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

Federal Grant Number: 69A3551847102

Project Title: Center for Advanced Infrastructure and Transportation (CAIT) Region 2 UTC Consortium Led by Rutgers, The State University of New Jersey

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DUNS Number: 001912864000

EIN Number: 1226001086A1

Recipient Identifying Number or Account Number, if any: Rutgers' account #824227

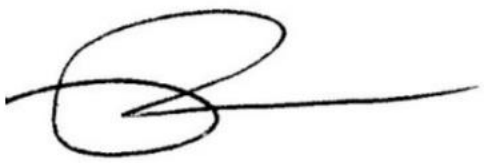
Project/Grant Period: June 05, 2018 through September 30, 2023

Reporting Period End Date: September 30, 2021

Report Term or Frequency: Semiannual

Submission Date: October 31, 2021

Signature of Submitting Official:



Impact Statement

Home to some of the oldest infrastructure in the country and a densely populated region, research at Rutgers CAIT has been focused on improving durability and extending the life of transportation infrastructure. New challenges posed by COVID-19, the economy, and climate factors have shaped CAIT's research to help meet these goals in a changing environment.

For example, NJ was one of the states hit hardest by COVID-19 with more than 1 million cases and 25,000 fatalities. Even now with a 66% statewide vaccination rate, only 60% of jobs lost have been recovered and unemployment remains high at 7.2% compared to 4.8% nationwide. Supply chain delays have been felt here as well. Ocean carrier costs have jumped approximately ten times since late 2019, affecting ports, businesses, and people in the state. This means increased costs and waiting times for hospital ventilators, construction materials, and more. These delays were exacerbated when Hurricane Ida struck the region in September 2021, causing millions of dollars' worth of damage, stalling transportation, and leaving people waiting for supplies. As the leader of the Region 2 University Transportation Center consortium, CAIT has built an extensive collaborator network with university partners, industry, and local state agencies to ensure its efforts closely align with the pressing needs of its stakeholders. This approach has helped the Center quickly address these new challenges as highlighted by the sample of projects below:

- Supporting Economic Recovery & Labor: CAIT established the **NJ Transit Resource Center** with **NJ Transit** to help align research with agency needs. This led to projects such as CAIT testing UV disinfection, upgraded air filters, and other new technologies on NJ Transit buses during the pandemic to ensure safety and improve customer confidence. Now, the Center is planning a workforce development initiative to address transportation labor shortages.
- Improving Supply Chain: Research with **GatewayJFK** and **JFK International Airport** is analyzing the benefits of an airport-wide Cargo Information System to coordinate air cargo ground operations and speed truck-traffic flow within the airport and surrounding community. The project also supports internships for students.
- Planning for Climate Change: Following Hurricane Ida, CAIT researchers surveyed the damage with drones and van-based lidar systems to quantify flooding and improve flood prediction models that can inform future safety decisions. The team has been doing similar research mapping infrastructure along the NJ Flood Plain with the **Federal Emergency Management Agency**. CAIT has also partnered with the **Port Authority of New York and New Jersey** on its new Low Carbon Concrete Program that will develop, test, and help implement more environmentally sustainable concrete mixes.
- Smart Transportation & Innovation: CAIT launched DataCity, its Smart Mobility Ground Testing Ground project with the **New Jersey Department of Transportation**, **Middlesex County**, **Verizon**, and other partners. This initiative will study urban mobility, enable evaluation of connected and autonomous vehicles and vehicle-charging technologies in a living-laboratory environment, improve safety, and attract industry.
- Supporting the Gateway Program: CAIT helped **NJ Transit** secure funding for replacement of the Portal North Bridge and other asset management projects along the Northeast Corridor. CAIT also studied the impacts of fire on tunnels and bridges. This research aligns with the

Gateway Program, which is investing in the NEC to improve reliability, resiliency, the regional economy, and overall quality of life for riders and people in the surrounding areas.

- Building Resilience: Following the widespread devastation of Puerto Rico from back-to-back Hurricanes Maria and Irma, researchers jumped into action. Consortium partners at the Polytechnic University of Puerto Rico engaged the **Puerto Rico and US Virgin Islands Division of the Federal Highway Administration** on a project to collect field data from damaged bridges and other infrastructure assets. Using the field data and modeling, the researchers were able to better understand structural failures and make design recommendations to strengthen the resilience of the island's overall transportation system.

The Center continues to tackle the primary research focus area of improving durability and extending the life of transportation infrastructure, however regional needs have expanded our focus to view infrastructure challenges in a wholistic manner, considering them as an ecosystem of interconnected and interdependent physical, cyber, and human elements. Building on stakeholder relationships and past successes, CAIT plans to prioritize projects that better address pressing issues during the next year of its grant and beyond.

Projects such as asset management and digital twin modeling for NJ Transit will ensure resilience against new climate threats and make improvements along the public transit system that better serve riders and open the door for economic opportunities. Collecting data and attracting autonomous-vehicle startups to CAIT's Smart Mobility Testing Ground will lead to significant job creation in the area as well as advancements in healthcare, mobility, and safety. Additionally, asset visualization efforts with the Port Authority of New York and New Jersey will go a long way to rebuilding the arteries of our economy by better informing maintenance decisions on lifeline bridges, tunnels, and roadways. Adapting to this post-pandemic paradigm shift, the grant extension will allow the consortium's faculty and students to generate substantial outputs and have significant, transformative impacts in the region.

