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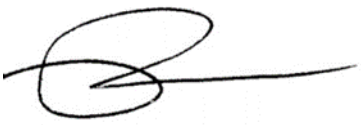


1. **ACCOMPLISHMENTS** (What was done? What was learned?)
What are the major goals and objectives of the program?

The CAIT Region 2 UTC Consortium's research vision aligns with the ongoing national dialogue on the state of the U.S. transportation infrastructure, and the emerging consensus on the need for significant investment to fill condition gaps, improve/expand existing systems, and build for the future.

The Consortium's **primary research focus** will be on "Improving the Durability and Extending the Life of Transportation Infrastructure," with additional elements of "Preserving the Existing Transportation System," such as resilience. Using Region 2 as a complex infrastructure laboratory, the Consortium will contribute to: 1) extending the life of the region's legacy systems, 2) building future systems with consideration to changes in living patterns and where people and products will move to and from, and 3) the use of technologies and better design approaches to maximize the use of both old and new transportation infrastructure assets.

The Consortium will structure its **education and workforce development activities** around a "cradle to grave" approach, developing programs that attract more people to the transportation industry, fostering skills to sustain them within the industry, and provide the workforce with professional development.

Gaining and sharing knowledge is the critical first step toward developing a transportation system that improves the durability and extends the life of transportation infrastructure. To this end, the Consortium will conduct **technology transfer** of research through implementation projects, knowledge transfer activities, and exploration of patents.

What was accomplished under these goals?
Research

The peer-review panel has approved 4 projects during this cycle. Two research projects are currently under review.

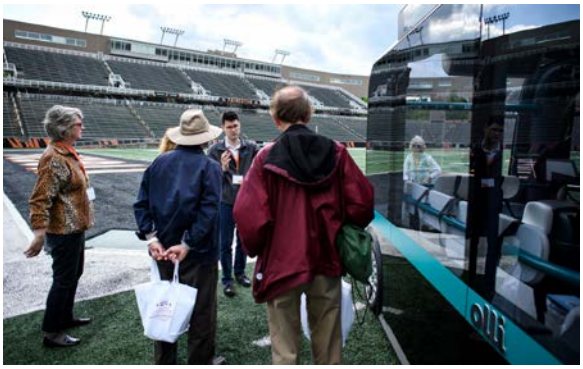
New Projects:

CAIT-UTC-REG 5	Implementation and Development of UAS Practical Training for Inspection and Monitoring Activities *Abstract:* Transportation organizations have been adopting Unmanned Aerial Systems (UAS) to aid with inspection and traffic monitoring activities. While there are multiple examples of these organizations using UAS to collect information, there still is a knowledge gap on how to collect data and operate safely. This project aims to design and develop training curricula to evaluate the practical flight abilities of prospective UAS pilots. The team will also research powered tether systems for long duration UAS flights. The team will evaluate UAS tether for use cases such as traffic monitoring.	Atlantic Cape Community College
CAIT-UTC-REG 21	Autonomous Vehicles: Capturing In-Vehicle Experience & Focus Group Follow-up with Persons with Autism and Other Disabilities at the 2019 Princeton University SmartDrivingCar Summit *Abstract:* The purpose of this project is to explore and document positive impacts Autonomous Vehicle (AV) transportation could have on persons with a broad array of disabilities and other transportation issues, as well as challenges that may hinder their successful usage of this revolutionary	RU

	technology. The Princeton Summit provides a unique opportunity to present AV to a sample of persons with disability so they can experience the technology first-hand and share their experiences.	
CAIT-UTC-REG 22	Simulation of Degradation and Failure of Suspension Bridge Main Cables due to Natural and Anthropogenic Hazards *Abstract*: The primary goal of this project is to develop a well-defined methodology to estimate the remaining strength of a suspension bridge cable that has been exposed to fire. The methodology will rely on a general purpose Finite Element code (ABAQUS) that is commercially available and widely used in the profession. The cable FEM model will be developed and calibrated using the extensive experimental data already available to the research team. This FEM model is expected to 1) provide high-confidence designs of new structures, 2) retrofit existing structures with novel hardening systems, 3) quantify more accurately the hazards associated with traffic patterns and general access to cables, and 4) perform high-fidelity forensic investigations of structures subjected to fire events.	Columbia
CAIT-UTC-REG 23	The Development of a Smart Intersection Mobility Testbed (SIMT) *Abstract:* The primary goal of this project is to establish the pilot Smart Intersection Mobility Testbed (SIMT) in downtown New Brunswick. The testbed will be equipped with AV-grade LiDAR and computer vision sensors to collect real-time vehicle, pedestrian, and infrastructure-change data. Data sharing and testing platforms will be built for testing and evaluating different mobility, safety, environmental, and energy applications.	RU/Columbia

Autonomous Vehicles: Capturing In-Vehicle Experience & Focus Group Follow-up with Persons with Autism and Other Disabilities at the 2019 Princeton University Smart Driving Car Summit.

The purpose of this project is to explore and document positive impacts autonomous vehicle (AV) transportation could have on persons with a broad array of disabilities and other transportation issues, as well as challenges that may hinder their successful usage of this revolutionary technology. The Princeton Summit provides a unique opportunity to present AV to a sample of persons with disability so they can experience the technology first-hand and share their experiences with the University researchers for analysis and discussions with policymakers, vehicle manufacturers, and others.



The Development of a Smart Intersection Mobility Testbed (SIMT)

The primary goal of this project is to establish the pilot Smart Intersection Mobility (SIMO) testbed in downtown New Brunswick. The testbed will be equipped with AV-grade LiDAR and computer vision sensors to collect real-time vehicle, pedestrian, and infrastructure change data. Data sharing and testing platforms will be built for testing and evaluating different mobility, safety, environmental, and energy applications.

