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Center Director Name, Dr. Ali Maher, CAIT Director.
E-mail address: mmaher@soe.rutgers.edu **Phone number:** 848-445-0579

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

Recipient Organization (Name and Address): Rutgers, The State University of New Jersey, Center for Advanced Infrastructure and Transportation, 100 Brett Road, Piscataway, NJ 08854-8058

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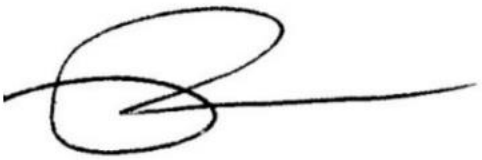


1. **ACCOMPLISHMENTS** (What was done? What was learned?)

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 12 projects during this cycle. Five research projects are currently under review.

New Projects:

CAIT-UTC REG24	Application of Advanced Analytic and Risk Techniques to Railroad Operations Safety and Management *Abstract*: The fundamental problem with the amounts of data collected by railroads is that they have generally lacked tools and the capability to analyze these data to develop predictive models to improve decisions regarding maintenance, operations and capital investments that improve safety, service and, ultimately, overall profitability. The primary goal of this project is to develop a prototype system that complements and improves the current tools and Decision Support Systems (DSS) used by the cooperating railroads.	RU
CAIT-UTCREG25	Investigation of Balanced Mixture Design for New York State Asphalt Mixtures *Abstract*: Current asphalt design procedures are solely based on volumetric principles and lack a valid methodology to ensure performance of the asphalt mixture considered during design. This research focuses on a state of the art practice called Balanced Mixture Design (BMD), where the gradation and optimum asphalt	RU

	content are not solely selected by the volumetrics of the mixture, but by the rutting and fatigue cracking resistance. The objectives of the study are to: 1. Evaluate the current performance of NYSDOT asphalt mixtures across the state; 2. Redesign the asphalt mixtures utilizing the BMD methodology; and 3. Recommend performance tests and finalize a design procedure methodology for NYSDOT adoption and implementation.	
CAIT-UTC-REG26	Passenger Flow Modeling on Platform Tracks in Transit Stations *Abstract*: Passenger flow is a very important parameter for understanding how passengers interact with built infrastructure. The primary goal of this proposal is to model and simulate passenger flows in transit stations using computer vision and agent-based simulation technologies.	RU
CAIT-UTC-REG27	Designing Concrete Mixtures with RCA *Abstract*: The use of recycled concrete aggregates (RCA) in new concrete can help to reduce landfilling, improve economics of concrete, and supplement dwindling aggregate supplies in urban areas. The NYCDOT has calculated that they spend $1.45 million/year to dispose of demolished concrete, and has invested in crushing units to produce RCA but have not yet developed a design process for using the material as a replacement aggregate. The primary goal of this proposal is to validate and improve a novel RAC design methodology through both experimental and computational methods.	NJIT
CAIT-UTC-REG28	Cost-effective Bridge Decks for Improved Durability and Extended Service Life *Abstract*: The primary goal of this proposal is to develop cost-effective standard open rib SOBD demonstrating similar performance as CRD. The objectives of this research are: (1) to promote increased implementation of SOBD for short and medium span highway bridges for improving durability, extending service life and safe operation of US bridge infrastructure; and (2) to enable domestic bridge design and fabrication industry to be productive and competitive.	RU
CAIT-UTC-REG29	Seismic Vulnerability Assessment of Deteriorated Bridges *Abstract*: The NYSDOT Seismic Vulnerability Manual provides the procedures for assessing and rating the seismic vulnerability of bridges in NYS to facilitate timely corrective actions. However, these procedures rely on prescriptive vulnerability scores based on as-built conditions and do not systematically account for the bridge deterioration over time, e.g. rebar mass loss in piers due to corrosion, which can be critical for the resilience of a bridge during an earthquake or other large loading events. The primary goal of this proposal is to demonstrate seismic vulnerability assessment of a group of NY state bridges subjected to deterioration due to corrosion or other factors. Assessment will be performed using a systematic framework that can combine the effects of corrosion	SUNY Buffalo

