PROGRAM PROGRESS PERFORMANCE REPORT

Awarding Federal Agency: US Department of Transportation, Office of the Assistant Secretary for Research and Technology of the Department of Transportation (OST-R)

Federal Grant Number: DTRT13-G-UTC28

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

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Signature of Submitting Official:

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

Over the course of its grant as a National University Transportation Center, the CAIT consortium has leveraged research expertise, stakeholders, and more to address the major goal of maintaining the state of good repair of the nation's infrastructure. This can be seen across many modes of transportation, from monitoring bridges to drones and aviation.

In summary, some of CAIT's major accomplishments over the course of this national project include:

- Generating a number of applied technologies and procedures such as THMPER, the Long-Term Bridge Performance (LTBP) Data Portal, Pneumatic Flow Tube Mixing, Naviator, and The BEAST.
- Publication in major transportation outlets and journals such as The Transportation Research Record, Progressive Railroading, and ASCE among others.
- Award-winning research highlighted by the ASCE Charles Pankow Award for Innovation, the Institute of Transportation Engineers' (ITE) Rising Star Program Award, and more.
- Reaching more than 12,000 transportation professionals nationwide through education and tech transfer initiatives.

One example comes from the Superstorm Sandy Geospatial Mapping Project. After Superstorm Sandy, CAIT researchers led a post-disaster research project using geospatial mapping to collect data that offered visual images and details about the scope and severity of the damage, as well as the path of the surge. Looking at this damage can help to develop models to simulate, to estimate, and even to predict damage in the future. Over time, CAIT has led other post-disaster reconnaissance missions during Superstorm Sandy, Hurricane Harvey, and Hurricane Michael too with the goal of advancing post-disaster damage assessment methods and turning disaster data into actionable knowledge for resilient rebuilding. Other innovations from CAIT's National UTC consortium come from new products developed. One being The Naviator, a drone that can spontaneously transition from flying to underwater operation—and could reduce the cost of bridge inspections by 30 percent as well as make them much safer. THMPER is another system developed by CAIT and is used for portable, rapid bridge evaluation. It uses custom software to process test data and calibrate finite element models on the spot. THMPER can determine bridge load ratings faster, more economically, and with less traffic disruption than other current methods. Another device for inspecting bridges, RABIT, is the first fully automated robotic device for making comprehensive condition assessments of concrete bridge decks based on quantitative data. It is a fast, safe, and thorough tool to help bridge owners make data-driven decisions that extend the service life of infrastructure. Both were winners of the Charles Pankow Award for Innovation.

In addition to these innovations, CAIT's various program and labs have further developed the center as a resource for transportation agencies and stakeholders. As the only university initiative addressing rail in the New York and New Jersey region, the CAIT Rail and Transit Program is a one-stop-shop for all technology and workforce development needs in a unique and busy location along the Northeast Corridor, for example. Also, The Rutgers Asphalt Pavement Lab (RAPL) is one of the few independent, college/university-based asphalt laboratories in the United States that is accredited by the American Association of Highway Transportation Officials (AASHTO). RAPL/CAIT research improves

existing infrastructure by shedding light on how pavements react to an array of variables, such as location, weather, traffic volume, and age. With improved understanding of these variables, they can develop pavements that have properties better suited to the specific environment in which it must perform. And finally, CAIT's Bridge Evaluation and Accelerated Structural Testing lab (The BEAST) is a truly unique facility that can quantitatively measure the effects caused by intense traffic and environmental extremes on actual bridge decks and superstructures—and do so in a highly compressed time frame. It is built to induce and speed up deterioration as much as 30 times, making it possible to simulate 15 to 20 years of wear-and-tear in just a few months.

You would be hard pressed to identify one task in the course of your day that doesn't involve infrastructure. CAIT's time as a National UTC allowed it to address the state of good repair, increasing safety, developing new and efficient tools, and more that tie into a healthy economy and benefit people's everyday lives.

What are the major goals of the program?
The major goal of the CAIT National 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 & 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 educational activities with a focus on K-12 to foster an initial interest in transportation and create opportunities for the students to continue onto other programs, thereby sustaining awareness in transportation careers beyond the initial exposure.

