay, R. Betti, H. Lus, Proceedings of the 32nd International Modal Analysis Conference, Orlando, FL, USA, 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.
- 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.
- 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.

- Shariati, A. and Schumacher, T. (2013). Video-Based Techniques in Structural Health Monitoring. Review of Progress in Nondestructive Evaluation (QNDE). Baltimore, MD. July 21-26.
- London, Mosi and Sue McNeil, (2013). "Capturing Changes in Investment, Demand and Policy Using the Transportation Performance Index", Presented at the 13th World Conference on Transport Research, Rio de Janiero, July, 2013.
- A poster presentation was made at the annual UDOT Conference based on the work from the project Forensic Testing of Prestress Concrete Girders After 40 Years of Service.

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

- As part of the research project titled "Analyses of Interactions between the Marine Terminal and Highway Operations Using Discrete Simulation" (collaboration with Rutgers CAIT), the research team developed a simulation model of a maritime container terminal in Arena simulation modeling software. This tool will provide insight into the dynamics of changes in highway volumes that can be attributed to the growth and change in character of the port operations, namely the increased vessel size and evolving vessel schedules and arrival frequencies. This model will be presented to the audiences such as MPO freight stakeholder committees and State DOT freight planning group to explore possible practical applications.
- Under research project entitled "Quantifying Impact of Port Truck Traffic on Highway Operations Using GPS-Based Speed Data," NJIT developed an analytical model that can be used to quantify effects of the port-related truck traffic (i.e., port drayage operations) on prevailing vehicle operating speed and level of service on the highway system providing regional access to port facilities. The model can be used to test "What-If" scenarios of larger ships arriving to the port and the related truck drayage traffic and to ascertain the impact of the increased truck volumes on the highway level of service on the highway facilities adjacent to the port terminal gates. This model will be presented to the audiences such as MPO freight stakeholder committees and State DOT freight planning group to explore possible practical applications.
- Under research project entitled "Highly efficient model updating for structural condition assessment of large-scale bridges," UTEP developed a new technique to perform model updating for large-scale bridges, which is faster and more accurate than traditional approaches. This approach is to apply the response surface (RS) method based on radial basis functions to generate a surrogate model of the complicated finite element model of the structure, and then perform a genetic algorithm on the surrogate model to update parameters of the structure. As a result, the computational amount is significantly reduced, making the model updating more quickly. The implementation of the RS method makes model updating promising in being applied to large-scale real-world structures.

Inventions, patent applications, and/or licenses

"Nothing to Report"

Other products: outreach activities, courses and workshops

- Brown Bag Seminars organized by CAIT at UDEL:
 - Gong, Jie and Farbod Farzan, Rutgers University, and Sue McNeil, (2013). University of Delaware, “Big Data: Opportunities and Challenges in Asset Management,” October 16, University of Delaware.
 - Atique, Farzana, Ryan Burke and Sue McNeil, (2013). “Updating the Transportation Performance Index and Better State-of-Good-Repair Indicators” October 23, University of Delaware.
 - Cook, Pam (Mathematics), Nii Attoh-Okine (Civil Engineering) and Yun Zeng (Civil Engineering), (2013). “Mathematical Modeling and Experimental Responses of Polymer Modified Asphalt” and Attoh-Okine, Nii, (2013). “Multi-Resolution Information Mining and a Computer Vision Approach to Pavement Condition Distresses” November 20, University of Delaware.
- CAIT at VTech presented the Concrete for Kids (C4K) program to three summer camps at Virginia Tech. The C-Tech2 camp provides rising senior high school girls a two week introduction to a wide variety of engineering disciplines. The C4K program was presented to the 50 girls in this program. The program was also presented to middle school boys and girls in two separate “Imagination” camps. These camps are also geared toward introducing students to engineering. VTech presented the program to 40 children in each of the two camps.

3. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS:

What individuals have worked on the program?

Program Director: Dr. Ali Maher

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

Consortium Universities Involved:

Rutgers, The State University of New Jersey (Lead)

University of Delaware, Newark, DE

Utah State University, Logan, UT

Columbia University, New York, NY

New Jersey Institute of Technology, Newark, NJ

Princeton University, Princeton, NJ

University of Texas, El Paso, TX

University of Virginia, Charlottesville, VA

Virginia Polytechnic Institute, Blacksburg, VA

What other organizations have been involved as partners?