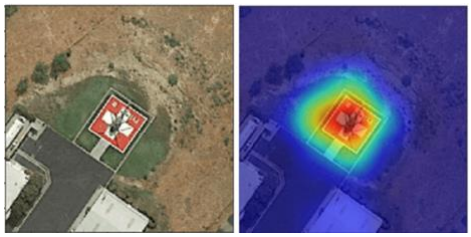
	and seismic hazards. The results can be used to prioritize bridges for maintenance when resources are limited.	
CAIT-UTC-REG30	Development of Durable and Smart eRoad for Electric Vehicles *Abstract*: The electrified pavement in the charging lane provides in-motion power supply for electric vehicles. However, the service life of pavement may be negatively impacted due to the complicated structure design for achieving the function of dynamic wireless charging. This primary goal of this research is to develop new design of electrified pavement that have durable performance while providing efficient charging functionality.	RU
CAIT-UTC-REG31	Evaluating the Safety and Mobility Impacts of American Dream Complex: Phase I (Feasibility Study, and Data Acquisition) *Abstract*: According to the American Transportation Research Institute (ATRI), New Jersey has the worst traffic bottleneck in the country. With the opening of the second largest retail and entertainment complex in the country, local officials and NJ Governor's office estimate that the American Dream complex will make congestion and safety even worse. The primary goals of this proposal are 1) to coordinate with the stakeholders to identify the traffic and safety issues associated with this complex and 2) to collect relevant data to develop an analytics framework using modern machine learning algorithms, such as convolutional neural networks, to identify conflicts between the different road user groups (e.g., drivers and pedestrians) in the vicinity of this complex.	Rowan
CAIT-UTC-REG32	Rotorcraft Landing Sites – An AI-Based Identification System *Abstract*: The updated information about the location and type of landing sites is an essential asset for the Federal Aviation Administration (FAA) and the Department of Transportation (DOT). However, the acquisition, verification, and regular updating of information about landing sites is not an easy or straightforward task, and the lack of current and correct information on helicopter landing sites is a risk factor in several accidents and incidents involving rotorcraft. The primary goal of this proposal is to create an AI-based system for the identification of helipads, heliports, and landing site infrastructure from various heterogeneous datasets, including video from rotorcraft, drones, satellite images, or aerial imagery, as well as textual data sources (i.e., data entered by helipad owners/operators or pilots) from other sources.	Rowan
CAIT-UTC-REG33	Real-Time Prediction of Storm Surge and Wave Loading on Coastal Bridges *Abstract*: According to FHWA, almost 36,000 bridges are located within 15 miles of the United States coastline. Many of these coastal bridges are vulnerable to storm surge and hurricane wave forces, and this is expected to worsen with rising sea levels associated with changing climate. The primary goal of this proposal is to lay the ground work for the development of tools	SUNY Buffalo

	and techniques for rapid prediction of storm surge and wave effects on coastal bridges.	
CAIT-UTC-REG34	Assessing and Mitigating Transportation Infrastructure Vulnerability to Coastal Storm Events with the Convergence of Advanced Spatial Analysis, Infrastructure Modeling, and Storm Surge Simulations *Abstract*: To protect the security of the public transportation infrastructure and the enormous amount of public assets, the proposed study intends to develop a decision support tool that can assist infrastructure stakeholders in making decisions at the day-to-day operation level (i.e. evacuation or shutting down of roads and bridges) to protect communities from impeding flooding events as well as in making long-term decisions in mitigating future flood risks facing their current infrastructure assets and their future projects (in particular those related to storm surge and extreme rainfall events). The expected outcome of this study is new software applications that are built for infrastructure resilience centered investigations. The software applications will be cloud-based which will allow infrastructure stakeholders such as DOT personnel, floodplain managers, and OEM coordinators to access and use it without any local installations on their computers.	RU
CAIT-UTC-REG-TT1	Infrastructure Cybersecurity and Emergency Preparedness Non-academic Course Design and Delivery *Abstract*: The risks associated with infrastructure are clearly identified but training to minimize the impact of these challenges is sparsely available or lacking in related content. This project will design and deliver workforce training focused on the risk assessment, mitigation of vulnerabilities, and potential emergency readiness related to transportation hubs including airports, shipping ports, bridges, busways, railways, and roadways. The proposed courses are "Infrastructure Computer Security" and "Transportation and Emergency Preparedness."	SUNY-Farmingdale

Evaluating the Safety and Mobility Impacts of American Dream Complex: Phase I (Feasibility Study, and Data Acquisition)

New Jersey has the worst traffic bottleneck in the country. With the opening of the second largest retail and entertainment complex in the country, local officials estimate that the American Dream complex will make congestion and safety even worse. The primary goals of this project are 1) to coordinate with stakeholders to identify traffic and safety issues associated with this complex and 2) to collect relevant data to develop an analytics framework using modern machine learning algorithms to identify conflicts between the different road user groups in the vicinity of this complex.