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	Sixty-one (61) projects have been approved and completed during the entire period of the award.	No new research project has been approved during this reporting period.
	Targeted Hits for Modal Parameter Estimation (THMPER™)	This portable bridge evaluation tool that provides faster, cheaper, and less disruptive than conventional methods was created by Dr. Franklin Moon and his research team. THMPER™ could revolutionize how America's 600,000 plus bridges are regularly assessed, rated, and prioritized for repair or replacement. THMPER™'s rapid testing is groundbreaking because it uses three advanced load-capacity estimating methods: modal impact testing, refined analysis and calibration of finite element models, In addition, it is portable, performs the whole operation on site and provides, in just one day, accurate results about how much load a bridge can safely carry. ASCE recognized the value and ingenuity of THMPER™ by awarding it the 2016 Charles Pankow Award for Innovation.		To date, THMPER™ has been used to assess more than 30 bridges in Delaware, Maryland, New Jersey, Pennsylvania, Oregon, and Washington under pilot programs with federal, state, and local transportation agencies.
	Development of accelerated infrastructure testing facility: Bridge Evaluation Accelerated System Testing (BEAST)	Supported by funding from NJDOT, FHWA, and Rutgers, CAIT construct a brand new facility that will create knowledge through UTC research projects and can validate existing research through and facility that will test the effects of heavy loads, extreme temperatures, and active weather on a full-scale concrete bridge deck. To reliably accomplish this, CAIT and its DOT and university partners are constructing the first full-scale accelerated infrastructure testing		BEAST will provide new and valuable information about the longevity and effectiveness of preservation treatments and concrete materials used across the United States. The study will also

		facility for the evaluation of new and advanced materials and devices: the Bridge Evaluation Using Accelerated System Testing (BEAST) facility. The facility will finally resolve unknown questions about the longevity and performance of preservation treatments and materials exposed to decades of heavy traffic loads and extreme weather patterns. The construction of the facility was completed in May 2015.	provide answers about the long-term effects of weight, weather, and temperature variations on bridges in a short period of time.
	Utilization of Pneumatic Flow Tube Mixing Technique (PFTM) for Processing and Stabilization of Contaminated Soft Sediments in the NY/NJ Harbor	Supported by funding from NJDOT and leveraging our investments in sediment research, this project is going to demonstrate the viability of the Pneumatic Flow Tube Mixing (PFTM) method for the processing and handling of contaminated navigational dredged materials from the NY/NJ harbor complex. The Center for Advanced Infrastructure and Transportation (CAIT) will implement a pilot project at the Koppers Seaboard site, New Jersey. Rutgers Soil and Sediment Management Laboratory in collaboration with international partners will test the raw and amended DM throughout the entire process to initially determine the optimum design of the mix and subsequently monitor the produced amended DM to document the results and quality control parameters. The entire process will be managed by Rutgers CAIT.	The ultimate aim of the project is to determine if Pneumatic Flow Tube Mixing more efficiently achieves Structural and environmental properties for amended dredged material while decreasing cost per cubic yard for dredged material amendment and placement than existing methods.

HIGHLIGHTS

Structural Health Monitoring of Representative Cracks in the Manhattan Bridge

Some 6,855 feet long, spanning the East River, and connecting the island of Manhattan to Brooklyn—the Manhattan Bridge is a signature and vital piece of infrastructure that carries approximately 1,000 trains and hundreds of thousands of passengers daily. Being exposed to so many repeated loads, especially those by trains running at full capacity, some portions of the bridge are beginning to show wear and tear. And, when bridge engineers noticed significant vibration whenever trains crossed over, they had questions about how these dynamic amplifications were impacting the infrastructure's long-term service life.

Drs. Franklin Moon and Sougata Roy, faculty within the Department of Civil and Environmental Engineering and affiliated researchers at Rutgers CAIT, have been leading a team investigating these concerns and developing criteria to help owners make informed asset-management decisions as part of CAIT's National University Transportation Center (UTC) project. Earlier this year, the team performed limited vibration tests at the Manhattan Approach, on each of the

transit beams that support a set of rails. The goal was to characterize the bridge response due to misalignment of bolted rail joints, which introduced strong vibration as trains crossed them.

To start, the researchers examined the bridge response using magnetically mounted accelerometers. The accelerometers were roved around to identify different levels of vibration associated with various bolted rail joints. Based on these results, they developed a criteria and organized the various rail joints into fair, poor, and severe, with severe being the most misaligned. As expected, the more severely misaligned splices resulted in more vibration on the bridge, almost double that of the fair splices. This was further corroborated by the long-term stress measurements, witch showed that more misaligned joints experienced higher stresses. The project as designed, instrumented, and deployed worked, and the causes of cracks/damage in the bridge structure could be identified by vibrations from rail traffic.