Ongoing Projects:

CAIT-UTC-REG2B	Sustainable, Rapid Repair Utilizing Advanced Cementitious Materials	SUNY Buffalo
CAIT-UTC-REG3	Large-Amplitude Forced Vibration Testing for St-Id of Bridges and Foundation Reuse Assessment	RU
CAIT-UTC-REG7	MEMS Sensor Development for In-Situ Quantification of Toxic Metals in Sediment	RU
CAIT-UTC-REG8	Prioritizing Infrastructure Resilience throughout the Capital Planning Process	RU
CAIT-UTC-REG9	Delivering maintenance and repair actions via automated/robotic systems	RU
CAIT-UTC-REG11	Pavement Design For Local Roads and Streets	Cornell
CAIT-UTC-REG12	Laboratory Performance Evaluation of Pavement Preservation Alternatives	Rowan
CAIT-UTC-REG13	Virtual Tour (VT), Informational Modeling (IM), and Augmented Reality (AR) for Visual Inspections (VI) and Structural Health Monitoring (SHM)	PU
CAIT-UTC-REG14	Performance-Based Engineering of Transportation Infrastructure Considering Multiple Hazards	SUNY Buffalo
CAIT-UTC-REG15	Flood Vulnerability Assessment and Data Visualization for Lifeline Transportation Network	Rowan
CAIT-UTC-REG16	Fire In Tunnel Collaborative Project	PU/SUNY-Buffalo/NJIT
CAIT-UTC-REG17	Improving Transportation Infrastructure Resilience against Hurricanes, other Natural Disasters, and Weathering: Part I - Analysis of failure of transportation signs due to Hurricane Maria	PUPR
CAIT-UTC-REG18	Improving Transportation Infrastructure Resilience against Hurricanes, other Natural Disasters, and Weathering: Part II - Analysis of pedestrian bridges failures due to Hurricane Maria	PUPR
CAIT-UTC-REG19	Improving Transportation Infrastructure Resilience against Hurricanes, other Natural Disasters, and Weathering: Part III - Analysis of motor vehicle bridges failures due to Hurricane Maria	PUPR
CAIT-UTC-REG20	Infrastructure Cybersecurity and Emergency Preparedness Academic and Non-academic Credential Development	SUNY-Farmingdale

Completed Projects:

CAIT-UTC-REG1	Augmented Reality (AR) in Life-Cycle Management of Transportation Infrastructure Projects	RU
CAIT-UTC-REG2A	Sustainability and Resiliency of Concrete Rapid Repairs Utilizing Advanced Cementitious Materials – Freeze/Thaw Loads	NJIT
CAIT-UTC-REG4	Rail Track Asset Management and Risk Management	RU
CAIT-UTC-REG6	Airfield Pavement Management Framework using a Multi-Objective Decision-Making Process	RU
CAIT-UTC-REG10	Policies, Planning, and Pilot Testing on Infrastructure Readiness for Electrical, Connected, Automated, and Ridesharing Vehicles	RU/Columbia

HIGHLIGHTS
Completed Projects

Augmented Reality (AR) in Life-Cycle Management of Transportation Infrastructure Projects (CAIT-UTC-REG1, Project Manager: Dr. Jie Gong)

Accomplishments: This project developed two Virtual Reality (VR) environments and software that provide innovative infrastructure training that is safer, more efficient, and less expensive than traditional methods. The first module is a full-scale bridge modeled after the Stan Musial Veterans Memorial Bridge. The second is a full-scale critical facility modeled after an in-service pump station. Workers can use these environments to simulate setting up work zones, experience traffic, and practice emergency protocols.

ROI: 1) Two virtual environments reduce training cost for transportation workforce and improve effectiveness. 2) These modules foster a safe working environment which will in return reduce transportation related fatalities. 3) Through demonstrations with stakeholders such as the Port Authority of New York and New Jersey, NJ Board of Public Utilities, highway construction unions, and others, the capabilities of this technology have been distributed to key stakeholders in the industry, which could help them save time and money.

Sustainability and Resiliency of Concrete Rapid Repairs Utilizing Advanced Cementitious Materials – Freeze/Thaw Loads (CAIT-UTC-REG2A, Project Manager: Matthew P. Adams)

Accomplishments: This project developed a guideline on how freeze-thaw damage impacts the bond and quality of overlays or repairs done with rapid-repair cements. By subjecting samples to 300 cycles of freezing and thawing, UTC partners at the New Jersey Institute of Technology (NJIT) simulated the freeze-thaw damage that concrete will see over a lifetime. With this information and additional testing, they developed a guideline on freeze-thaw damage and rapid-repair materials that will give agencies the tools to select the right materials, save money on repair costs, and improve system resiliency overall.

ROI: 1) A guideline was developed that can be implemented within agency laboratories that provides a detailed testing methodology to study the performance of overlay and repair materials under freeze-thaw cycling. 2) It has been estimated that road-construction costs total $238,000 per mile in new Jersey, according to the Garden State Initiative. This guideline will help agencies select optimal rapid-repair materials that will last and save time and money. 3) The New York City Department of Design and Construction expressed interest in the guideline. Richard Jones, Executive Director, said: "The testing program outlined in this work will help NYC agencies determine which materials are most suitable, durable, and cost efficient for rapid repair of concrete systems. This is a valuable tool in the decision-making process."

Policies, Planning, and Pilot Testing on Infrastructure Readiness for Electrical, Connected, Automated, and Ridesharing Vehicles (CAIT-UTC-REG10, Project Manager: Mohsen Jafari)

Accomplishments: This project delivers a comprehensive review of the existing ITS system architecture and implementation in New Jersey; documents the best practices in ITS system architecture in the country, which support the transition to connected and electric vehicles; and identifies gaps in New Jersey. Going forward, researchers hope to build on this report and information with the "Development of a Smart Intersection Mobility Testbed (SIMT)" project, where they will turn the city of New Brunswick, New Jersey into a hub for mobility-data collection.

ROI: 1) Researchers published studies, reports, and spoke at conferences to analyze the current infrastructure readiness for autonomous and connected vehicles and to disseminate this information. 2) Researchers developed a preliminary system architecture for New Jersey that supports connected and electric-vehicle technologies, and identified critical infrastructure barriers in New Jersey to make the transition. 3) Researchers developed a preliminary plan for a smart mobility testbed.

Rail Track Asset Management and Risk Management (CAIT-UTC-REG4, Project Manager: Dr. Yun Bai)

Accomplishments: This project developed a customized Concept of Operations (ConOps) for rail track asset management and risk management, building on existing practice, needs, and gaps based on communication with industry members. It summarizes the potential factors causing broken rails to help understand this problem, and concludes with major findings in broken-rail reduction benefits as well as a future work map.