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 ongoing national dialogue on the state of the U.S. transportation infrastructure, and the emerging consensus on the need for 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 providing 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 6 projects during this cycle. One research project is currently under review.

New Projects:

CAIT-UTC-REG56	Interactive decision support system for tunneling planning and construction: Hudson Tunnel case study *Abstract:* The primary goal of this proposal is to increase safety and minimize the risks of building major underground infrastructure systems by enhancing existing methods for stochastic subsurface characterization, hazard and risk assessment and management.	NJIT/Stevens
CAIT-UTC-REG57	Comparative analysis of rapid chloride penetration testing for novel reinforced concrete systems *Abstract*: Transportation agencies have been rapidly deploying emerging concrete materials to improve the sustainability and durability of reinforced concrete infrastructure. The goal of this research study is to create an understanding of how novel concrete materials such as ductile concrete systems and recycled aggregate concrete behave in rapid chloride environments.	NJIT
CAIT-UTC-REG59	Durability of Low Carbon Concrete Mixtures *Abstract*: The primary goal of this proposal is to develop a deeper understanding of the relative performance of a wide array of low-carbon concrete systems in environments where the concrete will be subjected to chlorides and other deicing salts.	NJIT
CAIT-UTC-REG60	Low-Carbon Concrete Pilot Program *Abstract:* Concrete is responsible for about 8.6% of the world's CO2 emissions, despite the production of concrete having a relatively low carbon intensity compared to other building materials. The goal of the proposed work is to provide the Port Authority with the ability to reduce the embodied carbon of the concrete mixtures used in construction activities.	PU
CAIT-UTC-REG61	QAD (Quality Assurance Division) Inspection Reporting and State of Good Repair (SGR) Planning *Abstract:* The main goal of this proposal is to develop a proof of concept (POC) for the Port Authority Engineering Department that will provide key stakeholders with improved access to and visualization of key infrastructure assets information to support SGR planning and maintenance.	RU
CAIT-UTC-REG63	State-of-the-art technologies for structural health monitoring of tunnels: an overview *Abstract:* The primary goal of this proposal is to perform extensive overview of the state-of-the-art technologies for structural health monitoring of tunnels. Such an overview aspires to serve as a source of information and basis on decision making for practitioners and asset managers, who are interested in instrumenting the tunnels for an improved safety and optimized maintenance.	PU

Low-Carbon Concrete Pilot Program

Concrete is everywhere — we walk on it, drive on it, and work with it — and it is vital to building and maintaining the bridges and roadways that make up our transportation systems. But due to its popularity and many uses, concrete also contributes approximately 8% of the world's CO2 emissions despite having a relatively low carbon intensity compared to other building materials. A new Low Carbon Concrete Pilot Program with stakeholders at the Port Authority of New York and New Jersey will develop and evaluate innovative low-carbon concrete mixes to help lead the industry in implementing these more sustainable methods.

Interactive Decision Support System for Tunneling Planning and Construction: Hudson Tunnel Case Study

This study plans to increase safety and minimize the risks of building major underground infrastructure systems by enhancing existing methods for stochastic subsurface characterization, hazard, risk assessment, and management. Recent research at CAIT has investigated tunnel safety, specifically the impacts of fire on tunnel lining and long-term disruption to traffic and rail services that can occur as a result and lead to major economic losses. Understanding asset risk is critical especially when it comes to building or maintaining lifeline transportation infrastructure such as tunnels in the region. This project will develop a framework calibrated for worldwide, large-scale tunneling projects capable of determining most likely hazards along a tunnel route.

QAD (Quality Assurance Division) Inspection Reporting and State of Good Repair (SGR) Planning

This project is developing a proof of concept for the Port Authority of New York and New Jersey Engineering Department that will provide key stakeholders with improved access to and visualization of infrastructure asset information. This research also helped identify the need for advanced Asset Management workforce training in the region, leading CAIT to make plans for its new Infrastructure Asset Management Academy. This initiative will give students the knowledge, tools, and experience needed to make more informed decisions that can help them extend the service life, account for resiliency, and minimize the risk of their assets.

Ongoing Projects:

CAIT-UTC-REG 5	Implementation and Development of UAS Practical Training for Inspection and Monitoring Activities	ACCC
CAIT-UTC-REG15	Flood Vulnerability Assessment and Data Visualization for Lifeline Transportation Network	Rowan
CAIT-UTC-REG25	Investigation of Balanced Mixture Design for New York State Asphalt Mixtures	RU
CAIT-UTC-REG26	Passenger Flow Modeling on Platform Tracks in Transit Stations	RU
CAIT-UTC-REG27	Designing Concrete Mixtures with RCA	NJIT
CAIT-UTC-REG28	Cost-effective Bridge Decks for Improved Durability and Extended Service Life	RU
CAIT-UTC-REG30	Durable and Electrified Pavement for Dynamic Wireless Charging of Electric Vehicles	RU
CAIT-UTC-REG31	Evaluating the Safety and Mobility Impacts of American Dream Complex: Phase I (Feasibility Study, and Data Acquisition)	Rowan