Long-Term Monitoring of a Geosynthetic Reinforced Soil Integrated Bridge System (GRS-IBS)

The geosynthetic reinforced soil integrated bridge system (GRS-IBS) is an innovative alternative to conventional bridge technology that utilizes closely spaced layers of geosynthetic reinforcement and compacted granular fill material to provide direct bearing support for structural bridge members. Using this technology, over 200 bridges in 44 states, Puerto Rico, and the District of Columbia, have been built as of early 2017. In 2013, the first GRS-IBS in the state of Delaware was constructed.

This project combined the UTC funding with some State and Federal money to install a demo bridge in Delaware. The UTC research acted as a force multiplier and generated interest among key stakeholders for additional research, bridge installations, and eventually outputs. These stakeholders included FHWA and other states, and results from initial installations led to changes in the design methodologies from FHWA. Overall, this research helped to advance the state of the art, and eventually was adopted as an EDC technology that led to more widespread use. Data from the 100+ sensors on the bridge appear to indicate that the structure is performing to standard, and there are factors for consideration for similar projects in the future regarding sensor installation and monitoring. This research highlights a number of interesting findings for GRS-IBS structures, including reactions to water, temperature, and load factors, that would be of interest to state and local governments interested in this approach.

Cloud-Based Virtual Traffic Sensor Network with 511 CCTV Traffic Video Streams

This project developed an efficient cloud-based video analytic system for generating traffic flow and occupancy data from a large-scale regional CCTV traffic video network suitable for large scale deployment. Concepts and approaches in this project relate to the New Brunswick Innovation Hub project at CAIT and larger themes of smart cities and infrastructure.

CAIT-affiliated researcher Dr. Peter J. Jin and his team built, deployed, tested, and evaluated a cloud-based traffic counting system based on CCTV traffic video streams. The system improved some of the existing traffic counting algorithms for low-angle CCTV camera by novel methods to use a fraction of the video frames for analytics (the STLine), efficient processing of static noises caused by roadway infrastructure, and signs and occlusion among vehicles. The streamlined workflow of the proposed platform alleviated the limitation and the instability of storage and the modularized system design allows for further improvement to be easily deployed in the future. The system is able to completely support the automatic detection of camera directions with three types of roadside and intersection camera location scenarios and the manual processing of the camera directions with other cameras. Compared with traditional video traffic monitoring systems, the proposed high-efficiency STMap-based system can process real-time video with low consumption of computing and publish the result data feed with slight delay.

Technology Transfer	Tech transfer activities for the National Center for Rural Road Safety	Support collaborative efforts and technology transfer with an impact on rural and local road safety.	As part of the NCRRS consortium, CAIT is leading several Tech Transfer efforts promoting rural and local road safety.	CAIT produced one center Safety Sidekick Newsletter and blog, as well as developed and maintained social media presence.
	Tech transfer for the Northeast Regional Transportation Center	Generate knowledge and support resource sharing transfer for workforce development issues in the NE.	As part of the NETWC team, CAIT is leading the communication efforts for the project and developing and promoting tech transfer events.	CAIT maintains the NETWC website and social media presence.

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:** Not applicable.
  - **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 OST-R. CAIT has and will continue to issue modifications to the master agreements with each partner as research projects are approved.
  - **Ongoing Research:** This is the final report for this project, but it is hoped that the consortium members will continue to collaborate to perform SGR oriented research in the near future.
- **EDUCATION AND WORKFORCE DEVELOPMENT ACTIVITIES:**

TECHNOLOGY TRANSFER ACTIVITIES:

Establishment of the CAIT Seminar Series, a monthly webinar hosted by CAIT featuring research from faculty members or industry partners with the purpose of sharing information with the transportation community.

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

Research projects awarded:

N/A

Publications, conference papers, and presentations

Journal publications.