ROI: 1) Freight rail carries more than 43% of ton-miles of goods and passenger rail transports millions of passengers annually in the United States. Track infrastructure is a valuable asset and this report fills a gap in the framework for rail-oriented track asset management. 2) This report demonstrates monetary benefits of prevented broken rails in two scenarios, during weekends and during weekdays, providing high and low-end estimates for slow and busy times. 3) If 10 broken rails are expected to be prevented, the reduction benefits are approximately between $1.8 - $4.4 million.

Airfield Pavement Management Framework using a Multi-Objective Decision Making Process (CAIT-UTC-REG6, Project Manager: Dr. Hao Wang)

Accomplishments: Hitting a pothole on your morning drive to work could mean spilling coffee, but a plane hitting one while landing could have catastrophic effects. This project examined the relationship of three Pavement Condition Indexes used for estimating airfield-pavement service life. It also developed a framework with the potential to inform airport authorities about the condition of their pavements, and when it might be time for maintenance.

ROI: 1) Replacing airfield pavement can cause delays and be costly. This framework shows what Pavement Condition Index gives airports the best indication of pavement service life, saving time and money. 2) The Federal Aviation Administration (FAA) currently uses an index covering all general pavement distresses to assess airfield pavement condition for planning of maintenance and

rehabilitation (M&R) treatment, this project considers variables that will cause certain pavement to deteriorate differently. 3) Foreign Object Damage (FOD) can cost up to $12 billion counting indirect costs from delays, additional fuel consumptions, and plane shifts. This project can potentially help airport authorities consider this type of damage in their planning.

CAIT Research Validates Street Smart NJ Campaigns

Accomplishments: Through its University Transportation Center (UTC) relationship with Rowan University, Rutgers CAIT was able to collaborate on this North Jersey Transportation Planning Authority (NJTPA) funded project that evaluated NJTPA's Street Smart NJ program, and validated its effectiveness at a number of critical intersections throughout the state.

ROI: 1) This report showed that Street Smart NJ campaigns created safety benefits at eight intersections across the state. 2) This report can help spawn future related safety initiatives building on the successes of the Street Smart NJ campaign. 3) Chair of the NJTPA Board of Trustees and Union County Freeholder Angel Estrada said: "These results illustrate that Street Smart NJ is helping make our roads safer for everyone. By combining education and enforcement we can make a difference and help New Jersey work toward its goal of zero fatalities."

Alleviating urban heat island effect using high-conductivity permeable concrete pavement

Accomplishments: This report shows how permeable concrete can benefit the environment and reduce "urban heat island effect." Dr. Hao Wang, a CAIT-affiliated researcher, also does pavement research funded through the UTC grant. He helped develop the designs for this special concrete.

ROI: 1) The Rutgers team developed designs for special permeable concrete that was found to give off slightly more heat on sunny days compared to conventional concrete pavement, but 25 to 30 percent less heat on days after rainfall. 2) In cities with 1 million or more people, average air temperatures can be 1.8 to 5.4 degrees Fahrenheit higher than in less densely populated areas, and the difference can be up to 22 degrees at night. This project helps address this problem of "urban heat island effect."

Application of Unmanned Aerial Vehicles to Inspect and Inventory Interchange Assets to Mitigate Wrong-Way Entries

Accomplishments: Traditional methods of collecting Wrong-Way Driving (WWD) data are time consuming and expose crews to traffic hazards. Through collaboration with UTC partners at Rowan University, a team was able to show that drones have the potential to collect accurate data in a faster, safer, and more efficient way—which could help in reducing WWD crashes and accomplishing the 'Toward Zero Deaths' goal of many transportation stakeholders in the future. This project was featured in the July 2019 edition of the Institute of Transportation Engineers Journal.

ROI: 1) This project helps keep roadside crews safe by using remote inspections. 2) Exit-ramp terminals are the most common location for drivers to enter a highway going the wrong direction. According to data from the National Highway Traffic Safety Administration (NHTSA) Fatality Analysis Reporting System (FARS) database, in 2018 there were 598 WWD crashes in New Jersey. This project will help authorities implement proper signs and features to efficiently improve safety. 3) This project demonstrates another innovative application of drone technology, as traditional field surveys are time-consuming, labor-intensive, and sometimes hazardous.

Ongoing Projects

Sustainable, Rapid Repair Utilizing Advanced Cementitious Materials (CAIT-UTC-REG2B, Project Manager: Ravi Ranade)

Outputs: A computational framework for systematic assessment of vulnerability of deteriorated bridges to earthquakes was developed. This framework improves decision-making processes, efficiency, and safety of bridges by determining corrosion and hazard vulnerabilities.
Outcome: Bridge engineers from NY and WA State DOTs are very much in support of this framework and suggested that a more developed version of this framework can be used as an assessment tool to prioritize structures for repair, choose between various repair strategies, and determine their resiliency to earthquakes.
Impacts: Improvements in safety and resilience of bridges are expected as a result of the application of the framework developed in this research. In addition, this framework will result in life cycle cost savings and facilitate informed allocation of state DOT's annual maintenance budget for prioritizing construction and repair activities.

Large-Amplitude Forced Vibration Testing for St-Id of Bridges and Foundation Reuse Assessment (CAIT-UTC-REG3-Project Manager: Dr. Nenad Gucunski)

Outputs: A methodology for establishing performance of bridges by considering the effects of dynamic soil-foundation-structure. Products such as a generic guideline for dynamic field-testing considering soil-structure interactions, data analysis and visualization, and the reuse of foundation systems based on the large-amplitude shaking are anticipated as deliverables.
Outcome: The findings will support performance-based management of highway infrastructure assets, which could broadly impact the current policies for foundation reuse and allocation of resources.
Impacts: This project will help enhance the State of Good Repair of highway-bridge structures, which will ultimately reduce life-cycle cost, and improve safety and quality of service for the travelling public.