Rotorcraft Landing Sites – An AI-Based Identification System



There is currently a lack of information about landing sites for helicopters and other rotorcrafts, and acquiring, verifying, and updating this database of information is no small task for organizations such as the FAA that need it. Rowan University is working to develop an AI-based algorithm that will automate the process of identifying landing sites from video data as well as satellite images—increasing safety and efficiency in the NAS. "This research aligns with the DOT Strategic Goal of Reducing Transportation-Related Fatalities and Serious Injuries across the Transportation System," said Cliff Johnson, FAA's lead for Vertical Flight Safety Research at the FAA William J. Hughes Technical Center. "By identifying locations of heliports, helipads, landing zones, and other infrastructure from various data sources, the research will increase safety for helicopter pilots and their flight crews/passengers." The primary goal of this project is to create an AI-based system to identify helipads, heliports, and landing site infrastructure from various datasets, including video from rotorcraft, drones, satellite images, aerial imagery, and textual data sources.

Ongoing Projects:

CAIT-UTC-REG9	Delivering maintenance and repair actions via automated/robotic systems	RU
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-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-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-REG 5	Implementation and Development of UAS Practical Training for Inspection and Monitoring Activities	Atlantic Cape Community College
CAIT-UTC-REG21	Autonomous Vehicles: Capturing In-Vehicle Experience & Focus Group Follow-up with Persons with Autism and Other Disabilities at the 2019 Princeton University SmartDrivingCar Summit	RU
CAIT-UTC-REG22	Simulation of Degradation and Failure of Suspension Bridge Main Cables due to Natural and Anthropogenic Hazards	Columbia
CAIT-UTC-REG23	The Development of a Smart Intersection Mobility Testbed (SIMT)	RU
CAIT-UTC-REG9	Delivering maintenance and repair actions via automated/robotic systems	RU
CAIT-UTC-REG13	Virtual Tour (VT), Informational Modeling (IM), and Augmented Reality (AR) for Visual Inspections (VI) and Structural Health Monitoring (SHM)	PU

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-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-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-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-REG10	Policies, Planning, and Pilot Testing on Infrastructure Readiness for Electrical, Connected, Automated, and Ridesharing Vehicles	RU/Columbia
CAIT-UTC-REG11	Pavement Design for Local Roads and Streets	Cornell
CAIT-UTC-REG12	Laboratory Performance Evaluation of Pavement Preservation Alternatives	Rowan
CAIT-UTC-REG14	Performance-Based Engineering of Transportation Infrastructure Considering Multiple Hazards	SUNY Buffalo
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-REG20	Infrastructure Cybersecurity and Emergency Preparedness Academic and Non-academic Credential Development	SUNY Farmingdale

HIGHLIGHTS
Completed Projects

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

Accomplishments: 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.
ROI: Reinforcement corrosion in highway bridges is one of the most common durability problems across the world. In the United States, the annual direct cost of repair and maintenance of deteriorating bridges due to corrosion is estimated to be $8.3 billion. 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. 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)

Accomplishments: A methodology was developed for establishing performance of bridges by considering the effects of dynamic soil-foundation-structure, and 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 large-amplitude shaking.
ROI: The findings support performance-based management of highway infrastructure assets, which could broadly impact the current policies for foundation reuse and allocation of resources. This project enhances the State of Good Repair of highway-bridge structures, which could reduce life-cycle cost, and improve safety and service quality for the travelling public.

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

Accomplishments: Researchers have developed a working prototype of highly accurate Microelectromechanical Systems chemical sensors, which is 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.

ROI: 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 be identified, which otherwise require dredging. This 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)

Accomplishments: 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.

ROI: 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. 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.

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

Accomplishments: The report 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 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” project, where they will turn the city of New Brunswick, New Jersey into a hub for mobility-data collection.

ROI: 1) Published studies, reports, and spoke at conferences to analyze current infrastructure readiness for autonomous and connected vehicles and to disseminate this information. 2) 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) Developed a preliminary plan for a smart mobility testbed.