- Gholizadeh, Azam & Sardar, S. & Francisco, Kelly & Maher, Ali & Miskewitz, Robert & Javanmard, M.. (2020). Towards In-Situ Environmental Monitoring: On-Chip Sample Preparation and Detection of Lead in Sediment Samples Using Graphene Oxide Sensor. IEEE Sensors Journal. PP. 1-1. 10.1109/JSEN.2020.3006021.
- Xiong Z, Glisic B. An inverse elastic method of crack identification based on sparse strain sensing sheet. Structural Health Monitoring. July 2020. doi:10.1177/1475921720939518
- Dimitrijevic, B., Darban Khales, S., Asadi, R., Lee, J., Kim,. K. "Crash Risk Analysis for New Jersey Highways Using Advanced Data Modeling," TRB paper No. 21-03591 accepted for presentation at the 2021 TRB Annual Meeting

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

- Pacheco-Torgal, F., Amirkhanian, S., Wang, H., & Schlangen, E. (2020). *Eco-efficient pavement construction materials*. Woodhead Publishing.

Other publications, conference papers and presentations.

- "Nothing to report."

Website(s) or other Internet site(s)

CAIT has established the internet site:

- https://cait.rutgers.edu/ to disseminate research results

Technologies or techniques

- Multiple CAIT projects, "Ultra-Compact and Rugged Electrochemical Sensor for Monitoring Toxic Metals in Natural Water Sources," and "MEMS Field Deployment," contributed to the development of an electronic platform using ultra-compact sensors to map the distribution of sediment contamination and other toxic compounds in New York harbor, and to continue that research to build a real-time in-situ probe to assess metal contaminants in marine sediments. Researchers have now developed a miniature device for measuring trace levels of toxic lead in sediments at the bottom of harbors, rivers, and other waterways within minutes – far faster than currently available laboratory-based tests, which take days.
- Another CAIT project, "Arrangement of Sensors and Probability of Detection for Sensing Sheets Based on Large-Area Electronics for Reliable Structural Health Monitoring" led to the methodology for evaluating probability of detection (POD) for bridge cracks as well as determined the design characteristics for POD of sensing sheets. The goal of this project was to develop a methodology for determining the arrangement of sensors and POD and define practical guidelines for POD diagrams for the most frequent types of damage. Researchers have completed the proof of concept phase of this project. Next steps include integrating the computational model into a complete prototype for real-world testing.
- CAIT, and multiple DOT and university partners, created the nation's first full-scale accelerated bridge deck testing facility in Piscataway, New Jersey. This facility, called the

Bridge Evaluation and Accelerated Structural Testing lab (BEAST), tests the effects of many years of heavy loads and extreme temperature and weather patterns on a full-scale concrete bridge deck over a short period of time. To leave the experiments undisturbed, observations will be recorded using a 24-hour closed circuit video recording system. The results of the study will give bridge engineers valuable new information about the longevity of preservation treatments and concrete materials that can be incorporated into future bridge repair and construction projects.

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. Marvin Halling (Utah State University), Dr. Raimondo Betti (Columbia University), Dr. Lazar N. Spasovic (NJIT), Dr. Branko Glisic (Princeton University), Dr. Abdul R. Pinjari (University of South Florida), Dr. Soheil Nazarian (University of Texas at El Paso, Dr. Carin Roberts-Wollmann and Dr. Gerardo Flintsch (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 South Florida, Tampa, FL
Virginia Polytechnic Institute, Blacksburg, VA

What other organizations have been involved as partners?

The consortium has collaborated with a number of external agencies across the United States:

New Jersey Department of Transportation	Trenton, NJ	Financial support and collaborative research on multiple projects, including ITS research and a time-accelerated infrastructure testing facility that will simulate extreme loads and environmental conditions in on a real bridge deck
Virginia Department of Transportation Virginia Center for Transportation Innovation and Research (VCTIR)	Richmond, VA	Collaborative research on multiple projects, including a time-accelerated infrastructure testing facility that will simulate extreme loads and environmental conditions in on a real bridge deck
Applied Research Associates, Inc.	Panama City, FL	Collaborative research on multiple projects, including a time-accelerated infrastructure testing facility that will simulate extreme loads and environmental conditions in on a real bridge deck
Drexel University	Philadelphia, PA	Collaborative research on multiple projects, including a time-accelerated infrastructure testing facility that will simulate extreme loads and environmental conditions in on a real bridge deck