MEMS Sensor Development for In-Situ Quantification of Toxic Metals in Sediment (CAIT-UTC-REG7, Project Manager: Dr. Mehdi Javanmard)

Outputs: Researchers have developed a working prototype of highly accurate Microelectromechanical Systems chemical sensors, which are capable of detecting lead in sediment samples. This technology can rapidly (within 5 minutes) quantify lead in sediment samples. This will significantly lower the cost and increase the speed in which sites can be mapped and assessed for identifying toxic hotspots.
Outcome: A technology that is capable of rapid and inexpensive identification and triaging of environmental-sediment hotspots in natural water sources. Rather than using brute force and costly

approaches, the contaminated hotspots can easily and rapidly be identified, which otherwise require dredging.
Impacts: This technology offers a more cost-effective method of environmental remediation. The New Jersey Department of Transportation (NJDOT) has been contacted to showcase this technology and further discuss its capabilities.

Prioritizing Infrastructure Resilience throughout the Capital Planning Process (CAIT-UTC-REG8, Project Manager: Jon Carnegie)

Outputs: Researchers have conducted a literature review and practice scan that examines how transportation agencies are incorporating resilience measures and considerations in: vulnerability assessments; asset management methodologies; benefit-cost (B-C) / return on investment (ROI) methodologies; project identification/prioritization approaches; and project design and construction. The scan also documents how agencies are coordinating regionally, addressing interdependencies and how resilience is treated in the organizational structure of the agency.
Outcome: The next step in the process will be to conduct a series of key informant interviews to develop case studies of leading and promising practices.
Impacts: The leading and promising practice case studies will be presented at a peer-learning exchange workshop where participants from regional transportation agencies will develop self-identified action agendas for advancing these practices at their own agencies. Outreach Activities: The Port Authority of New York and New Jersey; NJDOT.

Delivering Maintenance and Repair Actions via Automated/Robotic Systems (CAIT-UTC-REG9, Project Manager: Dr. Jie Gong)

Outputs: Researchers convened an invitation-only workshop on May 30, 2019 on identifying use cases, characterizing research priorities in robotic systems, and aligning research visions on various identified research dimensions.
Outcome: The workshop featured a mélange of three communities: R+D, practitioners, and end-users. There were approximately 70 attendees at the workshop. Several renowned speakers were invited too including Dr. Carl Hass, a member of the Canadian Academy of Engineering, a pioneer in developing robotic systems for infrastructure inspection and repair; and speakers from Tybot, a renowned company in construction automation.
Impact: The workshop informed infrastructure stakeholders and practitioners about available robotics tools to deliver infrastructure inspection and repair actions and provided critical projection on future jobs in infrastructure maintenance. This will contribute to safer and more efficient infrastructure inspection and repair practices.

Pavement Design for Local Roads and Streets (CAIT-UTC-REG11, Project Manager: Dr. David Orr)

Outputs: A user-friendly software tool using mechanistic-empirical methods to assist local agencies with designing streets for various traffic spectra associated with low-volume roads, set to approximately 2,000 vehicles per day, has been developed. The towns of Preble and Hartland, as well as Oswego and Schoharie counties in New York have been engaged in the development of this tool, and it is expected to officially launch this fall. A longer-term goal is to possibly develop this product into an app.
Outcome: The tools developed under this study will allow local agencies to design their roads properly for their required loads. “Experience,” budgetary constraints, and inappropriate tools often conspire in forcing towns and villages to under-build their roads, leading to premature failure and costly remediation.

Impacts: Unlike Mechanistic Empirical Pavement Design Guide (MEPDG), the tools developed under this study will require inputs that the local agencies understand and can obtain using the limited resources of small municipalities. Ultimately, they can make the best decisions to allocate their limited resources, while serving the traveling public and tax payers.

Laboratory Performance Evaluation of Pavement Preservation Alternatives (CAIT-UTC-REG12, Project Manager: Dr. Yusuf Mehta)

Outputs: Texas Overlay Tester sample fabrication procedures will be modified to evaluate cracking performance of asphalt pavement preservation mixes. Application of these treatments to Texas Overlay asphalt samples will be conducted to simulate field application as closely as possible.
Outcome: Recommendations will be made to local and federal highway agencies regarding decision-making guidelines for choosing the timing and appropriate pavement preservation treatments.
Impacts: Evaluation of cracking performance of pavement preservation treatments will improve decision-making processes, increase the effectiveness of treatments, and reduce costs.

Virtual Tour (VT), Informational Modeling (IM), and Augmented Reality (AR) for Visual Inspections (VI) and Structural Health Monitoring (SHM) (CAIT-UTC-REG13, Project Manager: Dr. Branko Glisic)

Outputs: Virtual Tour (VT)/Informational Modeling (IM) prototype software and Image/Augmented Reality (AR) prototype software.
Outcome: A demonstration software that can be accessed on a mobile device, laptop, desk computer, virtual reality (VR) headset, or AR headset, depending on a user's needs. Validation will be performed on real structures, in particular Streicker Bridge in Princeton, NJ and/or the US202/NJ23 overpass in Wayne, NJ.
Impacts: This will have an impact on asset durability, resilience, and preservation, as the project method provides means to assist the actions that improves these three features.

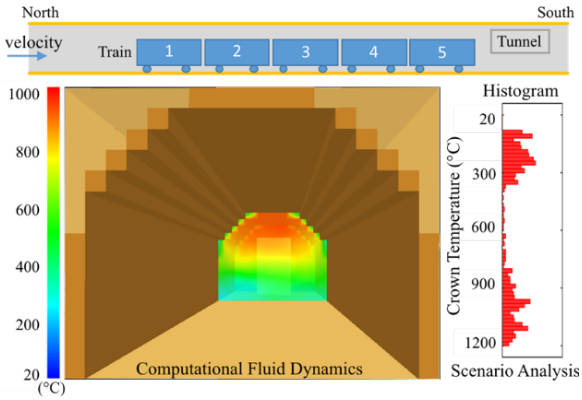
Performance-Based Engineering of Transportation Infrastructure Considering Multiple Hazards (CAIT-UTC-REG14, Project Manager: Dr. Kallol Sett)

Outputs: A novel risk-informed design framework that could enable a paradigm shift and the design of a resilient transportation network, moving away from the focus on individual components of a network.
Outcome: A case-study illustrating performance-based engineering of a simple network subjected to seismic and storm-surge hazards. Unless all components of a network are analyzed together, risks to the network may be underestimated. Also, an optimum retrofit strategy for any transportation network depends on the decision-maker: policy makers, owners, and insurance companies could potentially perceive risk from different perspectives and decide on different strategies for the same system.
Impacts: 1) Reducing repair costs and downtime of highway infrastructure subjected to hazards, 2) reducing community impacts, and 3) designing safer, more economical transportation infrastructure.