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

Accomplishments: A user-friendly software tool, RoadPE: LHI, 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. “Overall, I think it is a pretty impressive tool to use for pavement design,” said Tim

Kelley, Engineering Technician at the Wyoming County Highway Department. A longer-term goal is to possibly develop this product into an app.
ROI: Local highway departments including the towns of Preble and Hartland, Oswego, Schoharie, and Wyoming counties in New York State have been engaged. The tool allows agencies to design their roads properly for their required loads. Experience, budgetary constraints, and inappropriate tools often force towns and villages to under-build their roads, leading to premature failure and costly remediation.

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

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

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)

Accomplishments: Improvements in design and analysis of pedestrian bridges subjected to high winds and storms such as hurricanes.
ROI: The expected output is a design guide. This project will increase safety of the public during a hurricane, and also improve the resiliency of pedestrian bridges subjected to hurricanes.

Infrastructure Cybersecurity and Emergency Preparedness Academic and Non-academic Credential Development (CAIT-UTC-REG20, Project Manager: Kazem Oryani)

Accomplishments: This project designed and established academic credentials as well as non-credit short courses that prepare participants to assess vulnerabilities related to transportation hubs.
ROI: The development of two new academic certificates fills an educational void in infrastructure cybersecurity and emergency preparedness, as well as promotes future workforce development and technology transfer activities through the credentials.

Ongoing Projects

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

Outputs: Researchers held a 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.

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, such as 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. Another presentation took place during a lectern session at the 99th Annual Meeting of the Transportation Research Board. This project develops a methodology to achieve acceptable fire safety and minimize economic losses in a tunnel fire, and will improve structural safety guidelines.
Outcome: The intended outcome of this project is to improve modeling techniques, make recommendations, and propose design guidelines for structural fire resistance of railway tunnels. 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. If a key tunnel in an infrastructure network is shut down for repairs, and there is no redundancy in the system, the freight or people that need to go through that tunnel get

affected. Repairs can take months, which could mean millions of dollars in economic losses. 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: 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 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: The first impact of this project will be increased safety of the travelling public during a hurricane event, the second will be improving the resiliency of motor vehicle bridges subjected to hurricanes.

Implementation and Development of UAS Practical Training for Inspection and Monitoring Activities (CAIT-UTC-REG 5, Project Manager: James Taggart)

Outputs: This proposal aims to design and develop training curricula including the development of assessment instruments for deriving both formative and summative learning outcomes.
Outcome: These curricula will evaluate the practical flight abilities of prospective UAS pilots. The team will also provide research into powered tether systems for long duration UAS flights. The team will evaluate UAS tether for use cases such as traffic monitoring.
Impacts: The project will evaluate UAS operations and make recommendations on procedures for inspection to assist decision making by regional agencies. This tool can significantly impact the quality of data and lower the risk portfolio for missions.

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.

Outputs: 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 technology.
Outcome: The Princeton Summit was a unique opportunity to present AV to people with disabilities so to experience the technology first-hand.
Impacts: This project will allow for the experiences of users to be documented and shared with the stakeholders such as policymakers, vehicle manufacturers, and others for analysis and decision-making.

Simulation of Degradation and Failure of Suspension Bridge Main Cables due to Natural and Anthropogenic Hazards

Outputs: The goal of this project is to develop a well-defined methodology to estimate the remaining strength of a suspension bridge cable 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.
Outcome: The cable FEM model will be developed and calibrated using the extensive experimental data already available to the research team.
Impacts: 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.

The Development of a Smart Intersection Mobility Testbed (SIMT)

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

Education and Workforce Development Activities

The consortium has trained more than 1,254 professionals during this period.

- **Classes, Seminars, and Educational Opportunities**

Mr. Joseph Englot, National Director of Infrastructure Security at HNTB, gave a presentation on alternative fuel vehicles and their needs, benefits, and risks, including their behavior in fire events. This work relates to an ongoing collaborative UTC project between Region 2 Consortium partners The University at Buffalo, NJIT, Princeton University, and Rutgers CAIT to establish a framework to quantify fire damage to tunnel-concrete lining considering soil-liner interaction.

Jerry A. DiMaggio, Senior Principal Civil Engineer and Associate at Applied Research Associates, Inc., taught a Ground Improvement Methods course to professional engineers organized by Rutgers CAIT.

The Rutgers CAIT Rail and Transit Program hosted a seminar with engineers from the Long Island Rail Road's Track Standards and Specifications Department.