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
Parsons Transportation Group		Financial support; Collaborative research; Personnel exchanges
Virginia DOT	Richmond, VA	Financial support; Collaborative research; Personnel exchanges
Oregon DOT	Salem, OR	Project customers/managers
Delaware Department of Transportation	Dover, DE	Project customers/managers
Cambridge Systematics, Inc.	Cambridge, MA	Project customers/managers
TA Instruments-Waters LLC	New Castle, DE	Project customers/managers
TxDOT	Austin, TX	Financial support; Collaborative research; Personnel exchanges
California DOT	Sacramento, CA	Project customers/managers
El Paso MPO	El Paso, TX	Financial support; Collaborative research; Personnel exchanges
Applied Research Associates Inc	Panama City, FL	Financial support; Collaborative research; Personnel exchanges
U.S. Chamber of Commerce	Washington, D.C.	Financial support; Collaborative research; Personnel exchanges
HNTB	New York, NY	Project customers/managers
Town of Sea Bright, NJ	Sea Bright NJ	Financial support; Collaborative research; Personnel exchanges
Bridge Diagnostics Inc.	Boulder, Colorado	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.
 - **Research Collaborations:** 8 collaborative proposals to perform joint research with partners within the CAIT consortium have been approved.
- **collaborations or contact with others outside the UTC**
 - Dr. John Betak, Collaborative Solutions LLC collaborated with NJIT research team on the project entitled “Establishment of State Freight Advisory Committee to Guide Planning Investments and Other Policies in Support of MAP-21.”
 - Scott J. Parker, P.E., Jacobs Engineering Group Inc., collaborated with NJIT research team on the project titled “Freight System Performance Measures for NJDOT.”
- **collaborations or contacts with others outside the United States or with an international organization (country(ies) of collaborations or contacts).**
 - Dr. Yan from UTEP has been collaborating with Professor Jinping Ou from Dalian University of Technology. Experimental tests on a cable-stayed bridge model are being performed in his lab to validate the proposed approach experimentally.

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

Outputs	Expected Outcomes	Impacts
“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. The expected outcomes from this project are design recommendations to be incorporated into the AASHTO LRFD Specifications.	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.
“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	Evaluation of methods and protocols for efficient and beneficial uses of polymer-modified asphalt. An attempt will be made to introduce the proposed methodology as part of a

	<p>mathematical modeling to better understand the properties of polymer modified asphalts.</p>	<p>mechanistic pavement design approach. Finally, 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; examples of best practices used by state and local governments to achieve a SGR for sidewalks and related pedestrian facilities and methodology for state and local governments to quantitatively prioritize areas most in need of maintenance.</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 Management Practices” (University of Texas at El Paso)</p>	<p>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.</p>	<p>The multi-objective asset management model will improve the current decision making process of local and state agencies.</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>Current technologies for reducing nutrients usually require additional real estate to achieve greater nutrient removal, e.g., larger detention ponds. 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>

ONGOING RESEARCH PROJECTS

Outputs	Expected Outcomes	Impacts
<p>“Development of a Comprehensive Hot Mix Asphalt Pavement Specification” (Rutgers University)</p>	<p>The major goal of this study is to search and critically evaluate the literature to determine how the HMA quality characteristics can best be incorporated into the existing NJDOT HMA pavement specification to produce a comprehensive and effective multi-characteristic acceptance specification that can be easily understood and implemented. It is expected that successful completion of this project will significantly advance the asphalt technology development in NJ and extend the service life of flexible pavements.</p>	<p>Improve the state-of-good repair of multimodal transportation infrastructure systems</p>
<p>“Virginia Bridge Information Systems Laboratory” (University of Virginia)</p>	<p>The support from the UTC will help establish this laboratory which is intended to become an integral component of the VDOT’s bridge research activities. The products of this project will be</p> <ol style="list-style-type: none"> 1. An annual report summarizing the activities and accomplishments of the laboratory. 2. Special reports produced in response to requests for VDOT and VCTIR. 3. Papers submitted and published in archival quality journals. 4. Conference papers and presentations. 	<p>This research supports the US DOT’s State of Good Repair Strategic Goal by utilizing data from the Long Term Performance Bridge program as one of the ancillary data sources for the proposed laboratory; by helping to develop, evaluate and explore new system performance indicators for bridges; by examining the trends in permits for weights in excess of legal limits and quantifying bridge damage costs associated with those loads; by studying specific aspects of bridge performance and helping to develop a comprehensive process to regularly document the condition of VDOT’s bridge infrastructure; supporting and advancing sound asset management principles for bridges, the transfer of knowledge, and by providing technical assistance to more effectively manage the system; and by encouraging VDOT to use improved highway design and construction procedures, innovative quality assurance practices, innovative materials, and asset management practices by conducting special studies on the efficacy and cost effectiveness of such practices.</p>
<p>“Better State-of-Good-Repair Indicators for the Transportation</p>	<p>The goal of this project is to revise the Transportation Performance</p>	<p>The end result of the project is a revised TPI that can be used to</p>