Flood Vulnerability Assessment and Data Visualization for Lifeline Transportation Network (CAIT-UTC-REG15, Project Manager: Rouzbeh Nazari)

Outputs: A state of the art flood map for New Jersey towns that offers a unique picture of flood hazards, lifeline infrastructure, vulnerability assessments, and resiliency measures.
Outcome: This project provides more detailed, reliable, and current data on flood hazards resulting in a better picture of the New Jersey towns most likely to be impacted by flooding and a better foundation from which to make key legislative decisions/changes.
Impacts: This project assists decision makers and coastal communities with understanding the magnitude of flood events, quantifying impacts, and assisting with mitigation and resiliency planning.

Fire in Tunnel Collaborative Project (CAIT-UTC-REG16, Project Manager: Negar Khorasani)



Outputs: A presentation at the IABSE Congress in New York City took place and a paper was published in the conference proceedings. This project develops a methodology to achieve acceptable fire safety and minimize economic losses in a tunnel subjected fire, and will lead to improved structural safety guidelines.
Outcome: This work offers recommendations on preventive measures for tunnel structures subjected to fire. In addition, the project outcomes can be used to inform operation and inspection strategies and post-event analysis.
Impacts: Resilience of a tunnel subjected to fire is measured by expected downtime and loss of functionality following an event. This research will allow engineers to design and evaluate tunnels subjected to fire and implement proper mitigation actions.

Improving Transportation Infrastructure Resilience against Hurricanes, other Natural Disasters, and Weathering: Part I - Analysis of failure of transportation signs due to Hurricane Maria (CAIT-UTC-REG17, Project Manager: Dr. Héctor J. Cruzado)

Outputs: Improvements in design and analysis of highway signs subjected to high winds and storms such as hurricanes. This project specifically looks at damaged highway signs after Hurricane Maria.
Outcome: The expected output is a design guide.
Impacts: 1) This project will increase the safety of the travelling public during a hurricane, and improve the resiliency of highway signs subjected to excessive wind and hurricanes.

Improving Transportation Infrastructure Resilience against Hurricanes, other Natural Disasters, and Weathering: Part II - Analysis of pedestrian bridges failures due to Hurricane Maria (CAIT-UTC-REG18, Project Manager: Héctor J. Cruzado)

Outputs: Improvements in design and analysis of pedestrian bridges subjected to high winds and storms such as hurricanes. This project specifically looks at damaged pedestrian bridges after Hurricane Maria.
Outcome: The expected output is a design guide.
Impacts: This project will increase safety of the public during a hurricane, and also improve the resiliency of pedestrian bridges subjected to excessive wind and hurricanes.

Improving Transportation Infrastructure Resilience against Hurricanes, other Natural Disasters, and Weathering: Part III - Analysis of motor vehicle bridges failures due to Hurricane Maria (CAIT-UTC-REG19, Project Manager: Héctor J. Cruzado)

Outputs: Improvements in design and analysis of motor vehicle bridges subjected to high winds and storms such as hurricanes. This project specifically looks at motor-vehicle bridge damage after Hurricane Maria.
Outcome: The expected output is a design guide.
Impacts: 1) The first impact of this project will be increased safety of the travelling public during a hurricane event, 2) the second benefit will be improving the resiliency of motor vehicle bridges subjected to excessive wind and hurricanes.

Education and Workforce Development Activities
The consortium has trained more than 2,500 professionals during this period.

- **The BEAST brings UTC students and researchers together to take on infrastructure challenges**
  Rutgers CAIT poured concrete for a new project in The BEAST sponsored by the Federal Highway Administration (FHWA). Students from Rutgers and NJIT advanced several research projects. NJIT students prepared companion-material specimens that will be tested at NJIT's MatSlab. CAIT has always envisioned The BEAST as an opportunity for students to receive experiential learning through these types of collaboration.

- **ACCC drone program launches**
  Atlantic Cape Community College has tapped into a multi-billion-dollar industry with its new degree program that launched this fall designed to certify students as field technicians of small UAVs. The training will help students find jobs in an emerging field and develop the drone workforce. Students graduate with an Applied Science for Unmanned Aircraft Systems Field Technicians degree and can take a series of micro-credentials that act as individual workforce credentials.

- **Jerry DiMaggio will teach a course on modern Ground Improvement Methods at Rutgers CAIT**
  Presented by Jerry A. DiMaggio at Rutgers CAIT, this 2-day course will outline the best practices for dealing with poor ground conditions at the job site, and will provide professional engineers with information vital to their jobs. It will demonstrate more than 50 modern ground improvement methods that can be used in various forms of urban construction.

- **The Rutgers Asphalt and Pavement Lab visited Tilcon's Mt. Hope facility**
  As the largest asphalt plant on the East Coast, Tilcon's Mt. Hope facility can produce 600+ tons of asphalt per hour. Undergraduate students, graduate students, and staff from the Rutgers Asphalt and Pavement Lab toured the site to get a better sense of how an asphalt plant works.

- **NJLTAP to work with stakeholders on developing intersection and pedestrian safety workshops**
  The New Jersey Local Technical Assistance Program (NJ LTAP) will work to develop a statewide "Proven Safety Countermeasures" workshop alongside partners through a $16,000 grant that was recently awarded to the NJDOT.

- **Sustainable infrastructure expert named ASCE Educator of the Year**
  The American Society of Civil Engineers (ASCE) New Jersey Chapter announced Dr. Hao Wang as its 2019 Educator of the Year. He was selected for his research promoting sustainability in civil engineering, especially transportation infrastructure, and his dedication to engineering education.

- **Twenty-year milestone for NJ Work Zone Safety Conference**
  CAIT and the New Jersey Work Zone Safety Partnership welcomed more than 250 professionals to the annual New Jersey Work Zone Safety Conference at Rutgers Livingston Campus Student Center on April 5. This year was the conference's milestone 20th year of educating and supporting those who work on the state's roadways.