CAIT-UTC-REG32	Rotorcraft Landing Sites – An AI-Based Identification System	Rowan
CAIT-UTC-REG38	Risk and Resilience Analysis Tool for Infrastructure Asset Management	RU
CAIT-UTC-REG-40	Zero Speed Profiler Assessment for Pavement Smoothness and Continuous Pavement Texture Measurements	RU
CAIT-UTC-REG42	Enhanced Maritime Asset Management System (MAMS)	RU
CAIT-UTC-REG44	Assessment of Solidification / Stabilization as a Remedial Strategy for PFAS Contaminated Transportation Sites	RU
CAIT-UTC-REG45	The Development of the Digital Twin Platform for Smart Mobility Systems with High-Resolution 3D Data	RU
CAIT-UTC-REG46	Driving behavioral learning leveraging sensing information from Innovation Hub	Columbia
CAIT-UTC-REG48	Linking Physics-Based Deterioration Model to Field-Based Condition Assessments for Improving Asset Management	SUNY Buffalo
CAIT-UTC-REG49	Post-fire Damage Assessment of Concrete Tunnel Liners	SUNY Buffalo
CAIT-UTC-REG50	Post-disaster Damage Assessment of Bridge Systems	SUNY Buffalo
CAIT-UTC-REG51	Real-Time Decision Support System for Transportation Infrastructure Management under a Hurricane Event	SUNY Buffalo
CAIT-UTC-REG52	Bridge Deck Surface Profile Evaluation for Rapid Screening and Deterioration Monitoring	Rowan
CAIT-UTC-REG53	A Real-Time Proactive Intersection Safety Monitoring System Based on Video Data	Rowan
CAIT-UTC-REG54	Rotorcraft Landing Sites Identification – Scaling and Generalization of the AI Model	Rowan
CAIT-UTC-REG55	JFK Cargo View: A system to speed Truck Traffic Flow at JFK Airport	RU/ SUNY Farmingdale
CAIT-UTC-REG58	Supplemental Study of Filter Technology Efficacy for Transit Vehicles to Combat the Spread of COVID-19 and Other Respiratory Infections	RU

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-REG9	Delivering maintenance and repair actions via automated/robotic systems	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-UTCREG13	Virtual Tour (VT), Informational Modeling (IM), and Augmented Reality (AR) for Visual Inspections (VI) and Structural Health Monitoring (SHM)	PU
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
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-REG24	Application of Advanced Analytic and Risk Techniques to Railroad Operations Safety and Management	RU
CAIT-UTC-REG29	Seismic Vulnerability Assessment of Deteriorated Bridges	SUNY Buffalo
CAIT-UTC-REG33	Real-Time Prediction of Storm Surge and Wave Loading on Coastal Bridges	SUNY Buffalo
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	RU
CAIT-UTC-REG35	NJDOT Flood Risk Visualization Tool	RU
CAIT-UTC-REG36	Improving the Long-Term Performance of Bridge Decks through Full-Scale Accelerated Testing	RU
CAIT-UTC-REG37	Impact of Recycled Plastic on Asphalt Binder and Mixture Performance	RU
CAIT-UTC-REG39	FDR Stabilizer Selection Using Simple Soil Tests	Cornell
CAIT-UTC-REG41	Affordable On-Demand Testing of Water Contamination Using a Portable Nanoelectronic Lead Detector	RU
CAIT-UTC-REG42	Enhanced Maritime Asset Management System (MAMS)	RU
CAIT-UTC-REG47	Remote Sensing System Enhancement for Digital Twinning of the Built Infrastructure to Support Critical Infrastructure Protection Research	SUNY Buffalo

HIGHLIGHTS
Completed Projects

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

Accomplishments: This project demonstrated how autonomous technology can be used to improve current practices for maintaining infrastructure. CAIT's recent acquisition of the robotic dog Spot illustrates this.

ROI: With Spot, researchers and industry can use the adaptive robotic system to deploy and inspect hard-to-reach or dangerous environments, carry infrared cameras, inspect assets, and more, making job sites safer and easier to navigate.

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)

Accomplishments: To ensure the safety of existing infrastructure, on-site life-time inspections and monitoring are required, but current methods can lead to resource mismanagement.

ROI: This project investigated new technologies such as virtual and augmented reality, combined with informational modeling, to better understand their applications in structural health monitoring. This work can impact asset durability, resilience, and preservation, through the use of new and innovative technologies.

Assessing and Mitigating Transportation Infrastructure Vulnerability to Coastal Storm Events with the Convergence of Advanced Spatial Analysis, Infrastructure Modeling, and Storm Surge Simulations (CAIT-UTC-REG34, Project Manager: Jie Gong)

Accomplishments: This project developed a decision support tool to assist stakeholders in making decisions at the day-to-day level to protect communities from impeding flooding events, as well as in making long-term decisions in mitigating future flood risks.
ROI: This study helped develop software applications that are built for infrastructure resilience centered investigations. A recent real-world example of this technology being used happened when CAIT researchers deployed resources and gathered impactful flooding data to generate flood-prediction models after Hurricane Ida hit NJ in September 2021.

NJDOT Flood Risk Visualization Tool (CAIT-UTC-REG35, Project Manager: Dr. Jon Carnegie)

Accomplishments: This project developed a tool that can enhance capacity for NJDOT personnel to assess the flood vulnerability of its infrastructure and assets.
ROI: The tool will enable NJDOT to integrate data about current and future flood hazard vulnerability into existing capital planning and asset management processes. Over time, the intent is to improve overall resilience of transportation infrastructure to climate hazards.