ITS New Jersey (a state chapter of ITS America)	Trenton, NJ	Collaborative research and personnel exchanges for workshops, meetings, and conferences on ITS research
Parsons Brinckerhoff	New York, NY	Collaborative research and support on a number of research and technology transfer activities, including workshops, meetings, and conferences on ITS research
New Jersey Asphalt Paving Association	Trenton, NJ	Personnel resources, knowledge exchange, and technology transfer collaboration for annual paving conference
New Jersey metropolitan planning organizations (NJTPA, Delaware Valley Regional Planning Commission, and SJTPO)	Newark, NJ; Philadelphia, PA; Vineland, NJ	Collaborative research and knowledge exchange for freight advisory committee and other improvement task forces and projects
New York State Department of Transportation	Albany, NY	Personnel resources, knowledge exchange
Maryland State Highway Agency	Baltimore, MD	Personnel resources, knowledge exchange
Utah Department of Transportation	Salt Lake City, UT	Personnel resources, knowledge exchange, financial support
Idaho Department of Transportation	Boise, ID	Personnel resources, knowledge exchange, financial support
American Aerospace Technologies, Inc.	Bridgeport, PA	Personnel resources, knowledge exchange
University of Vermont	Burlington, VT	Collaborative research and partnership in the Northeast Regional Surface Transportation Workforce Center
Montana State University	Bozeman, MT	Collaborative research and partnership in the development of the National Center for Excellence in Roadway Safety
Clean Earth Dredging Technologies Inc.	Jersey City, NJ	Collaborative research, personnel exchange
JAFEC USA Inc.	San Jose, CA	Collaborative research, personnel exchange
ArtsBridge	Newark, DE	Collaborative research, personnel exchange
Cape May County	Cape May, NJ	Collaborative research on technology transfer events.
Delaware River Bay Authority	New Castle, DE	Collaborative research on technology transfer events.
MAGTUG	MidAtlantic	Served as a partner in delivering one-day meeting, helped with contacts, logistical support
Delaware T^2/LTAP	Newark, DE	Served as partner in delivering one-day meeting, helped with contacts and logistical support
Florida Department of Transportation	Tallahassee, FL	Financial support, knowledge exchange
Florida DOT District 7 office	Tampa, Florida	Financial support, knowledge exchange
Delaware Department of Transportation	Dover, DE	Collaborative research and financial support
National Cooperative Highway Research Program (NCHRP)	Washington, D.C.	Financial Support
McMahon & Mann Consulting Engineers, PC	Buffalo, NY	Collaborative research
University of Texas at Austin	Austin, TX	Collaborative research
American Transportation Research Institute (ATRI)	USA	Provided large streams of valuable GPS data on truck-movements in Tampa region.
Clemson University	Clemson, SC	Collaborative research

McMahon & Mann Consulting Engineers, PC	Buffalo, NY	Collaborative research
S-BRITE Center Purdue University	West Lafayette, IN	In-Kind Support
University of Illinois at Chicago	Chicago, IL	Collaborative research
New York City Department of Transportation	NY, NY	Helped with contacts, logistical support
New Jersey Division of Highway Traffic Safety	Trenton, NJ	Personnel resources, knowledge exchange, financial support

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 UTC partners communicated regularly throughout this reporting period.

Research Collaborations: The research selection process will yield many collaborative proposals to perform joint research with partners.
Ongoing collaborations for this reporting period include:

Accelerated Infrastructure Testing Facility: Bridge Evaluation Using Accelerated System Testing (BEAST)	• Utah State University • University of Delaware • NJDOT • VDOT • Applied Research Associates • Drexel University	The consortium created a working group to exchange ideas and knowledge about the construction of a massive, time-compressed facility that will study the effects of extreme weather and temperatures on real concrete bridge decks.

- **collaborations or contacts with others outside the UTC**
  Multiple DOT and University Partners

Additional ongoing collaborations include:

Northeast Regional Surface Transportation Workforce Center	• University of Vermont • CAIT	The objective of the new center is to forge relationships between private and public transportation agencies and an extensive network of education, labor, and workforce enrichment organizations to develop programs, resources, and opportunities aiming to prepare future transportation workers and provide current transportation workers with chances for career development.
National Center for Excellence in Roadway Safety	• Western Transportation Institute at Montana State University • CAIT	The center will offer training, technical support, and easily accessible information to transportation practitioners around the country, and provide national leadership in finding solutions to critical safety issues, especially on rural roads.

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

N/A

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

The consortium's research activities and conclusions will be made available through workforce development and technology transfer efforts and reach over 12,550 transportation professionals nationwide, including consortium members, external university partners, government officials, and private industry partners.

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

Workshops and conferences on advanced technologies, materials, and best practices will lead to the maintenance and construction of intelligent, resilient infrastructure systems that enhance commercial vitality and improve the safety, security, and quality of life for Americans who depend on them.