Technology Transfer

- **Robots' ever-growing uses for infrastructure management**
  On May 30, Rutgers CAIT brought together more than 70 researchers, agency officials, and private industry leaders to discuss the seemingly endless applications for robots in the transportation infrastructure sector, and how to overcome inertia in a portion of the market that has been reticent to adopt new technology.

- **Region 2 UTC partner meeting brings together researchers and their customers**
  As the Region 2 UTC lead institution, Rutgers CAIT gathered its consortium partners and high-level industry leaders to discuss priorities in the region and opportunities for collaboration. In attendance were members of the NJDOT, the Port Authority of New York and New Jersey, and more stakeholders who discussed the next steps in transportation.

- **The Polytechnic University of Puerto Rico presented preliminary findings at Expo Cumbre 2019**
  Through its current UTC project, The Polytechnic University of Puerto Rico has been studying the effects of Hurricane Maria on pedestrian bridges, vehicular brides, and traffic signs to help build more resiliently in the future. Researchers presented early findings at Expo Cumbre 2019 in May.

- **Presentations and Research Discussions**
  CAIT Associate Director for Technology Transfer and NJ LTAP Director Janet Leli presented on Safe Transportation for Every Pedestrian (STEP) at the National Local Technical Assistance Program/National Transportation Training Directors Conference.

  At the State Transportation Innovation Council, Among the agenda items was discussion of High Friction Surface Treatment (HFST), which was recently tested for the NJDOT by the Rutgers Asphalt and Pavement Laboratory. HFST is one of the FHWA's Every Day Counts (Round 2) initiatives.

- **CAIT coordinated a Tech Talk as part of NJDOT's Bureau of Research Technology Transfer program**
  Dr. Eric Brown of the FHWA Resource Center discussed designing safer and resilient waterway structures and advancing stakeholder communications during a Tech Talk coordinated by CAIT.

- **The Academy at Rutgers for Girls in Engineering and Technology (TARGET) program**
  TARGET at the Rutgers School of Engineering helps middle school and high school age girls learn more about career opportunities for them within engineering. To support these efforts, CAIT brought in professional female engineers to offer advice to these aspiring young girls.

- **A joint webinar between Tran-SET and CAIT**
  Dr. Jie Gong joined other researchers in a joint webinar between Tran-SET and CAIT about innovations in transportation infrastructure inspection. He discussed some of his recent work using AR as a bridge and infrastructure assessment and management too.

- **Automated Vehicles conference at Princeton University**
  Researchers at CAIT and Princeton University teamed up on a research project at the Automated Vehicles conference at Princeton University to help introduce autonomous vehicles to individuals with disabilities during the event.

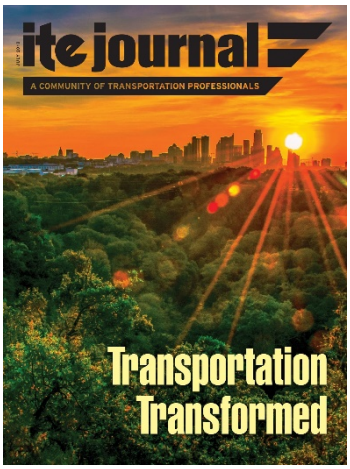
How have the results been disseminated?

CAIT has established the Consortium internet site: https://cait.rutgers.edu/

CAIT has distributed The CAIT Update, its monthly E-newsletter, to subscribers throughout the UTC community, industry, academia, and media.

CAIT has also disseminated results to the general public through the news media. Select coverage includes:

TR News Magazine



ITE Journal

Fox 5 New York

Forbes

NJBIZ

NJ101.5

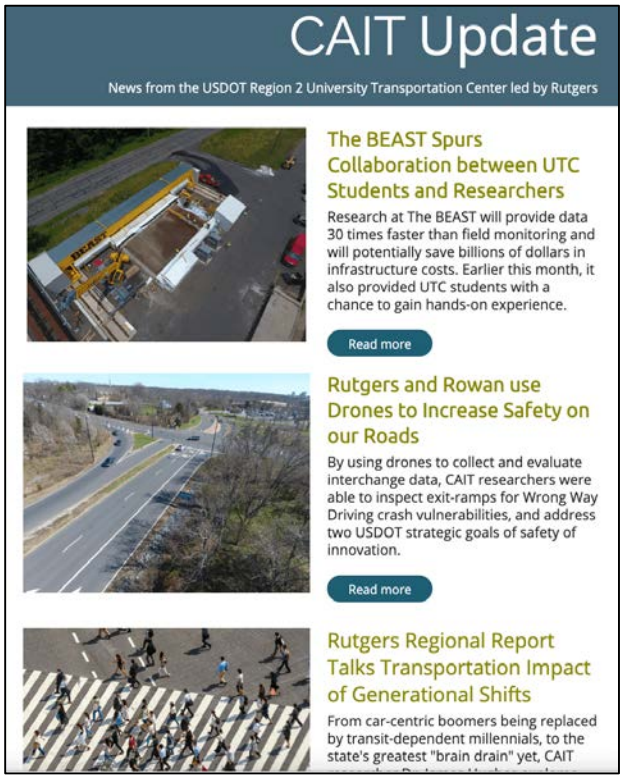
AASHTO Daily Transportation Update

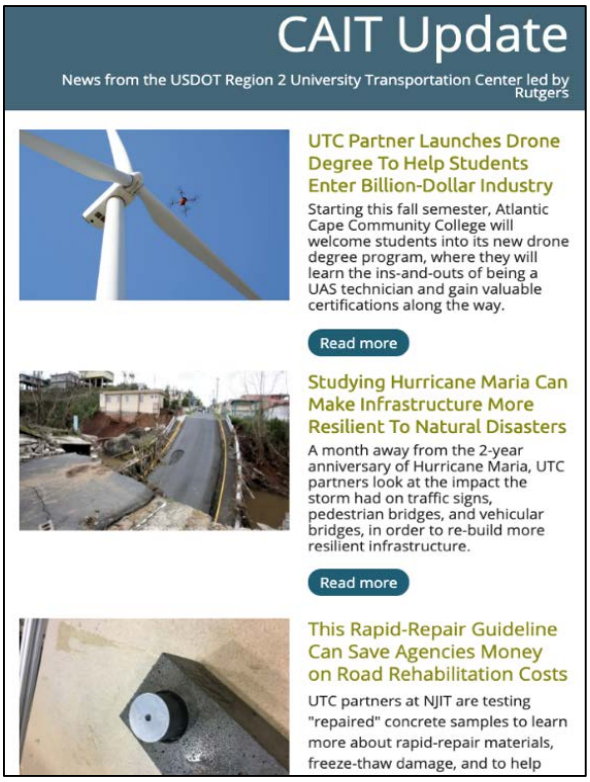
NJ.com

The Daily Record

Newsletter

CAIT has distributed The CAIT Update, its E-newsletter, on a monthly basis to more than 4,000 subscribers.