Improving the Long-Term Performance of Bridge Decks through Full-Scale Accelerated Testing (CAIT-UTC-REG36, Project Manager: Dr. Franklin Moon)

Accomplishments: The goal of this research was to leverage testing being conducted by FHWA within The BEAST to better understand the demands that bridge decks are exposed to.
ROI: This knowledge will help improve bridge deck design and provide more accurate estimation of deck demands. That will help ensure that new designs account for temperature effects, resulting in more durable bridge decks that are less prone to cracking.

Impact of Recycled Plastic on Asphalt Binder and Mixture Performance (CAIT-UTC-REG37, Project Manager: Dr. Thomas Bennert)

Accomplishments: This project evaluated the compatibility of different plastics within asphalt mixtures and the resultant asphalt binder and performance of the plastic-modified material.
ROI: It is anticipated that a series of webinars to state and local agencies will provide information pertaining to the appropriate waste plastic stream products for asphalt mixtures.

FDR Stabilizer Selection Using Simple Soil Tests (CAIT-UTC-REG39, Project Manager: Dr. David Orr)

Accomplishments: Full Depth Reclamation is a commonly used technique to improve the quality of the base for local roads and streets. One of the most important steps is choosing the correct stabilizer for the current road conditions. However, the choice of the material to be used is too often based upon discussions with a local vendor or other empirical methods.
ROI: This project evaluated the sand equivalent test with grain size analysis to overcome the limitations agencies face, and provide a more economical method to choose the best stabilizer.

Ongoing Projects

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

Outputs: This project aims to design and develop training curricula including the development of assessment instruments for deriving both formative and summative learning outcomes.
Outcomes: These curricula will evaluate the practical flight abilities of prospective UAS pilots. 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.

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

Outputs: A flood map for NJ towns that depicts flood hazards, lifeline infrastructure, vulnerability assessments, and resiliency measures.
Outcomes: 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.
Impacts: This project assists decision makers and coastal communities with understanding the magnitude of floods, quantifying impacts, and assisting with mitigation and resiliency planning.

Investigation of Balanced Mixture Design for New York State Asphalt Mixtures (CAIT-UTC-REG25, Project Manager: Dr. Thomas Bennert)

Outputs: A non-proprietary/non-confidential final report covering all aspects of the work performed under this research study.
Outcomes: Training and specifications around the new design method will be developed and implemented within NY State. Technical presentations are proposed for the annual NY State Materials Conferences and the National Asphalt Pavement Association meetings.
Impacts: It is anticipated that the results of the study will help NYSDOT improve their mixture design and performance-testing programs.

Passenger Flow Modeling on Platform Tracks in Transit Stations (CAIT-UTC-REG26, Project Manager: Dr. Xiang Liu)

Outputs: This research aims to model and simulate passenger flows in transit stations using computer vision and simulation technologies.
Outcomes: The research outcomes can potentially be used by NJ Transit in preparing proposals to apply for federal grants to improve infrastructure.
Impacts: The information from this project can be used by NJ Transit to understand the benefit of infrastructure design or upgrades in terms of changing passenger flow and less congestion.

Designing Concrete Mixtures with RCA (CAIT-UTC-REG27, Project Manager: Dr. Matthew P. Adams)

Outputs: A novel RAC design methodology through experimental and computational methods.

Outcomes: The results of the pilot RAC slab program completed as a part of this research will constitute one of the major outcomes of this work.
Impacts: This pilot program can be used by other agencies as a proof of concept.

Cost-effective Bridge Decks for Improved Durability and Extended Service Life (CAIT-UTC-REG28, Project Manager: Dr. Sougata Roy)

Outputs: This project is developing cost-effective standard open rib SOBD to promote increased implementation of SOBD for short and medium span highway bridges.
Outcomes: The new design specifications and companion guidelines are expected to be incorporated into the AASHTO Bridge Design Specifications.
Impacts: The research findings and standardization could be adopted by steel bridge fabricators for streamlining production, economizing fabrication, and competitive advantage.

Durable and Electrified Pavement for Dynamic Wireless Charging of Electric Vehicles (CAIT-UTC-REG30, Project Manager: Dr. Hao Wang)

Outputs: The primary goal of this research is to develop new design of electrified pavement that have durable performance while providing efficient charging functionality.
Outcomes: The intended outcome of the project is to provide an innovative solution on wireless charging techniques integrated in existing roadway pavements.
Impacts: The research results will contribute to the development of electrified roadway that provide energy sources for electric vehicles.

Evaluating the Safety and Mobility Impacts of American Dream Complex: Phase I (Feasibility Study, and Data Acquisition) (CAIT-UTC-REG31, Project Manager: Dr. Mohammad Jalayer)

Outputs: The primary goals of this project are to coordinate with stakeholders to identify and address traffic and safety issues associated with this complex using innovative technology.
Outcomes: Phase I of this project will provide a framework for larger data collection and analytics with the aim of developing effective and innovative solutions to alleviate traffic congestion and motor vehicle crashes.
Impacts: This project is providing a framework for alleviating traffic congestion in the area and developing intersection-safety tools using Artificial Intelligence.

