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Impact Statement

Throughout its Region II UTC grant, Rutgers CAIT has made significant progress in developing programs and relationships with key stakeholders in the Northeast region to tackle pressing SGR, infrastructure durability, resilience, mobility, and labor challenges. Multi-year projects and programs have been established with NJDOT, NJ TRANSIT, NJ Turnpike Authority, New York Metropolitan Transportation Council and Port Authority of NY & NJ, among other agencies, to improve the durability and extend the life of existing transportation infrastructure.

Lingering economic impacts of the COVID-19 Pandemic have at times delayed some of these programs, mirroring roadblocks that the Northeast region continues to face. For example, real estate data from this quarter shows Northern NJ office vacancy hit a 14-year high, reaching a 24.5% vacancy rate at the end of 2022, as labor shortages and workforce transformations from COVID-19 persist. Nationwide, more than 50 million workers quit their jobs last year — in what is now known as "The Great Reshuffle." The Northeast has been no stranger to these turbulent trends, as labor demand grows in the region's critical supply chain and transportation sectors. While starting to recover, CAIT and Rutgers are not immune to the challenges that plague universities nationwide. Overall enrollment is down by 2.8% across Rutgers' campuses as prospective students enter the job market in place of the college classroom.

Many stakeholders are reporting similar stories. A 2023 APTA survey found that 96% of U.S. transportation agencies are feeling the effects of prolonged labor shortages, while simultaneously navigating a "brain drain" as the transit industry suffers above-average retirement rates. Surveyed agencies reported that 24% of their recent turnover was due to retirements. In NJ, each month more than 100 thousand employees change jobs, continuing trends accelerated by COVID-19. These setbacks don't exist in a vacuum. High turnover and staffing shortages have in turn delayed multiple anticipated projects to the CAIT Consortium from agency partners across the region.

Despite these economic uncertainties, signs of recovery are slowly starting to show. Last fall, Rutgers' first-year enrollment hit an all-time high. CAIT has still been able to develop and grow impactful, multi-year research programs with key state and regional stakeholders. These programs are built around the Center's core infrastructure durability focus while expanding efforts into the USDOT's latest strategic goals of Economic Strength, Equity, Transformation, Climate & Sustainability, and Safety. Select examples are highlighted below.

DataCity Smart Mobility Testing Ground: Kickstarted by NJEDA funding in 2018 and developed by subsequent UTC seed projects, DataCity has grown into a 3.1-mile multi-modal corridor "living lab" in downtown New Brunswick, NJ, in collaboration with Middlesex County, NJDOT, Verizon and other industry partners. The lab is collecting multi-modal smart-mobility data for improving transportation safety, congestion, and equity in the region, while establishing NJ as a hub for R&D in the growing CAV industry.

Most recently, researchers have been using data streams from the lab to develop a smartphone-based "Collision Early Warning System" that can enable drivers along the

corridor to receive real-time traffic and safety alerts — from pedestrians crossing the street in front of them to another vehicle getting too close. The team aims to have a working prototype of this useful safety application by the end of the year.

• <u>Rutgers Youth Success Program</u>: During the past year, CAIT's Rutgers Youth Success Program has engaged more than **90 justice-impacted youth** and other vulnerable young people from the **Camden**, **NJ** area in activities helping them get back to school, land jobs, seek apprenticeship and career opportunities in transportation, and overcome barriers to success. Supported by the **NJ Department of Labor**, this project attracted more than \$1.2 million dollars to the City of Camden in Year 1.

Parallel to this NJDOL program, CAIT has multiple UTC projects supporting youth from the region's historically underserved communities and the broader USDOT goal of improving equity in transportation. The Camden Career Pathways Initiative is cataloging highly localized career opportunities within transportation and the Camden area to establish sustainable entry points into the industry for youth in the city. In another project, UTC partners at Rowan are generating an evaluation technique to develop equity principles for future transportation planning projects.