ONGOING RESEARCH PROJECTS DURING CURRENT REPORTING PERIOD

- All projects have been completed and final technical reports delivered and distributed.

PROJECTS COMPLETED DURING CURRENT REPORTING PERIOD

- "Segment-Level Crash Risk Analysis for New Jersey Highways Using Advanced Data Modeling" (NJIT)

Projects Previously Reported Completed:

- "Validation and Refinement of a Novel Deicing System for Stay Cables" (Rutgers University)
- "MEMs Field Deployment" (Rutgers University)
- "Development and Validation of Methodologies for Rapid Inspection and Assessment of Fatigue Damage" (Rutgers University)
- "Cloud-Based Virtual Traffic Sensor Network with 511 CCTV Traffic Video Streams" (Rutgers University)
- "Long-Term Performance Evaluation of Stabilized Sediments, Beneficial-Use, Projects" (Rutgers University)
- "Structural Health Monitoring of Representative Cracks in the Manhattan Bridge" (Rutgers University)
- "Impact Assessments of Automated Truck Platooning on Highway Traffic Flow and Adjacent Drivers" (NJIT)
- "Bond Performance of 1.125 Inch Diameter Prestressing Strands" (Utah State University)
- "Residual Capacity of Impacted Bridge Piers" (Utah State University)
- "Evaluation of Overlay Tester Test Procedure to Identify Fatigue Cracking Prone Asphalt Mixtures" (Rutgers University)
- "Sustainable Geotextiles for Transportation Applications from Recycled Textiles" (University of Delaware)
- "Reducing Stormwater Runoff Volumes with Biochar Addition to Highway Soils" (University of Delaware)
- "Long-Term Evaluation of Prestress Losses in Concrete Bridges using Long-Gauge Fiber Optic Sensors" (Princeton University)
- "Refined Load Rating through Rapid Modal Testing" (Rutgers University)
- "Evaluating Electrical Resistivity as a Performance based Test for Utah Bridge Deck Concrete" (Utah State University)
- "Prediction of Hydroplaning Risk of Trucks on Roadways" (Rutgers University)
- "Developing a Low Shrinkage, High Creep Concrete for Infrastructure Repair" (Utah State University)
- "Unmanned Aerial Vehicle Augmented Bridge Inspection Feasibility Study" (Utah State University)
- "Optimization of Pavement Surface Characteristics" (Virginia Tech)
- "Satellite Assessment and Monitoring for Pavement Management" (University of Delaware)
- "Methodological Framework for Optimal Truck Highway Parking Location and Capacity Expansion" (Rutgers University)
- "Development of a Risk Assessment Tool for Rail Transport of Flammable Energy Resources" (Rutgers University)