Rotorcraft Landing Sites – An AI-Based Identification System (CAIT-UTC-REG32, Project Manager: Dr. Ghulam Rasool)

Outputs: This project is creating AI-based algorithms to automate landing-site identification.
Outcomes: The intended outcome is to generate an AI algorithm that will automate the process of identification of landing sites from video data as well as satellite images. Once developed, the AI system would allow FAA to update its databases of landing sites regularly without delays.
Impacts: There is currently a lack of information about landing sites for helicopters and other rotorcrafts, and acquiring, verifying, and updating this information is no small task. This project aims to create an AI-based system to identify landing site infrastructure from various datasets.

Risk and Resilience Analysis Tool for Infrastructure Asset Management (CAIT-UTC-REG38, Project Manager: Dr. Yun Bai)

Outputs: Risk- and resilience-based infrastructure asset management is timely and important for infrastructure owners to anticipate various natural and man-made hazards and maximize the duration and service performance of capital-intensive infrastructure.
Outcomes: There is a pressing need from agencies for a quantitative, risk- and resilience-based framework that can address high level IAM questions.
Impacts: This project is evaluating the application of prevailing risk and resilience assessment approaches and integrating them in a holistic transportation asset management framework.

Zero Speed Profiler Assessment for Pavement Smoothness and Continuous Pavement Texture Measurements (CAIT-UTC-REG40, Project Manager: Michael Boxer)

Outputs: The primary goal of this project is to evaluate a state-of-the-art technology in roadway profiling called Zero Speed Profiling.
Outcomes: It is anticipated that with successful implementation, the Zero Speed Profiler will provide a better assessment of the current pavement profile in NJ when compared to others.
Impacts: A more realistic and comprehensive pavement surface assessment will result in better decisions regarding how to preserve or rehabilitate the pavement and state roadways.

Enhanced Maritime Asset Management System (MAMS) (CAIT-UTC-REG42, Project Manager: Dr. Yun Bai)

Outputs: CAIT has worked with NJDOT to develop a prototype Maritime Asset Management System that can meet transportation asset management plan requirements and aid with resource allocation.
Outcomes: The state-of-the-art TAM approach has been implemented in a desktop-based user interface software application.
Impacts: The goal of the project is to renovate the current MAMS prototype software to improve the user experience and extend the functionality of the tool.

Assessment of Solidification / Stabilization as a Remedial Strategy for PFAS Contaminated Transportation Sites (CAIT-UTC-REG44, Project Manager: Dr. Robert Miskewitz)

Outputs: This project seeks to determine if Solidification and Stabilization (S/S) is a viable remedial strategy for PFAS contaminated sediment.
Outcomes: If the process is effective at eliminating contaminant pathways out of the stabilized matrix, then this previously harmful material can be beneficially used as geotechnical fill.
Impacts: Beneficial reuse of contaminated soils on-site can represent a significant cost savings for treatment while providing a value as a product.

The Development of the Digital Twin Platform for Smart Mobility Systems with High-Resolution 3D Data (CAIT-UTC-REG45, Project Manager: Dr. Peter Jin)

Outputs: The primary goal of this project is the development of a digital twin for urban mobility, the Mobi-Twin platform, focusing on enabling the microscopic accurate modeling and simulation of Urban Mobility System of Systems with the emerging self-driving grade high-resolution 3D data.

Outcomes: The platform will use data collected from DataCity, the Smart Mobility Testing Ground project in partnership with NJDOT and Middlesex County, to support CAV research.
Impacts: The proposed digital twin platform will reproduce high-fidelity reality for modeling smart mobility objects with seamless object-level integration among different systems.

Driving behavioral learning leveraging sensing information from Innovation Hub (CAIT-UTC-REG46, Project Manager: Dr. Sharon Di)

Outputs: The primary goal of this project is to develop machine-learning algorithms for driving behavior mining, using real-time vehicle, pedestrian, and infrastructure data.
Outcomes: The intended outcome of the project is an algorithm suite to learn human behavior patterns from LiDAR and camera datasets.
Impacts: The proposed algorithms will improve our understanding of how people drive on both highways and urban roads, which will help monitor and maintain roadside infrastructure and support the transportation systems to accommodate not only the existing human-driven vehicle but also the upcoming connected and automated mobility systems.

Linking Physics-Based Deterioration Model to Field-Based Condition Assessments for Improving Asset Management (CAIT-UTC-REG48, Project Manager: Dr. Ravi Ranade)

Outputs: The main focus of the project is to establish a link between a physics-based corrosion model and condition rating assessments.
Outcomes: This will empower the DOTs to rationally explore the long-term benefits of investments in innovative technologies, such as advanced materials and innovative construction methods.
Impacts: If the framework is implemented on a larger group of bridges, DOTs will be able to better allocate assets by prioritizing bridges for repair and maintenance according to their true vulnerability quantified by the physics-based deterioration models whose results can be directly utilized in structural analyses.

Post-fire Damage Assessment of Concrete Tunnel Liners (CAIT-UTC-REG49, Project Manager: Dr. Negar Elhami-Khorasani)

Outputs: This project will make recommendations on post-fire tunnel damage assessment.
Outcomes: The research team will incorporate input from stakeholders and practicing engineers to align the project outputs with real-world applications and maximize the impact.
Impacts: The project outcomes are not only relevant to post-fire damage assessment but can also be used as performance objectives when designing or evaluating tunnel structures using performance-based design methodologies for resilience against fire.