- North American Regional Training Center: CAIT has been designated as the new UITP North American Regional Training Center. In partnership with The International Association of Public Transport (UITP) and NJ TRANSIT, The CAIT consortium is managing and facilitating high-level trainings on bus planning, rail operations, railroad maintenance, and more for professionals at transit agencies across North America. This partnership stems from growing collaboration with NJ TRANSIT, bringing two state entities closer together to continue serving NJ & NY, and growing labor demand across Region II and its transportation and supply chain sectors.
- **<u>Rutgers Asphalt Pavement Lab:</u>** CAIT's pavement lab has continued working closely with NJDOT to help manage the state's pavement network. Recently, the lab was engaged by the **NYC DOT** on a project monitoring the performance and environmental impact of two public roads in Staten Island paved with a mix using recycled waste plastics. CAIT is launching a supplemental UTC study to expand this effort and support research into the use of recycled plastics and other climate-friendly, sustainable roadway materials.

These highlighted programs demonstrate how CAIT has leveraged the UTC grant in recent years to strengthen ties with regional leaders and support projects that have meaningful and long-lasting impacts. CAIT has positioned itself to serve as a dynamic solution provider for local and state agencies through its variety of programs and depth of expertise. In the coming years, CAIT plans to continue growing these strategic partnerships and building programs that address pressing needs in the Northeast region while supporting the national vision of USDOT.

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

New Projects:

CAIT-UTC-REG72	Planning Project for Initiating A Large-scale 3D Printing Facility	RU/PU
	Abstract: The goal of this study is to identify a roadmap toward successful and sustainable large-	
	scale 3D printing facility to be used in construction of durable components of infrastructure.	
CAIT-UTC-REG73	Asphalt Viability in Recycled Asphalt Pavement (RAP) Using the Gyratory Compactor	RU
	Abstract: The goal of this project is to provide a quick and accurate means of evaluating recycled	
	asphalt pavement (RAP) that can be utilized back into new asphalt materials.	
CAIT-UTC-REG76	Advanced Testing and Modeling of Dredged Sediments for Beneficial Use	RU
	Abstract: The goal of this project is to develop modeling approaches and provide guidance for	
	the beneficial use of raw and stabilized sediments in various engineering applications.	
CAIT-UTC-REG77	Identification Potential of Microplastics from Recycled Plastic Modified Asphalt Mixtures	RU
	Abstract: Interest in the use of Hot Mix Asphalt modified with recycled plastic is growing. The	
	goal of this study is to evaluate the potential for release and detection of microplastics during	
	the service life and maintenance of these new asphalt mixtures with recycled-plastic modifiers.	

CAIT-UTC-REG78	Evaluation of the Effects of Superstructure Characteristics on the Performance of Bridge Decks	RU
	under Traffic Loads	
	Abstract: This study will investigate dynamic bridge behavior in response to operational-level	
	traffic and environmental loads, and analyze driving factors leading to bridge deck deterioration.	
CAIT-UTC-REG79	Resilience and Mobility Accessibility in Underserved Communities	RU/Rowan
	Abstract: Using CAIT's DataCity lab in NJ, this research will develop mobility solutions to alleviate	
	transportation barriers in underserved communities. It will develop guidance to engage local	
	communities in equitable planning and provide access to transformative mobility technology.	
CAIT-UTC-REG80	Full-scale "Living Pavement Testbed" for Testing and Evaluation of Sustainable Pavement	RU
	Abstract: This innovative testbed allows researchers to study the impacts of common	
	construction methods in a live environment. This project will investigate the impacts of milling	
	on pavement durability, Cold in Place Recycling, High Friction Surface Treatments and more.	
CAIT-UTC-REG81	A hydrologic modeling framework for assessing future riverine flood risk of critical	RU
	transportation infrastructure	
	Abstract: Assessment of inland flood risk due to climate change requires location-specific	
	analysis. This project is developing a hydrologic modeling framework to estimate riverine flood	
	risk under multiple scenarios. The framework will be fine-tuned for transit-critical NJ locations.	
CAIT-UTC-REG82	Risk and Resiliency Analysis of Infrastructure by Improving RAMCAP Framework	Rowan
	Abstract: RAMCAP provides a rigorous methodology for conducting resiliency analysis, using risk	
	assessment techniques to identify vital assets, potential hazards, and mitigation strategies. This	
	study will validate the RAMCAP framework through applying it to select infrastructure systems.	