- **Technology and Tools**

Under-designing roads can mean more expensive repairs for local towns and counties in the long run. Cornell's Dr. David Orr developed a user-friendly excel-based software tool that uses mechanistic-empirical methods to help local agencies with designing their low-volume roads for various traffic needs.

CAIT researchers at the Rutgers Asphalt and Pavement Laboratory have created RAAT-Pack: Rutgers Asphalt Analysis Tool Pack. This new free software can easily provide analysis for various asphalt-performance testing specifications while alleviating errors and decreasing testing time.

CAIT researchers used drones and Lidar to map a gas pipeline replacement project and capture geolocations of newly installed underground infrastructure in Fords, NJ. The data collected helped the

team develop enhanced As-Built models for a local infrastructure stakeholder, Elizabethtown Gas, that are vital for informing them about underground infrastructure in the area.

By using Storm Water Green Infrastructure such as rain gardens and porous parking lots, a CAIT-affiliated researcher is building and implementing environmentally-friendly measures to help control flooding Linden, NJ's Tremley Point—A low-lying area bordered by the Rahway River and Marshes Creek.

Self-driving shuttles are one part of NJ Transit's future plans for filling in the gap on first and last-mile transit options. Rutgers CAIT recently partnered with the agency to test this technology as part of an innovative pilot program.

Technology Transfer

- **Presentation and Events**

CAIT researchers won multiple awards, presented research, and shared presentations at the 99th Annual Meeting of the Transportation Research Board. Additionally, CAIT's Networking Reception brought together more than 300 transportation professionals for networking opportunities.

The Coastal Universities Coalition is a consortium of the nation's leading academic institutions convened to develop science-based solutions to pressing issues facing populated coastal regions. CAIT researcher Dr. Jie Gong spoke at a Capitol Hill Roundtable hosted by the CUC on gaps in infrastructure resilience.

Assemblyman Daniel Benson, Chair of the New Jersey Assembly Transportation and Independent Authorities Committee, met with members of Rutgers CAIT and partners such as the Voorhees Transportation Center and NJTIP, for a tour of the facilities and to learn more about recent work.

Rutgers professor and CAIT-affiliated researcher Dr. Peter Jin presented at The Intelligent Transportation Society of New Jersey's annual meeting on intelligent mobility. He discussed how one of his current projects is turning New Brunswick into a smart mobility testing hub.

CAIT-affiliated researcher Dr. Jie Gong hosted ASCE members, industry professionals, students, and more for a tour of his Virtual Reality Lab. He demonstrated the lab's different capabilities and various projects centered on the collection and processing of large geospatial data sets for coastal community resilience and the use of Virtual Reality environments for work zone training.

Thomas D. Everett, FHWA Executive Director, was honored for his service and received the prestigious Rutgers Engineering Society Distinguished Engineer Award at the 2019 Medal of Excellence Awards Dinner. He stopped by CAIT for a tour of The BEAST and other facilities too.

James Hughes, affiliated CAIT faculty and dean emeritus of Rutgers' Edward J. Bloustein School of Planning and Public Policy, gave a presentation on economic and demographic changes at a recent NJTPA board meeting.

Tom Bennert, head of the Rutgers Asphalt and Pavement Laboratory, hosted the New Jersey Asphalt Pavement Association's Technical Committee and NJAPA Executive Director Kevin Monaco for a discussion on the newest technologies and testing procedures in the asphalt industry.

Dr. Cecilia Feeley, Transportation Autism Project Manager at CAIT, was among select researchers personally invited to attend the USDOT Accessibility Summit. She discussed mobility services, the emerging autonomous vehicle market, and ways to make sure this technology is inclusive for all.

- **Research and Publications**

Rutgers was featured in the September/October 2019 edition of FHWA's R&T Now Newsletter for its work helping partners to develop an online laboratory where engineers can try out diagnostic tools and emerging technologies to examine the condition of virtual bridges.

CAIT published two Rutgers Regional Reports, which analyzed demographic trends in the Northeast region as well as the impact of demographic change over time. The two reports have garnered more than 4,000 downloads through the Scholarly Open Access at Rutgers database.

CAIT's Rail and Transit Program was featured in a recently-released issue of TR News for its work deploying artificial intelligence to help detect and analyze railroad trespassing events—utilizing an innovative solution to address one of the biggest challenges faced by the industry today.