Post-disaster Damage Assessment of Bridge Systems (CAIT-UTC-REG50, Project Manager: Dr. Xiao Liang)

Outputs: A novel signal processing technique will be developed to build a surrogate model for an accurate prediction of engineering demand parameters of interest.
Outcomes: The epistemic uncertainty of the surrogate model will be quantified and integrated with other uncertainties in performance-based engineering methodology so that rapid condition assessment and loss estimation can be provided in a probabilistic manner.

Impacts: The proposed framework will be first verified through the data generated using finite element analyses, and its reliability will be validated through proof-of-concept experiments.

Real-Time Decision Support System for Transportation Infrastructure Management under a Hurricane Event (CAIT-UTC-REG51, Project Manager: Dr. Teng Wu)

Outputs: This project will lay the groundwork for the development of a real-time decision support system for transportation infrastructure management under a hurricane event.
Outcomes: The intended outcome of the project is to deliver a tool to rapidly identify optimal traffic control policies under hurricane events.
Impacts: This project will investigate hurricane impacts on critical infrastructure and effects of various traffic control policies on traffic network performance. The project will then identify the optimal traffic control policy to minimize hurricane-induced losses.

Bridge Deck Surface Profile Evaluation for Rapid Screening and Deterioration Monitoring (CAIT-UTC-REG52, Project Manager: Dr. Adriana Trias)

Outputs: The primary goal of this project is to develop a procedure that ensures proper LiDAR data collection focused on bridge deck surface geometry capturing for inspection.
Outcomes: The intended outcome of the project is to help identify areas of possible early sources of deterioration of the bridge decks, allowing to better address life-cycle monitoring.
Impacts: This research is expected to impact the durability and preservation of bridge decks.

A Real-Time Proactive Intersection Safety Monitoring System Based on Video Data (CAIT-UTC-REG53, Project Manager: Dr. Mohammad Jalayer)

Outputs: This project is developing a real-time proactive safety monitoring system based on the trajectory of road users (e.g., cars, pedestrians, and cyclists) collected by video cameras.
Outcomes: The results of this project will provide a great opportunity for transportation agencies to rank and score intersections based on the analyzed data.
Impacts: The project will provide appropriate safety solutions to reduce intersection-related crashes and incidents and consequently reduce traffic congestion.

Rotorcraft Landing Sites Identification – Scaling and Generalization of the AI Model (CAIT-UTC-REG54, Project Manager: Dr. Ghulam Rasool)

Outputs: This project will address the challenging problem of automatic identification of helipads and landing sites using the machine and deep learning algorithms.
Outcomes: This project's deliverable is an AI-based system for the identification of helipads, heliports, and landing site infrastructure from satellite images.
Impacts: The intended impacts of the AI model are to automate the process of identification of landing sites for rotorcrafts from the Google Earth satellite imagery.

JFK Cargo View: A system to speed Truck Traffic Flow at JFK Airport (CAIT-UTC-REG55, Project Manager: Dr. Kazem Oryani)

Outputs: This project is identifying best practices to facilitate truck movements and minimize wait time at JFK International Airport for land-side cargo through a systems analysis.
Outcomes: The developed model can potentially be used as a framework for expansion in other airports with similar congestion issues and long truck wait time.

Impacts: This will help improve cargo flow, benefit the local economy, and support nearby communities with reduction of pollution caused by excessive truck wait-times.

Supplemental Study of Filter Technology Efficacy for Transit Vehicles to Combat the Spread of COVID-19 and Other Respiratory Infections (CAIT-UTC-REG58, Project Manager: Shane Mott)

Outputs: Airborne transmission of the COVID-19 virus has been identified as one of the primary modes through which COVID-19 is spread. MERV 13 filters can filter 85% of particles in the ideal size range for capturing respiratory droplets.
Outcomes: MERV 8+Ag filters contain a silver impregnated layer within and on top of the filter material. This silver layer has antiviral properties which can deactivate trapped viruses.
Impacts: The primary goal of this study is to determine if the performance on these filters change over time, specifically in the transit environment, and compare the results.

Education and Workforce Development Activities

The consortium has trained more than 1,410 professionals during this period.

- **Classes, Seminars, and Educational Opportunities**
  CAIT is establishing its Infrastructure Asset Management Academy, a 6-course program taught by experts at CAIT and industry partners designed to give students the knowledge, tools, and expertise needed to make better informed asset management decisions.

  CAIT researcher Dr. Thomas Bennert presented his work leading the Pavement Support Program for NJDOT's Pavement & Drainage Management and Technology Unit during a recent Lunchtime Tech Talk webinar.

- **Technology and Tools**
  Able to climb stairs, navigate rough terrain, and respond to commands, the mobile robotic dog, "Spot," offers Rutgers CAIT researchers an autonomous technology for innovations in infrastructure maintenance and repair.

  Since Tropical Storm Ida struck New Jersey, a team of Rutgers engineers, researchers and students has been in the field assessing flood damage and gathering critical data to help improve flood prediction models and inform how New Jersey responds to future storms.

Technology Transfer

- **Presentation and Events**
  At a groundbreaking ceremony in New Brunswick, NJ Governor Phil Murphy announced the NJ Innovation and Technology Hub, a 550,000 square foot development that will be a center of innovation, research, medical education, and a home to CAIT's DataCity.

  CAIT hosted Technology Takes the Wheel, part one of a three-part speaker series on the challenges and next steps in implementing connected and autonomous vehicles into transportation networks. The event was co-hosted by AAA Mid-Atlantic.

