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Impact Statement

2023 has been a year shaped by global conflicts, from the lingering effects of COVID-19 and potential economic recession to worsening climate change and wars in Europe and the Middle East. The global economy has been burdened by multiple complex conflicts, stressing the interconnected ties that bind us—from the trade of goods, energy, and materials to diplomatic relationships and the exchange of knowledge and educational resources.

Economic uncertainties stemming from these challenges have had tangible impacts at Rutgers University and throughout Region 2. For example, New Jersey's unemployment rate has jumped above the 3.8% national average over the course of 2023, from 3.3 to 4.4%. Large employers are feeling the impacts of these labor shortages, especially in the transit space where funding remains a concern and potential service cuts are looming. Specifically, multiple major rail agencies in the Northeast are anticipating up to a \$1B budget shortfall between 2024 and 2026 as federal aid ends. At the same time, worker unions across the rail sector have threatened to strike this year, citing expired contracts, wage gaps, and stalled negotiations.

The global exchange of students has slowed recently as well, impacting the number of students that can be involved in research projects. Students from China, a top country of origin for international students, enrolled in US colleges dropped last year. A decrease in international students shrinks the talent pool relied on by research universities across the country. Colleges have also felt similar budgetary shortfalls. Earlier this year, Rutgers University indicated it would be taking steps to address a \$100M+ budget deficit. Similar sentiments have been echoed by Big Ten schools across the country.

These hardships have at times required staggered scheduling of resources at CAIT, pushing back project deliverables and end dates. Simultaneously, CAIT's stakeholders have also experienced delays in project management due to leadership turnover and staffing shortages. To deal with these obstacles, the Center has relied on its long-term partnerships and research programs with many key state and regional transportation agencies. Leveraging these relationships has allowed CAIT to continue its impactful work addressing the durability and extending the service life of existing transportation infrastructure. Select developments from this reporting period are highlighted below:

- **Reducing GHG Emissions in Construction Projects:** This summer, **The Port Authority of NY & NJ** announced its strengthened requirements for using sustainable concrete mixes in all future construction projects as part of the agency's commitment to achieving net-zero emissions by 2050. This stems from PANYNJ's Low-Carbon Concrete Program designed to reduce Greenhouse Gas Emissions associated with producing cement for construction projects. A research team led by Rutgers CAIT and consortium partners NJIT and Princeton identified 18 concrete mix designs that can reduce emissions by up to 37%. UTC [research](#) provided critical support to the Port Authority in identifying approaches and opportunities to implement its Low-Carbon Concrete Program.

- **Supporting Innovation & Education in Regional Public Transit:** CAIT's relationship with **New Jersey Transit** has continued to grow as a result of innovative UTC projects supporting the adoption of [electric bus charging infrastructure](#), the use of digital twins to develop a [flood early warning system](#) for coastal transit facilities, and more. This growing partnership opened the door for NJ Transit, Rutgers CAIT, and the **International Association of Public Transport** (UITP) to come together and launch the North American Regional Training Center housed at CAIT. The training center has hosted three courses so far reaching 130+ transportation professionals from NJ Transit, NY City Transit, Washington DC WMATA, and STM-Montreal among other agencies.

This fall, Rutgers CAIT was 1 of 9 member institutions selected by the FRA to establish the inaugural [National University Rail Center of Excellence](#) (NURail CoE) led by the University of Illinois Urbana-Champaign. Representing the Northeast region, CAIT looks forward to leveraging this opportunity to continue conducting research that advances the safety, efficiency, and reliability of regional rail transportation.

- **Expanding Investment in Youth Development & Equity:** CAIT's Rutgers Youth Success /Rutgers Employment Success Program has expanded its relationship with the **NJ Department of Labor** (NJDOLE) launching two new grants: Job Opportunities for Building Success (JOBS) and Pre-Apprenticeship in Career Education (PACE). This new funding will grow the program and its critical work developing pathways for justice-impacted youth and emerging adults to gain successful employment in the transportation, construction, heavy equipment operation, and related fields.

Rutgers Employment Success has served 300+ participants since 2020 and has attained an 82% employment/return-to-education rate. With this new funding 500+ participants are anticipated by 2025. The CAIT consortium has played a critical role in supporting the program's development by leveraging its vast network of universities, transportation stakeholders, and employers. The UTC-funded [Camden Career Pathways Initiative](#) has also mined the region to develop critical first points of contact between youth in the program and transportation-related employers looking to hire them.

In these uncertain economic times, CAIT's approach has been to rely on the close partnerships that it has forged with state, regional, and national transportation agencies to continue conducting research that is practical, implementable, and advances knowledge in the field. The UTC designation has been critical in establishing these multi-year partnerships and growing the Center into a regional hub for research, education, and workforce training for transportation stakeholders.

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 4 projects during this cycle. Multiple research projects are currently under review.