<p>Performance Index” (University of Delaware)</p>	<p>Index to better capture the role state of good repair and safety play in transportation infrastructure performance.</p>	<p>assess the economic impact of maintaining the physical infrastructure in a state of good repair and safety improvements. In turn, the TPI can be used to evaluate alternative infrastructure repair and improvement policies.</p>
<p>“Multi-Resolution Information Mining and a Computer Vision Approach to Pavement Condition Distresses” (University of Delaware)</p>	<p>The research will provide a new and effective method in addressing pavement monitoring data as well as a new platform for training graduate students in advanced data processing-including image and signal processing, a new hybrid method – the use of GIS, signal analysis and computer vision application in asset management applications.</p>	<p>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.</p>
<p>“Mathematical Modeling and Experimental Responses of Polymer Modified Asphalt” (University of Delaware)</p>	<p>The goal of this project is to work cross-discipline (pavement engineering and mathematical science) to carry out experiments and couple those results with mathematical modeling to better understand the properties of polymer modified asphalts. In the process we will be cross training graduate students in understanding. The project will lead to the development a) mathematical models, b) laboratory studies to support the mathematical/theoretical models, c) field validation techniques.</p>	<p>The successful completion of the project will have direct impact on the SGR focus, especially in the area Advance/Innovative Materials and a major influence on the modeling and evaluation of innovative asphalt material. This will ultimately improve the understanding of flexible pavement deterioration performance modeling. It will also improve decision-making in asset management.</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 heal monitoring strategy applicable to real life bridges.</p>	<p>The robustness of the final unified scheme will be in its ability to address the practical constraints of incomplete instrumentation, unobserved/weakly excited vibration modes, unknown scaling in output-only situations, and effect of model uncertainty induced by environmental variations of the structural parameters.</p>
<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, and significantly reduces the life-cycle costs of bridges.</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>“Warehouse Location and Freight Attraction in the Greater El Paso Region” (University of Texas at El Paso)</p>	<p>The objectives of this project are to develop a methodological approach to analyze current and future warehouse/distribution center locations along border regions. It is expected that research results can provide greater accessibility and mobility for increasing bi-national freight flows that are safer and economically feasible.</p>	<p>It is anticipated that the to-be-developed decision support methodology will be readily used by metropolitan planning organizations, state and city departments of transportation for their land-use planning purposes.</p>
<p>“Improved Connection Details for Adjacent Prestressed Bridge Beams” (Virginia Polytechnic Institute)</p>	<p>The primary outcome of the project will be recommendations for improved connection details for adjacent precast/prestressed member bridges.</p>	<p>Bridges constructed with the new details are expected to have longer service lives with reduced maintenance costs. Safety is also addressed, because with the new detail the shear transfer between members will not break down and compromise the redundancy of the system.</p>
<p>“Mixing and Compaction Recommendations for Warm Mix Asphalt (WMA) with Recycled Asphalt Shingles (RAS)” (Rutgers University)</p>	<p>The anticipated outcome of the research is a set of general guidelines that could be used when producing warm mix asphalt (WMA) with recycled asphalt shingles (RAS). It is envisioned that the results of the research would be adopted in a best practices for handling RAS with WMA technologies.</p>	<p>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.</p>
<p>“Development for Transportation Asset Management Inventory & Management Tools” (Utah State University)</p>	<p>Major expected outcomes are increased technology in the maintenance processes; data availability for decision makers; training workshops for LTAP customers and algorithms for optimization of maintenance investments.</p>	<p>This project strongly supports the USDOT goal of State of Good Repair by providing added value to the maintenance funding that is being expended by UDOT and other state DOTs. Also, this research will contribute to the goals of safety by providing roadways with better signage which will contribute to less driver confusion and less crashes on the roadways.</p>
<p>“Railroad Operations Research and Training” (Rutgers University)</p>	<p>The goal of this research is to explore the possibilities for railroad education leading to the implementation of short courses for</p>	<p>Training courses will provide ideas for better maintenance techniques for rail and mass transit system employees while college level</p>