Rutgers recently hosted U.S. Secretary of Commerce Gina Raimondo and Congressman Frank Pallone for a tour, including the lab of CAIT researcher Dr. Jie Gong who showcased the robotic dog Spot that he recently acquired as part of a UTC project.

Research and Publications
Officials recently celebrated the grand opening of a new 2-mile asphalt trail near Skillman Road in Montgomery Township, NJ. In partnership with NJDOT, FHWA, and Rutgers CAIT, the pathway includes areas of porous concrete designed to alleviate flooding and puddling.

UTC partners at Rowan University analyzed potential mobility and safety concerns of the transportation network surrounding the American Dream Mall in East Rutherford, New Jersey. The team also developed an innovative AI tool to assess intersection safety.

- **CAIT Researchers Win Awards**
  The American Council of Engineering Companies of New Jersey celebrated its 50th annual Engineering Excellence Awards this July, and recognized Rutgers professor and CAIT-affiliated researcher Dr. Nenad Gucunski as its Educator of the Year.

  The Associate Director of CAIT, Dr. Patrick Szary, was recently elected Vice President of CUTC for 2021-2022. Dr. Szary leads CAIT's research efforts helping to align them with USDOT's national vision and the needs of stakeholders in the Northeast region.

How have the results been disseminated?
CAIT established the Consortium internet site: https://cait.rutgers.edu/. CAIT has distributed The CAIT Update, its monthly E-newsletter, to subscribers in the transportation industry. CAIT has also shared results to the general public through news media. Select coverage includes:

AIP.org

NewYork.CBSLocal.com

ConstructionEquipmentGuide.com

NJ.com

Cities-Today.com

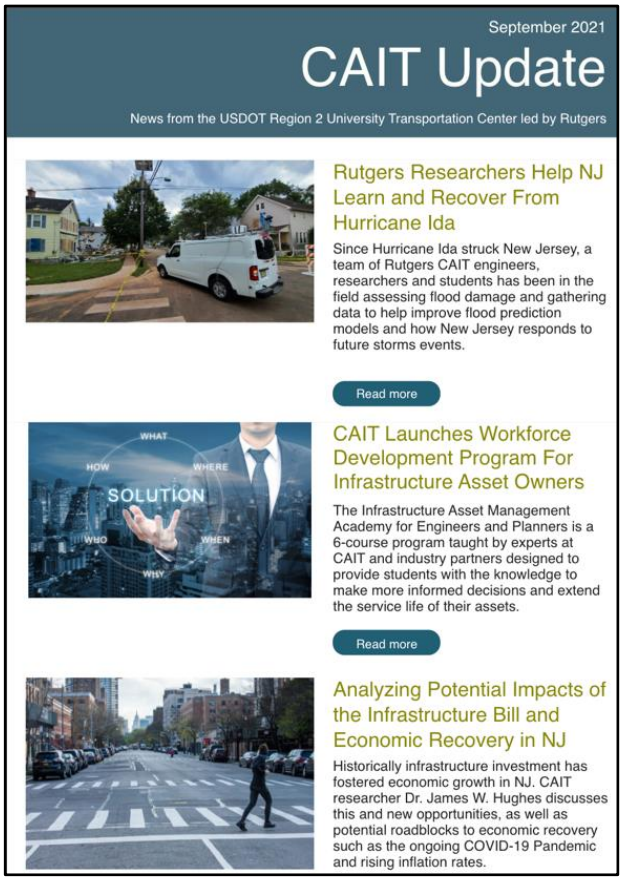
AASHTO Daily Transportation Update

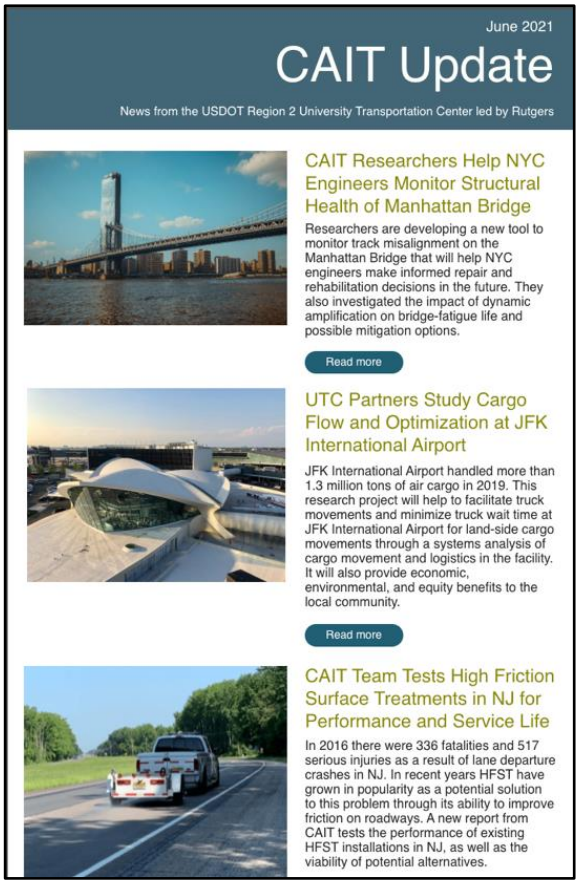
BizJournals.com

Rutgers.edu

MyCentralJersey.com

Newsletter
CAIT has distributed The CAIT Update, its E-newsletter, monthly to 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.