New Projects:

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| CAIT-UTC-REG83 | Assessment of Waterfront Asset Resiliency <i>Abstract:</i> The goal of the study is to enhance the understanding of hazards, vulnerabilities, and potential impacts on critical assets at the Little Egg Harbor Yacht Club and develop effective strategies for risk reduction and resilience enhancement. | RU |
| CAIT-UTC-REG84 | Test Bed Mesocosms for Improved Stabilized Sediment Laboratory Specimen Preparation and Field QA/QC <i>Abstract:</i> This project will utilize a combination of field and laboratory testing to improve the preparation of laboratory specimens and to help guide the development of QA/QC guidelines. | RU |
| CAIT-UTC-REG85 | Identifying the Effect of Bridge Deterioration on Load Distribution <i>Abstract:</i> This research aims to develop a model for predicting the remaining service life of structural members based on strain responses and other monitoring data. | RU |
| CAIT-UTC-REG86 | Development of A Digital Testbed for Connected Transit Technologies <i>Abstract:</i> This research aims to create a cloud-based digital testbed by seamlessly integrating sensor technologies, connectivity solutions, and advanced data analytics. It will build a digital twin, mirroring the operation of a light rail network within a specific corridor. | RU |

Identifying the Effect of Bridge Deterioration on Load Distribution

Over 75% of this nation’s more than 600,000 bridges have spans shorter than 75 feet and nearly half of them are more than 50 years old. Many of these structures are highway overpass bridges critical to our collective mobility. It is important to understand the performance of these structures and what factors affect their deterioration, however little guidance exists on what responses should be monitored and how the resulting data may be analyzed and interpreted. Utilizing CAIT’s BEAST Lab, researchers will develop a model for predicting the remaining service life of structural members based on strain responses and other data. This research will develop tools and guidelines for leveraging structural monitoring data to improve the durability of bridges and extend their service life.



Ongoing Projects:

| | | |
|----------------|---|--------------|
| CAIT-UTC-REG25 | Investigation of Balanced Mixture Design for New York State Asphalt Mixtures | RU |
| CAIT-UTC-REG40 | Zero Speed Profiler Assessment for Pavement Smoothness and Continuous Pavement Texture Measurements | RU |
| CAIT-UTC-REG56 | Interactive decision support system for tunneling planning and construction: Hudson Tunnel case study | NJIT/Stevens |
| CAIT-UTC-REG59 | Durability of Low Carbon Concrete Mixtures | NJIT |
| CAIT-UTC-REG62 | AI-supported Monitoring and Resiliency Analysis for the Coastal Area of the Luis Muñoz Marín International Airport in Puerto Rico | RU/PUPR |
| CAIT-UTC-REG63 | State-of-the-art technologies for structural health monitoring of tunnels: an overview | PU |
| CAIT-UTC-REG64 | NJ Transit Northern Bus Garage Planning and Community Impact Evaluation | RU |
| CAIT-UTC-REG66 | Comparison Analysis of Charging System Designs for Battery Electric Bus | RU |
| CAIT-UTC-REG69 | Camden Career Pathways Initiative | RU |
| CAIT-UTC-REG70 | Developing Indicators for Comprehensive Evaluation of Equity in Transportation System | Rowan |
| CAIT-UTC-REG71 | Bio-mediated method for improving the erosion resistance of coastal embankment | Rowan |
| CAIT-UTC-REG72 | Planning Project for Initiating A Large-scale 3D Printing Facility | RU/PU |
| CAIT-UTC-REG73 | Asphalt Viability in Recycled Asphalt Pavement (RAP) Using the Gyrotory Compactor | RU |
| CAIT-UTC-REG74 | Rapid Damage Assessment in Infrastructure Systems using Vibration Measurements within a Machine Learning Framework | Columbia |
| CAIT-UTC-REG75 | Mitigating Cracks in Concrete Members for Durable Bridge Construction | UB |
| CAIT-UTC-REG76 | Advanced Testing and Modeling of Dredged Sediments for Beneficial Use | RU |
| CAIT-UTC-REG77 | Identification Potential of Microplastics from Recycled Plastic Modified Asphalt Mixtures | RU |
| CAIT-UTC-REG78 | Evaluation of the Effects of Superstructure Characteristics on the Performance of Bridge Decks under Traffic Loads | RU |
| CAIT-UTC-REG79 | Resilience and Mobility Accessibility in Underserved Communities | RU |
| CAIT-UTC-REG80 | Full-scale “Living Pavement Testbed” for Testing and Evaluation of Sustainable Pavement | RU |
| CAIT-UTC-REG81 | A hydrologic modeling framework for assessing future riverine flood risk of critical transportation infrastructure | RU |
| CAIT-UTC-REG82 | Risk and Resiliency Analysis of Infrastructure by Improving RAMCAP Framework | Rowan |

Completed Projects:

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|----------------|--|--------------------------|
| 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-REG5 | Implementation and Development of UAS Practical Training for Inspection and Monitoring Activities | ACCC |
| 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-UTC-REG13 | Virtual Tour (VT), Informational Modeling (IM), and Augmented Reality (AR) for Visual Inspections (VI) and Structural Health Monitoring (SHM) | PU |
| CAIT-UTC-REG14 | Performance-Based Engineering of Transportation Infrastructure Considering Multiple Hazards | SUNY Buffalo |
| CAIT-UTC-REG15 | Flood Vulnerability Assessment and Data Visualization for Lifeline Transportation Network | Rowan |
| CAIT-UTC-REG16 | Fire In Tunnel Collaborative Project | PU/SUNY- Buffalo/NJIT |
| CAIT-UTC-REG17 | Improving Transportation Infrastructure Resilience against Hurricanes, other Natural Disasters, and Weathering: Part I - Analysis of failure of transportation signs due to Hurricane Maria | PUPR |
| CAIT-UTC-REG18 | Improving Transportation Infrastructure Resilience against Hurricanes, other Natural Disasters, and Weathering: Part II – Analysis of pedestrian bridges failures due to Hurricane Maria | PUPR |
| CAIT-UTC-REG19 | Improving Transportation Infrastructure Resilience against Hurricanes, other Natural Disasters, and Weathering: Part III - Analysis of motor vehicle bridges failures due to Hurricane Maria | PUPR |
| CAIT-UTC-REG20 | Infrastructure Cybersecurity and Emergency Preparedness Academic and Non-academic Credential Development | SUNY Farmingdale |
| 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-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-REG29 | Seismic Vulnerability Assessment of Deteriorated Bridges | SUNY Buffalo |
| 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 |

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| CAIT-UTC-REG32 | Rotorcraft Landing Sites – An AI-Based Identification System | Rowan |
| 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-REG38 | Risk and Resilience Analysis Tool for Infrastructure Asset Management | 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-REG43 | Artificial Intelligence-Aided Rail Transit Infrastructure Data Mining | 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-REG47 | Remote Sensing System Enhancement for Digital Twinning of the Built Infrastructure to Support Critical Infrastructure Protection Research | RU |
| 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-REG57 | Comparative analysis of rapid chloride penetration testing for novel reinforced concrete systems | NJIT |
| CAIT-UTC-REG58 | Supplemental Study of Filter Technology Efficacy for Transit Vehicles to Combat the Spread of COVID-19 and Other Respiratory Infections | RU |
| CAIT-UTC-REG60 | Low-Carbon Concrete Pilot Program | PU |
| CAIT-UTC-REG61 | QAD (Quality Assurance Division) Inspection Reporting and State of Good Repair (SGR) Planning | RU |
| CAIT-UTC-REG65 | Development of a Geometric Extraction Tool as Part of a Pilot Digital Twin Framework for Open-Deck Rail Bridges | RU |

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| CAIT-UTC-REG67 | Enhancing the resilience of coastal box girder bridges through geometric modifications | PU |
| CAIT-UTC-REG68 | A Machine Learning Decision-Support System for Selecting Optimal Innovative Project Delivery Methods for Bundled Transportation Projects | NJIT |

HIGHLIGHTS

Completed Projects *(select highlights from projects completed during this cycle)*

Low-Carbon Concrete Pilot Program (CAIT-UTC-REG60, Project Manager: Dr. Reza Moini)

Accomplishments: CAIT and consortium partners NJIT and Princeton identified 18 concrete mix designs that can reduce GHG emissions by up to 37% for the Port Authority of NY & NJ.

ROI: This critical work supports the Port Authority’s agency wide GHG reduction target of 80% by 2050. Over the summer, Port Authority announced its strengthened requirements for using sustainable concrete mixes in all future construction projects following research done as part of this Low-Carbon Concrete Pilot Program.

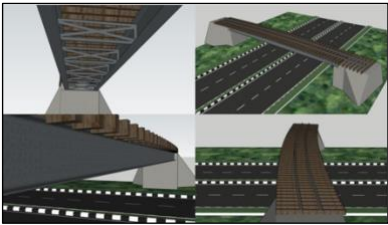
QAD (Quality Assurance Division) Inspection Reporting and State of Good Repair (SGR) Planning (CAIT-UTC-REG61, Project Manager: Dr. Ali Maher)

Accomplishments: A proof of concept was developed for the Port Authority of NY & NJ Engineering Department, providing staff and leadership with improved access to and visualization of vital infrastructure assets (wharves, bridges, etc.).

ROI: The prototype application provides PANYNJ engineers with a collection of visualization and analysis tools to enhance and support State of Good Repair planning. These tools allow the agency to leverage data that may currently reside in siloed repositories across departments.