What do you plan to do during the next reporting period to accomplish the goals and objectives?

No change to plan and process to accomplish our goals.

2. PARTICIPANTS AND OTHER COLLABORATING ORGANIZATIONS (Who has been involved?)
Consortium Universities Involved

Rutgers, The State University of New Jersey • Piscataway, NJ 08854 (**LEAD**)
Atlantic Cape Community College • Mays Landing, NJ 08330
Columbia University • New York, NY 10027
Cornell University • Ithaca, NY 14853
New Jersey Institute of Technology • Newark, NJ 07102
Polytechnic University of Puerto Rico • San Juan, Puerto Rico 00918
Princeton University • Princeton, NJ 08544
Rowan University • Glassboro, NJ 08028
SUNY–Farmingdale State College • Farmingdale, NY 11735
SUNY–University at Buffalo • Buffalo, NY 14260

- ***What organizations have been involved as partners?***

New Jersey Department of Transportation	Trenton, NJ	Financial support and collaborative research on multiple projects, personnel resources, knowledge exchange
Port Authority of New York and New Jersey	New York, NY,	Collaborative research on multiple projects, personnel resources, knowledge exchange, financial support
New Jersey Board of Public Utilities	Trenton, NJ	Financial support and collaborative research on multiple projects, including PHMSA State Damage Prevention Grant
New York State Department of Transportation	Albany, NY	Financial support, personnel resources, knowledge exchange
Washington State Department of Transportation	Olympia, WA	Personnel resources, knowledge exchange
Port Authority Trans-Hudson	Jersey City, NJ	Personnel resources, knowledge exchange
New York State County Highway Superintendents Association	Oneida and Chemung Counties	Personnel resources, knowledge exchange
New York Association of Town Superintendents of Highways	Canaan, NY	Personnel resources, knowledge exchange
Mistras Group	Princeton Junction, NJ	Personnel resources, knowledge exchange
Arup	New York, NY	Personnel resources, knowledge exchange
New Jersey Department of Community Affairs	Trenton, NJ	Personnel resources, knowledge exchange
Arora and Associates, P.C.	Lawrenceville, NJ	Personnel resources, knowledge exchange
Pennsylvania Department of Transportation	Bridgeville, PA	Personnel resources, knowledge exchange
Puerto Rico Highway and Transportation Authority	San Juan, PR	Personnel resources, knowledge exchange
Federal Highway Administration, Puerto Rico Division	San Juan, PR	Personnel resources, knowledge exchange

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

  Nothing to report

3. **OUTPUTS** (What new research, technology or process has the program produced?)
Publications, conference papers, and presentations

- H. Cruzado, G. Pacheco and A. Vélez. "Analysis of failure transportation signs, pedestrian bridges, and vehicular bridges due to Hurricane Maria." CIAPR Expo Cumbre, San Juan, PR, May 24, 2019.
- H. Cruzado, "Studying the Damage from Hurricane Maria Can Make Future Infrastructure More Resilient," CAIT E-newsletter, 23, August 2019.
- J. Gong, "Innovative Technology, Techniques, and Processes in Transportation Infrastructure Inspection," Tran-SET Webinar, 2019.
- J. Gong, "Rutgers CAIT is Using VR to Make Workforce Training Safer and More Efficient," CAIT E-newsletter, July 2019.
- J. Gong, "Robots' ever-growing uses for infrastructure management," CAIT E-newsletter, June 2019.
- M. Adams, M. Bandelt, N. Thibodeaux, "NJIT is Helping Agencies Save Money with Research on Best Rapid-Repair Materials," CAIT E-newsletter, 26, August 2019.
- M. Jalayer, M. O'Connell, H. Zhou, P. Szary, S. Das, "Application of Unmanned Aerial Vehicles to Inspect and Inventory Interchange Assets to Mitigate Wrong-Way Entries," Institute of Transportation Engineers Journal, July 2019.
- H. Wang, P. Okumus, R. Ranade, "Seismic Fragility of Bridges Subjected to Corrosion", 10th New York City Bridge Conference, New York, NY, Aug 26-27, 2019.
- H. Wang, R. Ranade, P. Okumus, "Seismic Fragility of Bridges Subjected to Corrosion", presentation to New York State Association of Transportation Engineers - Section 4, Buffalo, NY, April 3, 2019.
- H. Wang, R. Ranade, P. Okumus, "Influence of improved durability with a ductile fiber-reinforced concrete on the resilience of a reinforced-concrete bridge," Submitted to Transportation Research Record on Aug 1, 2019.
- H. Wang, "CAIT Researcher Develops Mechanism for Evaluating Airfield Pavement Conditions," CAIT E-newsletter, 30, September 2019.
- Z. Zang, X. Liu, K. Holt, "Prevention of End-of-Track Collisions at Passenger Terminals via Positive Train Control, "Transportation Research Record," 8, May 2019.
- N. Gucunski, "Short course on the use NDE technologies in the condition assessment of bridges," Connecticut DOT, June 14.
- N. Gucunski, "A lecture at the SHMII19, International Conference on Structural Health Monitoring," St. Louis, MO, August 6.
- Y. Huang, S. Jiang, M. Jafari, P. Jin, "Infrastructure Readiness for Transformative Changes in Transportation," Int'l Conf. on Smart Infrastructure and Construction, University of Cambridge, July 2019.
- A. Nikellis, K. Sett, "Multi-hazard risk assessment of a bridge-roadway-levee system considering downtime losses", Proceedings, ASCE 2019 Engineering Mechanics Conference, California Institute of Technology, Pasadena, CA, June 18-21, 2019, oral presentation only
- A. Nikellis, K. Sett, "Risk assessment of a bridge-roadway-levee system subjected to multiple hazards", Proceedings, 2nd International Conference on Natural Hazards and Infrastructure, Chania, Greece, June 23-26, 2019, oral presentation and publication.
- A. Nikellis, K. Sett, T. Wu, A. S. Whittaker, "Multi-hazard financial risk assessment of a bridge-roadway-levee system", Proceedings, 10th New York City Bridge Conference, New York, NY, August 26-27, 2019, accepted for oral presentation and publication
- N. Hua, A. Tessari, N. Elhami Khorasani, "Design fire scenarios for railway tunnel fires." Proceedings of the IABSE Congress, 2-6, September 2019.