Planning Project for Initiating A Large-scale 3D Printing Facility

3D printing is an emerging innovation with the potential to advance manufacturing processes and improve infrastructure resilience. A joint project between Rutgers and Princeton, this effort will develop the roadmap for building a large-scale 3D printing facility here in New Jersey. This facility will help the industry overcome 3D-printing adoption barriers, while creating a new generation of 3D-printed cementitious materials and construction elements supporting more durable and sustainable transportation infrastructure.



Resilience and Mobility Accessibility in Underserved Communities

Using the DataCity Smart Mobility Testing Ground in the City of New Brunswick, NJ, this research focuses on developing mobility solutions to alleviate access barriers in underserved communities. With mobility data collected at DataCity, advanced technological services can be made available to all road users in the community — providing transformative and equitable solutions to support local transportation needs. This research will also establish guidance on engaging underserved communities in equitable transportation and mobility planning.

Identification Potential of Microplastics from Recycled Plastic Modified Asphalt Mixtures

To help reduce the surplus of waste plastic in the US, it has been proposed that recycled waste plastic could be incorporated into Hot Mix Asphalt (HMA) applications as a potential modifier. Since 2021, multiple test roadway sections have been constructed incorporating this material, but little research has gone into the potential release of microplastics during the construction, service life and rehabilitation of these roads. This project will evaluate the potential for release and detection of microplastics from MHA with recycled plastic modifiers.

Ongoing Projects:

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CAIT-UTC-REG25	Investigation of Balanced Mixture Design for New York State Asphalt Mixtures	RU
CAIT-UTC-REG28	Cost-effective Bridge Decks for Improved Durability and Extended Service Life	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-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-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-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
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-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

Completed Projects:

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CAIT-UTC-REG1	Augmented Reality (AR) in Life-Cycle Management of Transportation	RU
	Infrastructure Projects	
CAIT-UTC-REG2A	Sustainability and Resiliency of Concrete Rapid Repairs Utilizing Advanced	NJIT
	Cementitious Materials – Freeze/Thaw Loads	
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-REG 5	Implementation and Development of UAS Practical Training for Inspection and Monitoring	ACCC
	Activities	
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,	RU/Columbia
	Automated, and Ridesharing Vehicles	
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)	PU
	for Visual Inspections (VI) and Structural Health Monitoring (SHM)	
CAIT-UTCREG14	Performance-Based Engineering of Transportation Infrastructure Considering Multiple Hazards	SUNY Buffalo
CAIT-UTC-REG15	Flood Vulnerability Assessment and Data Visualization for Lifeline	Rowan
	Transportation Network	

CAIT-UTC-REG16	Fire In Tunnel Collaborative Project	PU/SUNY-
CAIT-UTC-REG17	Improving Transportation Infrastructure Resilience against Hurricanes, other Natural Disasters,	PUPR
	and Weathering: Part I - Analysis of failure of transportation signs due to Hurricane Maria	
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,	PUPR
	and Weathering: Part III - Analysis of motor vehicle bridges failures due to Hurricane Maria	
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	RU
	with Autism and Other Disabilities at the 2019 Princeton University SmartDrivingCar Summit	
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	531 Evaluating the Safety and Mobility Impacts of American Dream Complex: Phase I (Feasibility Study, and Data Acquisition)	
CAIT-UTC-REG32	2 Rotorcraft Landing Sites – An Al-Based Identification System	
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	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-REG65	Development of a Geometric Extraction Tool as Part of a Pilot Digital Twin Framework for Open- Deck Rail Bridges	RU

HIGHLIGHTS Completed Projects

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

<u>Accomplishments</u>: A flood map for NJ towns that depicts flood hazards, lifeline infrastructure, vulnerability assessments, and resiliency measures was developed through this UTC work. <u>ROI</u>: This tool 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. It has the potential to assist decision makers and coastal communities in understanding the magnitude of floods, quantifying and visualizing impacts, and creating mitigation and resiliency plans.