Development of a Geometric Extraction Tool as Part of a Pilot Digital Twin Framework for Open-Deck Rail Bridges (CAIT-UTC-REG65, Project Manager: Dr. Amirali Najafi)

Accomplishments: Open-deck railway bridges require expensive and customized timber sleepers. When these sleepers are replaced, the manual process for geometry measurement is time consuming, often inaccurate, and expensive. This project investigated an alternative approach using UAV-based inspections and artificial intelligence.



ROI: An algorithm was developed for rapidly identifying the geometry of individual railway bridge components. Using 3D scans and automation reduces the maintenance costs and accuracy challenges for open-deck bridge maintenance procedures.

Enhancing the resilience of coastal box girder bridges through geometric modifications (CAIT-UTC-REG67, Project Manager: Dr. Maria Garlock)

Accomplishments: The potential increase of natural disasters led by climate change indicates higher risks for coastal bridges: they may be lifted off the pier or otherwise fail during hurricane and tsunami strikes because of elevated water and wave forces.

ROI: This project evaluated effective geometric forms to enhance the resilience of coastal box

girder bridges, and provided guidelines for asset owners on innovative coastal bridge designs considering hazard mitigation and the influence of climate change.

A Machine Learning Decision-Support System for Selecting Optimal Innovative Project Delivery Methods for Bundled Transportation Projects (CAIT-UTC-REG68, Project Manager: Dr. Rayan H. Assad)

Accomplishments: Project bundling is the process of awarding a single contract to several infrastructure projects to address construction and/or maintenance needs. This novel approach has time and cost-saving benefits; however, little guidance currently exists for agencies.

ROI: This research equips state DOTs with guidelines and a structured approach for making project delivery decisions. It also developed a better understanding of project bundling decision-making factors and how agencies can best prioritize them.

Ongoing Projects

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

Outputs: A non-proprietary final report covering the work performed under this research study.

Outcomes: Training and specifications will be developed and implemented within NY State.

Impacts: Study results will help NYSDOT improve mixture design and testing programs.

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: Potential design specifications to be incorporated into AASHTO Specifications.

Impacts: The research findings have the potential to be adopted by steel bridge fabricators for streamlining production, economizing fabrication, and competitive advantage.

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 surface profiling called Zero Speed Profiling.

Outcomes: Equipment that can provide a more accurate and efficient assessment of NJ's pavement profile when compared to other tools currently used by the State.

Impacts: A more realistic and comprehensive pavement surface assessment will result in better management decisions regarding how to preserve or rehabilitate NJ pavements and roadways.

Interactive decision support system for tunneling planning and construction: Hudson Tunnel case study (CAIT-UTC-REG56, Project Manager: Dr. Matthew Bandelt)

Outputs: This project aims to increase safety and minimize the risks of building major underground infrastructure systems by enhancing existing methods for risk assessment.

Outcomes: A framework for global large-scale tunneling projects able to determine hazards.

Impacts: This interactive decision support system will have the potential to be used in the design and construction of different tunnels in the US by local, regional, and federal agencies.

Durability of Low Carbon Concrete Mixtures (CAIT-UTC-REG59, Project Manager: Dr. Matthew P. Adams)

Outputs: This research will help develop a deeper understanding of the relative performance of low-carbon concrete systems when exposed to chlorides and deicing salts.

Outcomes: Life-cycle models for various low-carbon concrete mixtures to be developed.

Impacts: The intent of this project is to present a systematic approach to examining the durability of low-carbon concrete mixtures, supporting asset management decision-making.

AI-supported Monitoring and Resiliency Analysis for the Coastal Area of the Luis Muñoz Marín International Airport in Puerto Rico (CAIT-UTC-REG62, Project Manager: Dr. Roger Wang)

Outputs: Develop a surveillance camera-based coastal monitoring system for the San Juan International Airport and surrounding areas to support a resiliency study.

Outcomes: A climate adaptation/resiliency report for the Airport the surrounding area.

Impacts: New guidelines will help Puerto Rico consider climate change needs and improve airport resilience. The monitoring system can also analyze hazards to other local infrastructure.

State-of-the-art technologies for structural health monitoring of tunnels: an overview (CAIT-UTC-REG63, Project Manager: Dr. Branko Glisic).

Outputs: Successful implementation and effectiveness of monitoring systems for tunnels requires good understanding of the structure and limitations of the monitoring technology.

Outcomes: Extensive review of state-of-the-art technologies for tunnel SHM will be conducted.

Impacts: This project will generate guidelines for using new tunnel-monitoring technologies.

NJ TRANSIT Northern Bus Garage Planning and Community Impact Evaluation (CAIT-UTC-REG64, Project Manager: Dr. Peter Jin)

Outputs: This project will help NJ TRANSIT create a complete roster of the 500-bus capacity Northern Bus Garage and determine critical facility metrics.

Outcomes: Several modules for bus dispatching, including data archiving, processing and visualization, will be developed and integrated with the NJ TRANSIT bus scheduling system.