CAIT-affiliated researcher at Rowan University, Dr. Mohammad Jalayer, received a $40,000 NCHRP grant to continue critical work studying Wrong-Way Driving events and preventing fatalities caused by this highway phenomenon. Since 2012, Dr. Jalayer has investigated this issue nationwide.

- **CAIT Researchers Win Awards**

Dr. Perumalsamy N. Balaguru, a CAIT researcher, won the 2019 NJDOT Research Implementation Award for his innovative work developing a new protocol for accepting paint systems for over-coating steel surfaces. He received the award at the 21st Annual NJDOT Research Showcase.

A prestigious honor held by only 3% of ASCE members, an ASCE Fellow is someone who has made celebrated contributions and developed creative solutions that change lives around the world. CAIT Director Dr. Ali Maher was recently elected to the position of Fellow.

Dr. Cecilia Feeley, Transportation Autism Project Manager at Rutgers CAIT, won the William W. Millar Award for best paper in the area of public transportation at the 99th Annual Meeting of the Transportation Research Board.

CAIT UTC partner Dr. Negar Elhami Khorasani won the Early Career Faculty Award from the American Institute of Steel Construction in recognition of her work in structural steel research. Her research focuses on the impact fire and elevated temperatures have on steel structures.

CAIT-affiliated researcher Dr. Husam Najm was named the 2019 Educator of the Year by the ASCE Central New Jersey Branch.

At the 99th Annual Transportation Research Board Meeting, NJIT student Noah Thibodeaux was recognized by CUTC as a Student of the Year. The award highlights outstanding UTC students and their accomplishments in the field of transportation.

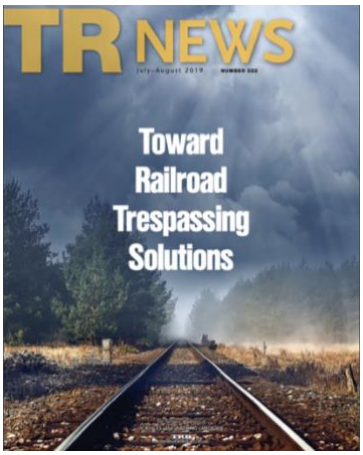
A total of 75 university engineering programs nationwide were honored in ASEE's inaugural Diversity Award class, and both the University at Buffalo and Rutgers School of Engineering were among an elite group to receive "exemplary" standing.

How have the results been disseminated?

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

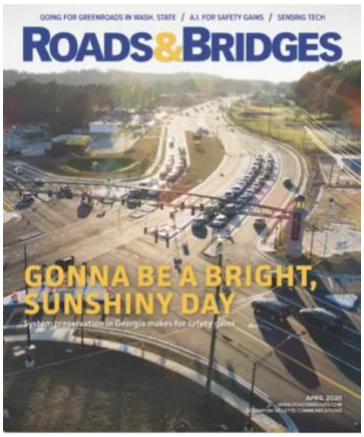
CAIT has distributed The CAIT Update, its monthly E-newsletter, to subscribers throughout the UTC community, industry, academia, and media members.

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



TR News Magazine

FHWA R&T Now



Roads & Bridges

POLITICO

Politico.com

nj.com True Jersey.

NJ.com

NJTPA NORTH JERSEY TRANSPORTATION PLANNING AUTHORITY
Defining the Vision. Shaping the Future.