	professionals and ultimately to develop courses for undergraduate Civil Engineering curriculums.	courses will expose Civil Engineering students to topics such as railroad design and management.
“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), which is defined as a truck volume that deteriorates the highway infrastructure performance below the acceptable minimum level of service.
“The Effects of Network Characteristics on Traffic Flows and Emission” (Rutgers University)	The objective of this research is to use state-of-the-art macroscopic traffic models to relate the characteristics of a street network and the level of travel demand to aggregated properties of the traffic demand. This relationship will provide the inputs to greenhouse gas emissions models as developed through EPA MOVES.	These results will be useful for developing insights about the environmental performance of urban street networks in general, and provide a foundation for studying specific networks and improvement plans on real street networks.
“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” (Rutgers University)	The purpose of this research is to develop a real-time vibrator tracking based intelligent concrete consolidation system. The expected outcome of the study is a new intelligent concrete consolidation tool.	This new tool can significantly benefit concrete bridge construction and retrofitting by allowing contractors to pro-actively address concrete consolidation issues.
“Development of a Bridge Resource Program for the New Jersey Department of Transportation” (Rutgers University)	The support from the UTC will help establish a program that is intended to become an integral component of the NJDOT’s bridge research activities. The products of this project will be a report on the state’s structural asset management activities as well as a pilot plan to provide enhanced nondestructive evaluation and inspection on a sample of the State bridges.	Through improving asset management strategies and incorporating nondestructive evaluation strategies, the Bridge Resource Program will provide NJDOT with advanced tools to manage the state's structural assets. In addition, the Bridge Resource Program will incorporate advanced load rating analyses to evaluate ten bridges.
“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	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

	large areas of a structure. This multi-sensing approach could also be applied as a research tool to study damage initiation and propagation.	remaining service-life of structures. Professional development opportunities and training include seminars on the benefits of monitoring techniques for informed decision making.
“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. Innovative numerical models will be developed to document and understand the theoretical limitations and sensitivity of this technology in order to generate more rigorous specifications.	The deliverable of this project will be recommendations to implementation of IC based on numerical model results that can be used with confidence to evaluate the effectiveness of the existing and future instrumented rollers. The almost continuous quality control of the final product will improve the productivity of the contractors and the longevity of the highway and airport infrastructure, thus minimizing the delay to user of the transportation facilities.
“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: 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. In addition, the researchers will explore how the use of data mining can be used to reduce costs by more quickly identifying problems before more costly interventions are needed.	The research will provide information on how data mining can be used to provide better information to decision makers to keep infrastructure assets in a state of good repair.
“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: Analysis of Interactions between the Marine Terminal and Highway Operations” (Rutgers University and New Jersey Institute of Technology)	The goal of the study is to develop a simulation model that will be capable of ascertaining the interactions between the marine terminal operations and a highway system that provides access to the port.	It is expected that the type of analysis provided by this modeling framework will find application in regional strategic planning.