Impacts: Data generated will provide insights into the impact of the new garage, specifically on improvements to NJ TRANSIT bus operations within the service areas.

Comparison Analysis of Charging System Designs for Battery Electric Bus (CAIT-UTC-REG66, Project Manager: Dr. Hao Wang)

Outputs: A robust charging system for battery electric buses considering economic and environmental impacts will be developed and analyzed through this research project.

Outcomes: This project is developing a methodology to help NJ TRANSIT select the best charging system design with less life-cycle cost and carbon footprint.

Impacts: The results will help NJ TRANSIT develop its deployment strategy for charging infrastructure and refine its garage modification plans to support zero-emission bus systems.

Camden Career Pathways Initiative (CAIT-UTC-REG69, Project Manager: Dr. Patrick Szary)

Outputs: This project identifies career pathways in transportation for people from historically underserved NJ communities, helping them find careers in the growing transportation sector.

Outcomes: By identifying highly localized transportation-related positions in and around Camden NJ, this project will develop data points that support future job placement efforts.

Impacts: This work will provide entry points into the transportation sector for a historically underserved community, helping to overcome current barriers to access and employment.



Developing Indicators for Comprehensive Evaluation of Equity in Transportation System (CAIT-UTC-REG70, Project Manager: Dr. Mohammad Jalayer)

Outputs: An evaluation technique to assess and maintain equity principles in transportation planning and construction processes, and further incorporate them into decision-making.

Outcomes: Indicators for transportation agencies to better consider equity in projects.

Impacts: These guidelines will help industry adopt more equitable transportation practices.

Bio-mediated method for improving the erosion resistance of coastal embankment (CAIT-UTC-REG71, Project Manager: Dr. Cheng Zhu)

Outputs: A bio-mediated technique to improve the physical properties of soil embankment and mitigate coastal erosion in the State of New Jersey.

Outcomes: Guidelines for implementing the bio-mediated soil reinforcement technique in NJ.

Impacts: The developed bio-mediated soil reinforcement technique will be deployed on select embankment sites of interest along NJ coastal roadways.

Planning Project for Initiating A Large-scale 3D Printing Facility (CAIT-UTC-REG72, Project Manager: Dr. Meiyin Liu)

Outputs: This project will identify the roadmap towards a successful and sustainable large-scale 3D printing facility to be used in construction of durable components of infrastructure.

Outcomes: a comprehensive review of 3D printing for transportation and/or general civil infrastructures, which can work as a fundamental knowledge base for decision-making process.

Impacts: This research has the potential to advance the manufacturing process for improvements towards sustainable and resilient civil infrastructure using 3D.

Asphalt Viability in Recycled Asphalt Pavement (RAP) Using the Gyratory Compactor (CAIT-UTC-REG73, Project Manager: Dr. Thomas Bennert)

Outputs: This project will evaluate the viability of asphalt binder in RAP materials using a simplified procedure with the gyratory compactor.

Outcomes: The intended outcome of the project is to provide a quick and accurate means of evaluating RAP that can be utilized back into new asphalt materials.

Impacts: The researchers will generate a proposed parameter and recommended thresholds that would allow asphalt mixture suppliers to determine maximum RAP contents based on existing asphalt binder grades, softer binder grades, and recycling agents.

Rapid Damage Assessment in Infrastructure Systems using Vibration Measurements within a Machine Learning Framework (CAIT-UTC-REG74, Project Manager: Dr. Raimondo Betti)

Outputs: Machine Learning algorithms for the rapid identification of damage in bridge structures using the bridge's dynamic response during regular service operation.

Outcomes: Software package and diagnostic tools for rapid damage assessment.

Impacts: Innovative tools supporting bridge managers and advancing the civil engineering field.

Mitigating Cracks in Concrete Members for Durable Bridge Construction (CAIT-UTC-REG75, Project Manager: Dr. Ravi Ranade)

Outputs: The primary goal of this project is to investigate the use of steel wool in concrete to increase its crack resistance and enable durable, crack-free bridges.

Outcomes: Guidelines for implementing the newly developed concrete mix in field applications.

Impacts: Support accelerated bridge construction through the development of a concrete mix using steel wool that has high tensile strength suitable for precast concrete bridge applications.

Advanced Testing and Modeling of Dredged Sediments for Beneficial Use (CAIT-UTC-REG76, Project Manager: Dr. Tyler Oathes)

Outputs: This project will generate modeling approaches for the beneficial use of raw and stabilized sediments in engineering applications.

Outcomes: Guidance and methodologies will be developed for modeling sediments in engineering applications using approaches tailored to different beneficial uses.

Impacts: There are a wide range of potential beneficial uses that require varying levels of engineering performance and modeling breadth, which this project will support.

Identification Potential of Microplastics from Recycled Plastic Modified Asphalt Mixtures (CAIT-UTC-REG77, Project Manager: Dr. Thomas Bennert)

Outputs: This project will evaluate the potential release and detection of micro-plastics from hot mix asphalt modified with recycled plastic modifiers.