NJTPA News

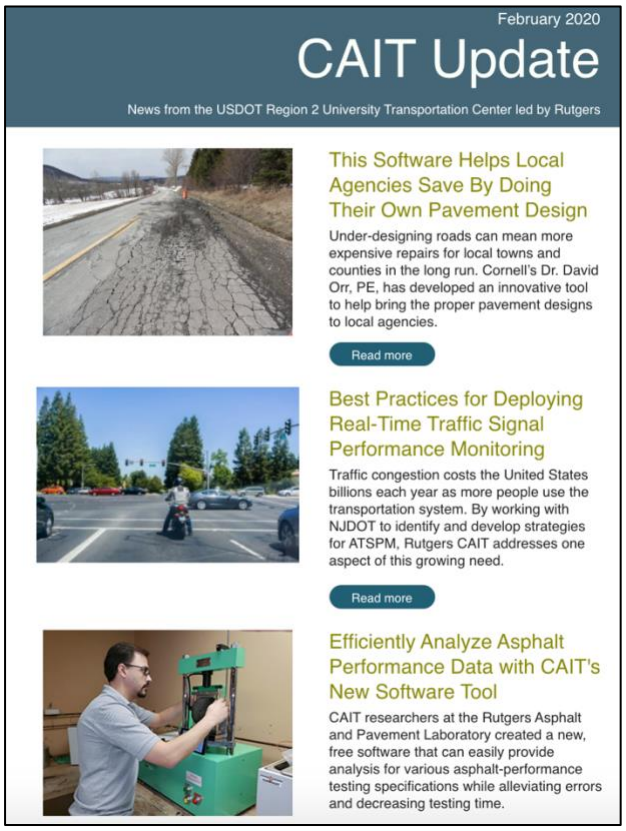
U.S. News & WORLD REPORT

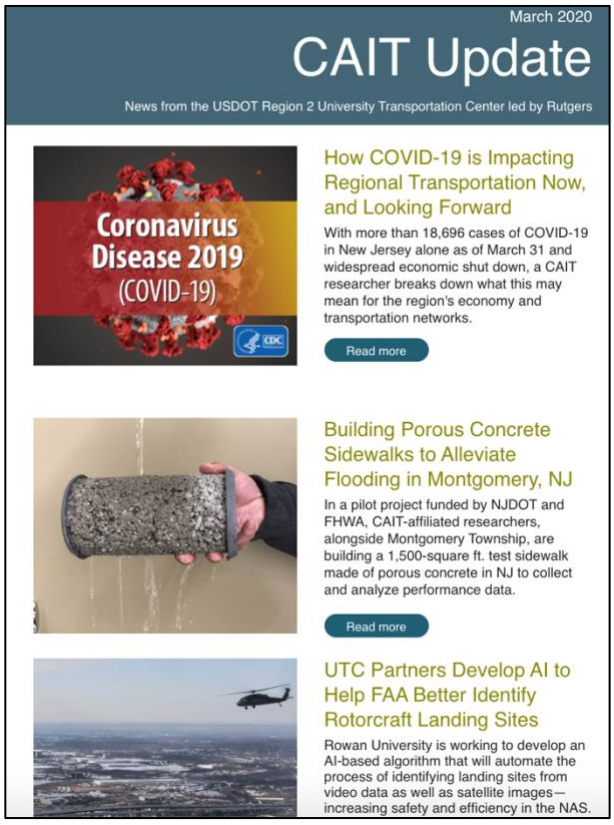
U.S. News & World Report

NEW JERSEY 101.5

NJ101.5

Newsletter
CAIT has distributed The CAIT Update, its E-newsletter, on a monthly basis to more than 5,000 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
New York City Department of Transportation-Division of Sidewalk and Inspection Management	New York, NY	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
North Jersey Transportation Planning Authority	Newark, NJ	Personnel resources, knowledge exchange
Monmouth County Division of Engineering	Freehold, NJ	Personnel resources, knowledge exchange
Rotorcraft	Atlantic city, NJ	Personnel resources, knowledge exchange
The Everett Railroad	Duncansville, PA	Personnel resources, knowledge exchange
NJ Transit Corporation	Newark, NJ	Personnel resources, knowledge exchange
American Institute of Steel Construction	Lancaster, PA	Personnel resources, knowledge exchange

Monmouth County Sheriff's Office	Freehold, NJ	Personnel resources, knowledge exchange
Washington State Department of Transportation	Olympia, WA	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