COMPLETED RESEARCH PROJECTS

Outputs	Expected Outcomes	Impacts
"ABC Deck Panel Testing" (Utah State University)	The research findings will result in design recommendations that can be used by state agencies for precast concrete deck panel connections.	Accelerated Bridge Construction techniques are a promising way of reducing the overall cost of bridge replacements.
"Forensic Testing of Prestress Concrete Girders after Forty Years of Service" (Utah State University)	It is anticipated that the research findings will result in design recommendations that will aid state agencies in better estimate the behavior of in-service bridges.	This project has direct implications for operation and maintenance practices as well as new construction planning.
"Fiber Optic Monitoring Methods for Composite Steel-concrete Structures Based on Determination of Neutral Axis and Deformed Shape" (Princeton University)	The objective is to research and develop Structural Health Monitoring methods (SHM), including structural identification and damage detection, based on strain monitoring using long-gauge fiber-optic sensors. The main outcomes are the developed SHM methods for determination of these parameters.	This research will allow comparison between laboratory results and data from a real structure under true service conditions. The research is therefore directly linked to real world application and knowledge gained from this data can be applied to other construction and preservation projects.
"Life Cycle Assessment of Asphalt Pavement Maintenance" (Rutgers University)	The main research objective is to develop a Life Cycle Assessment (LCA) methodology to consider the energy and environmental impacts of pavement maintenance at its construction and usage stage.	The methodology developed under this study will aid state transportation agencies in selecting the most efficient maintenance and preservation treatments.
"Correlation between Hurricane Sandy Damages along NJ Coast with Land Use, Demographic and Other Local Characteristics" (Rutgers University)	This study builds on the "FEMA Flood Mitigation Research and Modeling" project conducted by Rutgers Bloustein School of Planning and Public Policy. The goal is to understand the correlation between Hurricane Sandy damages along NJ Coast with land use, demographic and other local characteristics and to evaluate whether modifying or adding additional sea wall and sand dune infrastructure would have reduced the surge related damages that occurred from Sandy.	The modeling results will help determine the most feasible flood reduction strategy to be adopted by areas undergoing extensive rebuilding.
"Quantitative Acoustic Emission Monitoring of Fatigue Cracks in Fracture Critical Steel Bridges" (University of Delaware)	The objective is to evaluate quantitative AE methods for monitoring of fatigue crack detection, propagation, and retrofitting in steel bridges. Anticipated outcomes include recommendations on sensor locations, effective analysis methods to be used, and how to	The proposed quantitative monitoring tool may provide owners of fracture critical bridges and bridges with fracture-prone details with a novel tool to make (1) objective informed decisions on when to intervene and repair, (2) enable safe operation during service, (3) verify that implemented

	interpret the obtained data to ensure informed decisions can be made by bridge owners.	repair methods are effective, and (4) ensure repairs are made only if necessary which increases economic competitiveness.
“Elevated Temperature Properties of Weathering Steel (Princeton University)	Bridge fires, which result in extended congested detours for damage assessment and repair, affect the welfare of our transportation system. The goal of this work is to develop a database of mechanical properties of weathering steel that has been exposed to high temperatures.	The information generated by this study will aid in reducing the assessing and repair time and, possibly, bridge replacement.

RESEARCH PROJECT STATUS UPDATE

Final research reports will be posted on Center’s websites and distributed to designated repositories.

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 approach is to apply the response surface (RS) method based on radial basis functions to generate a surrogate model of the complicated finite element model of the structure, and then perform a genetic algorithm on the surrogate model to update parameters of the structure. 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. Thus, electrical engineers expand their field of application. 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?

Outputs	Outcomes/Impacts
Traveling Distinguished Lecture Series	Exposure to transportation issues for students, researchers, and professionals with experts in the industry from other parts of the world
96 th Annual NJ League of Municipalities Conference	The annual conference exposes CAIT to thousands of local officials, engineers, and public works individuals who currently do and will use the resources of CAIT. In 2013, CAIT presented the concept of Pavement Management Systems in a special session to close to 100 individuals.
NJDOT Research Showcase: Infrastructure and Resiliency: Infrastructure Recovery	The annual NJDOT research showcase brings together hundreds of the state’s premiere transportation researchers together to share ideas; including members of the Consortium: Rutgers, NJIT, and Princeton.
Annual NJ Safety Forum	Hundreds of safety professionals, including traffic engineers and public institutions gathered to exchange ideas and concepts and listen to a world class set of presentations regarding safety initiatives and solutions.

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

“Nothing to Report”

What is the impact on technology transfer?

- It is anticipated that all projects will lead to the adoption of new practices or inform policy. For example, 1) the output of the model developed by NJIT under project titled “Quantifying Impact of Port Truck Traffic on Highway Operations Using GPS-Based Speed Data” can be used to ascertain the impact of the increased truck volumes on the highway level of service on the highway facilities adjacent to the port terminal gates; 2) the multi-sensing prototype for monitoring surface strains being developed by Princeton in collaboration with UDEL and Columbia, has the potential to be used to assess bridge condition over time and facilitate maintenance scheduling and management through damage monitoring and identification.

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. 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”