Outcomes: Training products, such as a webinar and/or training classes, will be developed and distributed to industry members investigating the use of plastic waste in roadway paving.

Impacts: This research will help the asphalt industry identify when potential release of microplastics from asphalt mixtures can occur. As asphalt mixes using plastic waste are investigated, it is important to ensure their safety and environmental sustainability.

Evaluation of the Effects of Superstructure Characteristics on the Performance of Bridge Decks under Traffic Loads (CAIT-UTC-REG78, Project Manager: Dr. Sharef Farrag)

Outputs: This project will assess stresses exhibited by the deck under traffic loads.

Outcomes: Researchers will conduct a parametric study evaluating the extent to which varying bridge superstructure and deck aspects contribute to the deterioration of the bridge deck.

Impacts: This research will reveal which type of bridges are more prone to mechanical/vibration damage as opposed to those that exhibit electrochemical deterioration.

Resilience and Mobility Accessibility in Underserved Communities (CAIT-UTC-REG79, Project Manager: Dr. Peter Jin)

Outputs: This project will identify the existing traffic, safety, and environmental problems caused by pass-through traffic and natural calamities in New Brunswick, NJ.

Outcomes: New partnerships with local agencies and communities will be formed to better understand their mobility, safety, and transportation needs.

Impacts: This research will boost the local transportation system's resilience and efficiency, ensuring its longevity and that it is serving the community in an equitable and effective way.

Full-scale “Living Pavement Testbed” for Testing and Evaluation of Sustainable Pavement (CAIT-UTC-REG80, Project Manager: Dr. Thomas Bennert)

Outputs: This project will study the impacts of both common and innovative construction techniques on pavement performance and durability in a living environment on the Rutgers University Busch Campus.

Outcomes: Industry will better understand the impacts of common and innovative construction methods such as milling, “Cold in Place Recycling,” and High Friction Surface Treatments.

Impacts: Currently no lab in the state is studying these cutting-edge pavement preservation methods. This research can develop best practices for innovative construction techniques that help to address climate and sustainability challenges. It also opens the door for advanced, hands-on training at the living lab of DOT staff and other pavement professionals.

A hydrologic modeling framework for assessing future riverine flood risk of critical transportation infrastructure (CAIT-UTC-REG81, Project Manager: Dr. Efthymios Nikolopoulos)

Outputs: This research will develop a high-resolution distributed hydrologic model for NJ.

Outcomes: The model will provide space-time information of streamflow during flood events and will be calibrated/validated against USGS streamflow stations.

Impacts: Researchers will use this model to identify “hot spots” in the region for future riverine flood risk, and will engage local stakeholders to disseminate this information.

Risk and Resiliency Analysis of Infrastructure by Improving RAMCAP Framework (CAIT-UTC-REG82, Project Manager: Dr. Seyed Hooman Ghasemi)

Outputs: This project will develop a comprehensive risk and resilience assessment framework for critical transportation and coastal infrastructure using the RAMCAP framework.

Outcomes: The framework will identify potential risks to the infrastructure and analyze its resilience against natural and artificial hazards.

Impacts: This research can provide valuable insights into critical transportation and coastal infrastructure risks and develop a comprehensive framework for assessing these factors.

Education and Workforce Development Activities

The consortium has trained more than 493 professionals during this period.

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

CAIT hosted its first three training programs as part of the UITP North American Regional Training Center. These courses covered Fundamentals of Public Transit, Electric Bus Planning, and Rail Operations and Maintenance. So far, the program has trained 130+ transportation professionals from NJ Transit, New York City Transit, WMATA, and STM-Montreal among other agencies.



- **Technology and Tools**

At CAIT's DataCity Smart Mobility Testing Ground (SMTG), researchers are working closely with Middlesex County to develop safety applications stemming from SMTG data. One prototype being developed is the *Collision Early Warning System* that will enable any driver on the corridor with a smart device to receive advanced CAV roadside safety warnings and other traffic information.

Technology Transfer

- **Presentation and Events**

CAIT researcher Dr. Hao Wang gave a presentation on sustainable and resilient roadways in September as part of the 2023 Kent Seminar Series on Transportation and Climate Change at the University of Illinois Urbana-Champaign.

- NJDOT Assistant Commissioner Parth Oza and colleagues visited CAIT for a tour of the Rutgers Asphalt Pavement Lab. Dr. Thomas Bennert demonstrated some of the equipment and tools that help CAIT researchers study how pavements in the region react to location, weather, traffic volume, and age. This critical work helps NJDOT maintain its infrastructure across the state.