- Nikellis, A. and Sett, K., "Multi-Hazard Risk Assessment and Cost-Benefit Analysis of a Bridge-Roadway-Levee System", Journal of Structural Engineering, Vol. 146, No. 5, pp. 04020050-1-13, 2020
- Wang, H., Ranade, R. and Okumus, P., "Influence of Improved Durability with a Ductile Fiber-reinforced Concrete on the Resilience of a Reinforced-concrete Bridge," Transportation Research Board Annual Meeting, 12-16 January, 2020, Washington D.C.
- Hua, N., Tessari, A., Elhami Khorasani, N. (2020). "Concrete lining damage and structural stability assessment during tunnel fires: Case studies," Proceedings of the Transportation Research Board, Washington, D.C., January 12-16.
- Hua, N., Tessari, A., Elhami Khorasani, N. "Quantifying uncertainties in the temperature-time evolution of railway tunnel fires," Fire Technology, in revision.
- Hua, N., Tessari, A., Elhami Khorasani, N. "Characterizing damage to a concrete liner during a tunnel fire," submitted to Journal of Tunnelling and Underground Space Technology.
- "Low-Volume Road Pavement Design." The Cornell Local Roads Program is developing a new tool to design the thickness of low-volume road (LVR) pavements for town and county roads and village streets. This workshop organized by Dr. David Orr provided an overview of how pavements fail, how they work structurally, and showed attendees when and how to use the new LVR design tool. These were held in 3 counties: Genesee (10/8/10); Tompkins (10/8/19) and Rockland (10/10/19). Total # of participants: 42.
- "Preparing the Emerging Autonomous Vehicle Market for Paratransit Services and Meeting the Needs for Persons with Disabilities." Conducted by Dr. Cecilia Feeley, TRB, 1/12/20.
- Poster Session: Information Systems and Technology (1/13/20)
- "CCTV Traffic Video ANALYTICS with Fast Recalibration Assisted by 3D Infrastructure Data." Presented by Tianya Zhang, Rutgers, The State University of New Jersey, Mengyang Guo, Rutgers, The State University of New Jersey, Jing Jin, Rutgers, The State University of New Jersey and Jie Gong, Rutgers, The State University of New Jersey
- Poster Session: Sweet Sixteen: State DOT High Value Research Projects (1/13/20)
- "New Protocol for Accepting Overcoating Paint on Steel." Presented by Perumalsamy N Balaguru, Rutgers, The State University of New Jersey
- Poster Session: Young Professional Research in Aviation (1/13/20)
- "ACRP Student Research: Investigation of Piezoelectric Energy Harvesting Potential at Airport for Green Energy Solutions." Presented by Jingnan Zhao, Rutgers, The State University of New Jersey; Hao Wang, Rutgers, The State University of New Jersey
- Poster Session: Modeling, Simulation, Analysis, and Evaluation of Connected and Automated Vehicle Applications (1/13/20)
- "Multi-Player Dynamic Game–Based Automatic Lane-Changing Decision Model under Mixed Autonomous Vehicle and Human-Driven Vehicle Environment." Presented by Jing Jin, Rutgers, The State University of New Jersey

- Poster Session: Best Presentations from Annual Interuniversity Symposium on Infrastructure Management 2019 (1/14/20). Hao Wang, Rutgers, The State University of New Jersey
- Poster Session: Railroad Safety and Incident Analysis Methods (1/14/20)
- "Safety Analysis of End-of-Track Collisions in Passenger Stations via Systems-Theoretic Accident Modeling and Processes." Presented by Zhipeng Zhang, Rutgers, The State University of New Jersey and Xiang Liu, Rutgers, The State University of New Jersey
- Poster Session: Asphalt Binders: Rejuvenation, Non-Specification Testing, and Investigations (1/14/20)
- "Thermal Characteristics and Non-Isothermal Kinetics Analysis of Asphalt Sara Fractions." Presented by Hao Wang, Rutgers, The State University of New Jersey

- **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	Semi-Annual Metric
1) a traditional or online training program.	3	1
2) a presentation and/or webinar.	10	12
3) a demonstration and/or pilot project.	3	4
4) a guidebook or similar publication in addition to an academic report.	8	2
5) a new specification.	1	0
6) new software or an app.	3	0
7) a new material and/or tangible product.	1	1
8) a potential patent or otherwise marketable product.	2	0
9) Primary or secondary customers will be tracked.	15	20
10) Implementation stakeholders will be tracked.	15	30
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	2/6
b. Researchers and/or developers	1 / 5	2/7
c. Early adopters and problem owners	5 / 5	9/12
d. Late adopters that follow the technology's development	3 / 5	3/13
e. Deployment team	3 / 3	6/9
f. Others, e.g., trade organizations, regulators, suppliers, etc.	1 / 3	2/13
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	22
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	4

b. Infrastructure: Invest in infrastructure to ensure mobility and accessibility and to stimulate economic growth, productivity, and competitiveness for American workers and businesses.	5	11
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	11
d. Accountability: Serve the nation with reduced regulatory burden and greater efficiency, effectiveness, and accountability.	2	3

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	Semi-Annual Metric
1) MOU/letters of commitment indicating a customer's commitment to adopt or that they have adopted/used	5	5
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	Semi-Annual Metric
1) cost savings (time, money, or life-cycle performance)	$280k year one - $2.575M each subsequent year	$3,103,471
2) durability and/or resilience and/or preservation	Zero in year one - 30 years each subsequent year	20 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