- “Bridge Health Monitoring using a Machine-Learning Strategy” (Columbia University)
- “Arrangement of sensors and Probability of Detection for Sensing Sheets Based on Large -area Electronics for Reliable Structural Health Monitoring” (Princeton University)
- “Bridge Retrofit or Replacement Decisions: Tools to Assess Sustainability and Aid Decision-making” (University of Delaware)
- “Using Information at Different Spatial Scales to Estimate Demand to Support Asset Management Decision Making” (University of Delaware)
- “Load Testing and Analysis of 48 year old out-of-service Double Tee Girder Bridge” (Utah State University)
- “Carbon Fiber Shear Reinforcement for Prestressed Bridge Girders” (Virginia Tech)
- “Development of Concrete Mix Proportions for Minimizing/Eliminating Shrinkage Cracks in Slabs and High Performance Grouts” (Rutgers University)
- “Port Authority of New York and New Jersey Resiliency Initiative” (Rutgers University)
- “A Study on 3D Printing and its Effects on the Future of Transportation” Rutgers University)
- “Live-Load Testing and Finite-Element Modeling of a Fracture Critical Bridge” (Utah State University)
- “Unmanned Aerial Vehicle (UAV) based Traffic Monitoring and Management” (Rutgers University)
- “Initial Evaluation of the Albedo and Solar-Radiation Flux of Asphalt Pavements” (Rutgers University)
- “Long-Term Monitoring of a Geosynthetic Reinforced Soil Integrated Bridge System (GRS-IBS)” (University of Delaware)
- “Development of Protocols and Instrumentation Plan for Accelerated Structural Testing Facility” (Rutgers University)
- “Dynamic Effects and Friction Values of Bridge Moves for ABC Bridges” (Utah State University)
- “Modeling the Impacts of Changes in Freight Demand, Infrastructure Improvements and Policy Measures on a Metropolitan Region” (NJIT)
- “Multi-Scale Condition and Structural Analysis of Steel Bridge Infrastructure” (University of Delaware)
- “Lean Construction Applications for Bridge Inspection” (University of Delaware)
- “Development & Implementation of NJ TRANSIT's Access Link Program“ (Rutgers University)
- “The Hudson River Rail Tunnel Like Study” (Rutgers University)
- “Improving the Durability of the Inverted T-Beam Bridge System” (Virginia Tech)
- “Characterization and Modeling of Recycled Pavement Sections” (Virginia Tech)
- “Infrastructure Issues Related to In-Motion Electric Wireless Power Transfer” (Utah State University)
- “Truck Route Choice Modeling Using Large Streams of GPS Data” (University of South Florida)
- “Installation of Embedded Accelerometers in Precast Girders for the Nibley Utah Bridge” (Utah State University)
- “Installation of Thermocouples, and Analysis of Temperature Data from the 21st South Bridge” (Utah State University)
- “Investigating the effects of corrosion protection coatings on the ductility of welded wire reinforcement” (Utah State University)
- “The Impact of Tolls on Access and Travel Patterns of Different Socioeconomic Groups: A Study for the Greater New York Metropolitan Area” (Rutgers University)
- “Ultra-Compact and Rugged Electrochemical Sensor for Monitoring Toxic Metals in Natural Water Sources” (Rutgers University)
- “Utilizing Unmanned Aircraft Systems for Infrastructure Management” (Rutgers University)
- “Collaborative Proposal: The Connection Between State of Good Repair and Resilience: Measures for Pavements and Bridges” (Delaware, Virginia Tech, and Rutgers)
- “National University Transportation Consortium: A Speaker Recognition Based Damage Detection” (Columbia University)
- “Experimental Evaluation of the Engineering Behavior of Soil-biochar Mixture as a Roadway Construction Material” (University of Delaware)
- “Sustainable Geotextiles for Transportation Applications from Recycled Textiles” (University of Delaware)
- “New Methodology for Evaluating Incompatibility of Concrete Mixes in Laboratory: A Feasibility Study” (University of Texas at El Paso)
- “Development of a Robust Framework for Assessing Bridge Performance using a Multiple Model Approach” (University of Texas at El Paso)

- "Evaluating Corrosivity of Geomaterials in MSE Walls: Determination of Resistivity from Power Water Chemistry" (University of Texas at El Paso)
- "Piezoelectric Energy Harvesting in Airport Pavement" (Rutgers University)

What is the impact on other disciplines?
N/A

What is the impact on the development of transportation workforce development?
It is anticipated that research projects will lead to the adoption of new practices, policies, or methods that will be disseminated to the transportation workforce through training. These training events will enhance the transportation industry through the creation of new career paths and an industrywide understanding of best practices and the USDOT state-of-good-repair mission. The partners have employed Post-doctoral researchers, PhD, MS, and undergraduate students on almost all of the research projects. These students will graduate and many will become leaders in the transportation industry of the future. Also, the opportunity for the undergraduates to participate in these innovative projects encourages them to progress and pursue advanced degrees themselves.

What is the impact on physical, institutional, and information resources at the university or other partner institutions?
It is anticipated that CAIT and its partners will share personnel and technological resources to streamline research, workforce development, and technology transfer efforts. The impact has been felt probably most markedly in the discipline of Structural Engineering and Bridge Engineering. There has been a steady flow of both PhD and Masters students that have participated in UTC projects due to the existence and activity of the Center. In addition, state and private funding sources have increased due to the opportunities to match funding which results in a beneficial relationship and leveraging of funds for all parties involved.

What is the impact on technology transfer?
It is anticipated that research projects will lead to the adoption of new or more efficient practices or inform policy.

What is the impact on society beyond science and technology?
Workshops and conferences on advanced technologies, materials, and best practices will lead to the maintenance and construction of intelligent, resilient infrastructure systems that enhance commercial vitality and improve the safety, security, and quality of life for Americans who depend on them. For example, the project on electric wireless power transfer will have an impact on all the traveling public and the way the future of transportation looks. In addition, the reduction of emissions and the positive effects on the urban environment will affect the overall population in many ways. The use of small unmanned aerial systems has the potential to increase inspector and public safety.

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"