- **Research and Publications**

As part of their UTC project on mitigating cracks in concrete members for durable bridge construction, partners at the University at Buffalo have developed two new concrete materials with 1.5% steel wool by volume. These materials show improved mechanical properties compared to base concretes without any steel wool. This is one of the first such applications of steel wool in concrete that could prove vital for improving the durability of reinforced-concrete and prestressed-concrete bridge elements in a cost-effective manner.

- **Supporting the Transportation Workforce and Youth Employment**

The American Public Works Association awarded its New Jersey Chapter with the Presidential Award for Chapter Excellence (PACE). The Chapter was commended on its long-term relationship with Rutgers CAIT in partnering on educational opportunities for their membership. This has included many workshops on pavement maintenance and repair, work zone safety, engineering ethics, and roadway safety topics.

- CAIT, as part of the NJ Work Zone Safety Partnership, is in development of an ad-hoc work zone safety accountability campaign. Its first deliverable will be a brochure with a safety checklist distributed among construction industry members to use for toolbox talks and safety meetings. This is designed to combat complacency that often occurs with repetitive tasks and encourage all to be accountable for safety in what can be a dangerous profession.
- This fall, a group of 2023 graduates from the Mastery High School in Camden NJ started paid apprenticeships at the United Brotherhood of Carpenters and Joiners of America — where they will study tuition-free for the next four years. CAIT’s Rutgers Youth Success Program aided these students in developing critical automotive and transportation skills over their senior year of high school, while also connecting them to career opportunities.

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:



USDOT FRA Press Release



DVRPC October 2023 Newsletter



Railway Age Magazine



NJ.com



NJDOT Technology Transfer Research Spotlight



Engineering News Record



Association of Metropolitan Planning Organizations



NJTPA Safety Links Article



New Jersey Business Magazine

Newsletter

On a regular basis, CAIT has distributed *The CAIT Update*, its monthly E-newsletter, and *The CAIT Seminar Series* to a regional transportation audience of 5,000+ subscribers.

Select stories highlighted in this reporting period include:

- CAIT researchers helping the Port Authority of NY & NJ investigate and implement low-carbon concrete mix designs for construction projects.
- CAIT hosting its inaugural class as part of the North American Regional Training Center in collaboration with NJ Transit and UITP.

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Center for Advanced Infrastructure and Transportation

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CAIT Research Helps Port Authority Adopt Industry-Leading Sustainable Concrete Standards

Home » News & Publications » News » CAIT Research Helps Port Authority Adopt Industry-Leading Sustainable Concrete Standards

New Low-Carbon Concrete Requirements Mark Significant Milestone in Agency's Clean Construction Program; Advance Agency's Commitment to Reducing Direct Emissions. All Future Agency Construction Contracts Must Incorporate Low Carbon Concrete Specifications.

In September 2020, the Port Authority of New York and New Jersey introduced one of the most ambitious low-carbon concrete programs of its kind among U.S. transportation agencies to dramatically reduce the embodied carbon of concrete mixes that are approved for contractors to use in agency projects.

Last month, the agency announced it has achieved a major milestone in that program by significantly strengthening its requirements to use sustainable concrete mixes in all its future construction projects as part of its clean construction program.

The entrance to the Lincoln Tunnel

CAIT Update

News from the USDOT Region 2 University Transportation Center led by Rutgers

CAIT, NJ TRANSIT and UITP Establish the North American Regional Training Center

NJ TRANSIT, the International Association of Public Transport (UITP) and Rutgers CAIT have partnered to create the North American Regional Training Center. The center will engage international experts to provide high-level courses on the fundamentals of public transport, bus planning, rail operations, railroad maintenance, fare management and more. The first course, Public Transport Fundamentals, is being offered in July.

[Read more](#)

Rutgers CAIT Researchers Featured for 'Engineering Advances' Across NJ

From testing methods to fix potholes on state roadways to building them with more environmentally friendly materials and lessening their traffic burden using CAV technology, CAIT researchers have been driving engineering solutions into practice here in NJ. A few experts at CAIT were recently featured by NJBIZ in an article on "Engineering Advances."

[Read more](#)

2023 NJ Work Zone Safety Conference Promotes Roadway Safety & Awareness

UITP North American Regional Training Center

Registration Opens for Inaugural Courses at the UITP North American Regional Training Center

Supported by a partnership with NJ TRANSIT and Rutgers CAIT, the training courses assemble public transportation professionals from across North America and internationally to share best practices, strategies, and tactics.

These courses will cover critical topics including electric buses; railroad track servicing, inspection and repair; fare management; and new trends in urban mobility for maintenance managers, fleet supervisors, operations coordinators, planning and finance staff, and other professionals in public transport.

Courses will be offered in July, September, October and November of this year at Rutgers CAIT in Piscataway, NJ.

Course Offerings

- Public Transport Fundamentals for North America – July 10-12, 2023
- Electric Buses: Fleet & Infrastructure Planning, Operations and Maintenance for North America – September 27-29
- Rail Operations and Maintenance for North America – October 2-4, 2023
- Ticketing and Fare Management for North America – November 6-8, 2023
Click to register.