- N. Hua, A. Tessari, N. Elhami Khorasani, “Application of structural fire engineering for performance-based design of tunnels.” Structures Congress, 24-27, April 2019.
- N. Hua, A. Tessari, N. Elhami Khorasani, “Concrete lining damage and structural stability assessment during tunnel fires: case studies.” 2020 TRB Annual Meeting, under review.
- R. Napolitano, A. Moshirfar, Z. Liu, B. Glisic, “Virtual Tours and Augmented Reality for Direct Data Integration,” International Association for Bridge and Structural Engineers, 4-6, September 2019.
- A. Blyth, R. Napolitano, B. Glisic, “Structural health monitoring in workflows for preservation engineering,” 8th International Conference on Structural Health Monitoring of Intelligent Infrastructure, 4-7, August 2019.
- R. Napolitano, A. Moshirfar, Z. Liu, B. Glisic, “Combining image-based documentation and augmented reality to create a cyber physical system for the built environment,” Engineering Mechanics Institute, 18-21, June 2019.
- A. Blyth, R. Napolitano, B. Glisic, “Damage diagnosis for historic marine infrastructure: Documentation, numerical modeling, and structural health monitoring of Morris Island Lighthouse,” Engineering Mechanics Institute Conference, 18-21, June 2019.
- R. Napolitano, Z. Liu, C. Sun,B. Glisic, “Augmented and virtual reality environments for structural health monitoring,” Structures Congress, 24-27, April 2019.
- R. Napolitano, Z. Liu, A.Blyth, B. Glisic, “SHM-based Virtual and Augmented Reality for Visual Inspection and Nondestructive Evaluation,” Transportation Research Board (TRB) Webinar, 29, November 2019.
- M. Jalayer, P. Szary, T. Hillman, C. Wyce, D. Patel, “Street Smart New Jersey Behavioral Pedestrian Safety Survey: Final Report,” North Jersey Transportation Planning Authority, 16, August 2019.
- M. Jalayer, P. Szary, T. Hillman, D. Patel, N. Khaki, “Street Smart New Jersey Observational Pedestrian Safety Survey: Final Report,” North Jersey Transportation Planning Authority, 16, August 2019.
- **Policy Papers**
  Nothing to report
- **Website(s) or other Internet site(s)**
  https://www.facebook.com/RutgersCAIT/
  https://www.instagram.com/rutgerscait/
- **New methodologies, technologies or techniques**
  Incorporated into earlier sections of this report
- **Inventions, patents, and/or licenses**
  Nothing to report
- **Other products**

Outputs	Annual Goal	Annual Metric
1) a traditional or online training program.	3	6
2) a presentation and/or webinar.	10	51
3) a demonstration and/or pilot project.	3	4
4) a guidebook or similar publication in addition to an academic report.	8	10
5) a new specification.	1	2
6) new software or an app.	3	3
7) a new material and/or tangible product.	1	1
8) a potential patent or otherwise marketable product.	2	2
9) Primary or secondary customers will be tracked.	15	37

10) Implementation stakeholders will be tracked.	15	61
11) Implementation stakeholders that identify in each of the following will be tracked.	Customer / Implementer	Customer / Implementer
a. Sponsors of research and T2	2 / 2	1/2
b. Researchers and/or developers	1 / 5	4/20
c. Early adopters and problem owners	5 / 5	17/31
d. Late adopters that follow the technology's development	3 / 5	5/13
e. Deployment team	3 / 3	7/10
f. Others, e.g., trade organizations, regulators, suppliers, etc.	1 / 3	1/13
12) Conceptual methodologies to calculate actual impact. How the PI expects to calculate the actual impact that a customer will realize by implementing the results.	15	48
13) The number of projects that help meet each USDOT Strategic Plan goal	-	-
a. Safety: Reduce transportation-related fatalities and serious injuries across the transportation system.	5	9
b. Infrastructure: Invest in infrastructure to ensure mobility and accessibility and to stimulate economic growth, productivity, and competitiveness for American workers and businesses.	5	16
c. Innovation: Lead in the development and deployment of innovative practices and technologies that improve the safety and performance of the nation's transportation system.	5	19
d. Accountability: Serve the nation with reduced regulatory burden and greater efficiency, effectiveness, and accountability.	2	4

4. OUTCOMES (What outcomes has the program produced? How are the research outputs described in section (3) above being used to create outcomes?

Outcomes	Annual Goal	Annual Metric
1) MOU/letters of commitment indicating a customer's commitment to adopt or that they have adopted/used	5	6
2) full-scale adoption of a new technology technique, or practice, or the passing of a new policy, regulation, rule making, or legislation including commercialized or patented product	5	6

5. IMPACT (What is the impact of the program? How has it contributed to improve the transportation system: safety, reliability, durability, etc.; transportation education; and the workforce?)

Impacts	Annual Goal	Annual Metric
1) cost savings (time, money, or life-cycle performance)	$280k year one - $2.575M each subsequent year	$896,260
2) durability and/or resilience and/or preservation	Zero in year one - 30 years each subsequent year	10 years
3) workforce proficiency or documented success stories	4 success stories	5

6. 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 animals, human subjects, and/or biohazards.***
  Nothing to report