1. **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
NYCDOT-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	Financial support, 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
Federal Aviation Administration	Washington, DC	Personnel resources, knowledge exchange
Middlesex County	Middlesex, NJ	Financial support, Personnel resources, knowledge exchange
JFK International Airport	Queens, NY	Personnel resources, knowledge exchange
Gateway JFK	Queens, NY	Personnel resources, knowledge exchange
AAA Mid-Atlantic	Wilmington, DE	Personnel resources, knowledge exchange
Verizon	New York, NY	Personnel resources, knowledge exchange

- ***Have other collaborators or contacts been involved?***
  Nothing to report

2. **OUTPUTS** (What new research, technology or process has the program produced?)

   Publications, conference papers, and presentations

- (Published) Wang, H., Ranade, R., Okumus, P. (2021) "Seismic Fragility of Reinforced Concrete Bridge Columns Utilizing Ductile Fiber-Reinforced Concrete Covers." Structure and Infrastructure Engineering, https://doi.org/10.1080/15732479.2021.1973040

- (Under review) Wang, H., Ranade, R., and Okumus, P. "Estimating chloride exposure of reinforced-concrete bridges using vehicle spray and splash mechanisms." Submitted to Structure and Infrastructure Engineering.

- G. Pacheco-Crosetti and H. Cruzado, THE ANALYSIS OF STRUCTURAL FAILURES IN TRANSPORTATION INFRASTRUCTURE USED TO ESTIMATE WIND SPEEDS OF HURRICANE MARIA IN PUERTO RICO, 1st RIDNAIC Virtual Summit, International Journal of Natural Disasters, Accidents and Civil Infrastructure - RIDNAIC, 3/16/2021

- G. Pacheco-Crosetti and H. Cruzado, Improving Transportation Infrastructure Resilience: Case Studies of Damages Caused by Hurricane Maria in Puerto Rico, Hurricane Symposium, College of Engineers and Land Surveyors of Puerto Rico – CIAPR, 6/3/2021

- Jalayer, M. "Evaluating the Mobility Impacts of American Dream Complex and Developing Innovative Intersection Safety Tools." CAIT Seminar Series. 8/30/2021

- Jayasuriya, A, ES Shibata, T Chen, MP Adams (2021); "Development and statistical database analysis of hardened concrete properties made with recycled concrete aggregates;" Journal of Resources, Conservation and Recycling; Volume 164, Issue 1; Elsevier.

- Adams, MP (2021); "Low carbon concrete: A primer on forms, impacts, and costs;" Decarbonizing Concrete through State Procurement: A Proposal for Virginia; Natural Resources Defense Council Webinars; Virtual; June 16, 2021.

- Dick, C.T., Zhao, J., Liu, X., Kirkpatrick, S.W. (2021). Quantifying Recent Trends in Class 1 Freight Railroad Train Length and Weight by Train Type. TRR, 03611981211031534.

- Zhang, Z.P., Liu, X., Hu, H. (2021). Passenger rail station safety improvement and analysis of end-of-track collisions based on systems-theoretic accident modeling and processes (STAMP). Smart and Resilient Transport.

- Zhang, Z.P., Liu, X., Hu, H. (2021). Statistical Analysis of Seasonal Effect on Freight Train Derailments. Journal of Transportation Engineering, Part A: Systems, 147(10), 04021073.

- Wang, Y., Wang, P., Tang, H.Y., Liu, X., Xu, J.H., Xiao, J.L., Wu, J.S. (2021). Assessment and prediction of high speed railway bridge long-term deformation based on track geometry inspection big data. Mechanical Systems and Signal Processing, 158, 107749.

- **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	10
2) a presentation and/or webinar.	10	19
3) a demonstration and/or pilot project.	3	6
4) a guidebook or similar publication in addition to an academic report.	8	11
5) a new specification.	1	2
6) new software or an app.	3	5
7) a new material and/or tangible product.	1	3
8) a potential patent or otherwise marketable product.	2	4
9) Primary or secondary customers will be tracked.	15	34
10) Implementation stakeholders will be tracked.	15	47
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	8/10
b. Researchers and/or developers	1 / 5	3/12
c. Early adopters and problem owners	5 / 5	13/19
d. Late adopters that follow the technology's development	3 / 5	6/21
e. Deployment team	3 / 3	10/15
f. Others, e.g., trade organizations, regulators, suppliers, etc.	1 / 3	3/13
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	44
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	5
b. Infrastructure: Invest in infrastructure to ensure mobility and accessibility and to stimulate economic growth, productivity, and competitiveness for American workers and businesses.	5	19
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	20
d. Accountability: Serve the nation with reduced regulatory burden and greater efficiency, effectiveness, and accountability.	2	6

3. **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	7
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

4. **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	$3,580,396
2) durability and/or resilience and/or preservation	Zero in year one - 30 years each subsequent year	40 years
3) workforce proficiency or documented success stories	4 success stories	8

5. **CHANGES/PROBLEMS**

- ***Changes in approach and reasons for change.***
  Nothing to report

- ***Actual or anticipated problems or delays and actions or plans to resolve them.***
  Nothing to report

- ***Changes that have a significant impact on expenditures.***
  Nothing to report

- ***Significant changes in use or care of animals, human subjects, and/or biohazards.***
  Nothing to report