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

- Chen, X., Wang, H., & Venkateela, G. (2023). Asphalt Pavement Pothole Repair Using the Pre-Heating Method: An Integrated Experiment and Modeling Study. Transportation Research Record, 0(0). <https://doi.org/10.1177/03611981231164066>
- Gustavo Pacheco-Crosetti, Héctor J. Cruzado, and Geoffrey J. Vega-Rosado, Lessons Learned from Hurricane Maria to Improve Transportation Infrastructure Resilience, College of Engineers and Land Surveyors of Puerto Rico Hurricane Seminar 2023, September 15, 2023.
- Zhu, Y., Ni, K., Li, X., Zaman, A., Liu, X., & Bai, Y. (2023). Artificial Intelligence Aided Crowd Analytics in Rail Transit Station. Transportation Research Record, 0(0). <https://doi.org/10.1177/03611981231175156>
- Ge, Y., Jin, P. J., Zhang, T. T., & Chen, A. (2023). Roadside LiDAR Sensor Configuration Assessment and Optimization Methods for Vehicle Detection and Tracking in Connected and Automated Vehicle Applications. Transportation Research Record, 0(0). <https://doi.org/10.1177/03611981231172949>
- Patel, Deep & Hosseini, Parisa & Jalayer, Mohammad. (2023). A framework for proactive safety evaluation of intersection using surrogate safety measures and non-compliance behavior. Accident Analysis & Prevention. 192. 107264. <http://dx.doi.org/10.1016/j.aap.2023.107264>
- Soares, L., & Wang, H. (2023). Design Study and Potential Implementation of Photovoltaic Noise Barriers for Sustainable Highways. Transportation Research Record, 0(0). <https://doi.org/10.1177/03611981231182977>

- Alfaris, R. E., Patel, D., Jalayer, M., & Meenar, M. (2023). Barriers Associated with the First/Last Mile Trip and Solutions to Bridge the Gap: A Scoping Literature Review. *Transportation Research Record*, 0(0). <https://doi.org/10.1177/03611981231170184>
- Zaman, A., Huang, Z., Li, W., Qin, H., Kang, D., & Liu, X. (2023). Artificial Intelligence-Aided Grade Crossing Safety Violation Detection Methodology and a Case Study in New Jersey. *Transportation Research Record*, 2677(10), 688-706. <https://doi.org/10.1177/03611981231163824>
- Zhang, R., Dai, J., Bai, Y., Barone, D., & Hill-Beaton, L. (2023). Risk-based transportation infrastructure management: An integrated framework and case study in USVI against coastal flood and sea level rise. *Ocean & Coastal Management*. Volume 242. 106723. ISSN 0964-5691. <https://doi.org/10.1016/j.ocecoaman.2023.106723>
- **Policy Papers**
Nothing to report
- **Website(s) or other Internet site(s)**
<https://www.facebook.com/RutgersCAIT/>
<https://www.linkedin.com/company/center-for-advanced-infrastructure-and-transportation-cait>
- **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 | 12 |
| 2) a presentation and/or webinar. | 10 | 14 |
| 3) a demonstration and/or pilot project. | 3 | 5 |
| 4) a guidebook or similar publication in addition to an academic report. | 8 | 13 |
| 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 | 3 |
| 9) Primary or secondary customers will be tracked. | 15 | 10 |
| 10) Implementation stakeholders will be tracked. | 15 | 10 |
| 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 | 6/1 |
| b. Researchers and/or developers | 1 / 5 | 2/2 |
| c. Early adopters and problem owners | 5 / 5 | 4/6 |
| d. Late adopters that follow the technology's development | 3 / 5 | 0/3 |
| e. Deployment team | 3 / 3 | 2/5 |
| f. Others, e.g., trade organizations, regulators, suppliers, etc. | 1 / 3 | 4/4 |
| 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 | 13 |
| 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 | 1 |
| b. Infrastructure: Invest in infrastructure to ensure mobility and accessibility and to stimulate economic growth, productivity, and competitiveness for American workers and businesses. | 5 | 8 |
| 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 | 6 |
| d. Accountability: Serve the nation with reduced regulatory burden and greater efficiency, effectiveness, and accountability. | 2 | 2 |

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 | 8 |
| 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 | 7 |

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 | \$7,528,526 |
| 2) durability and/or resilience and/or preservation | Zero in year one - 30 years each subsequent year | 54 years |
| 3) workforce proficiency or documented success stories | 4 success stories | 14 |

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.**
A decline in international students prolonged by the pandemic has at times caused delays in engaging students on research. Labor shortages have also caused project management delays for research stakeholders, at times pushing back project timelines. CAIT has mitigated these challenges by building diverse teams, maintaining close communication with stakeholders, and efficiently leveraging resources throughout the Region II Consortium.
- **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