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

<u>Accomplishments</u>: Built a comprehensive database of Recycled Concrete Aggregate (RCA) mechanical properties. Using this database researchers investigated RCA system applications, simulating different RCA replacement levels and more than 200 mechanical loading scenarios. <u>ROI</u>: This research provides agencies with guidance on how to best use RCA in construction projects. By 2027 the global RCA market is projected to pass 6.2 million tons as infrastructure ages and natural aggregate sources and landfill space become increasingly limited.

Durable and Electrified Pavement for Dynamic Wireless Charging of Electric Vehicles (CAIT-UTC-REG30, Project Manager: Dr. Hao Wang) <u>Accomplishments:</u> Developed a partially magnetized pavement design of electrified pavement that is durable and has efficient charging functionality. <u>ROI:</u> This innovative design provides a potential solution for wireless charging integrated into existing roadway pavements. Results show a 1.5-13.3%



improvement in charging efficiency over conventional pavements for wireless power transfer.

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)

<u>Accomplishments</u>: The American Dream Complex, located outside NYC, is a major retail center opened in 2019 expected to attract 40 million annual visitors. This project analyzed nearby congestion and mobility concerns, using traffic data to develop an intersection safety tool. <u>ROI</u>: The research team developed an innovative artificial intelligence (AI)-based video analytic tool to assess intersection safety and vehicle trajectories through busy nearby intersections, using surrogate safety measures. The prototype tool so far has shown between 95% and 98% accuracy in detecting and tracking vehicle trajectories.

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

<u>Accomplishments</u>: Developed a Flood Risk and Resilience Analysis Tool, a GIS-based web platform, that can be used to assess and visualize risk for infrastructure susceptible to flooding. The tool was built with the Univ. of the Virgin Islands and the USVI Dept. of Public Works. <u>ROI</u>: Officials can make data-driven asset management decisions that better account for climate risks. Built for the US Virgin Islands, the tool can also be customized to unique agency needs.

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

<u>Accomplishments</u>: CAIT worked with NJDOT to develop a Maritime Asset Management System that can meet transportation asset management plan requirements and aid with resource allocation. The TAM approach was implemented into a desktop-based software application. <u>ROI</u>: This project provided a state agency with a helpful tool for maritime asset decision making, such as scheduling dredging activities for maintaining ship navigational channels. The team is now renovating the MAMS prototype to improve user experience and extend its functionality.

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

<u>Accomplishments</u>: This project developed modules and algorithm models for the DataCity lab to build live digital twins of the New Brunswick, NJ test corridor. DataCity has grown strong support from regional and industry partners including Middlesex County, NJDOT, and Verizon. <u>ROI</u>: The developed digital twin is now conducting near-miss analyses at intersections in the DataCity test corridor to generate smart safety applications. For example, researchers are working on a smartphone-based "Collision Early Warning System" that can enable nearby drivers to receive real-time traffic and safety alerts utilizing mobility data collected at the lab.

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

<u>Accomplishments</u>: During hurricanes, transportation stakeholders need to restrict traffic to vulnerable areas in the network. This project developed a deep-reinforcement learning-based decision support system to aid in transportation management during a hurricane event.

<u>ROI</u>: Proof-of-concept case studies were conducted and demonstrated positive performance from the support tool when enhanced with travel advisories. The final version of this tool could be a critical resource for traffic control and emergency response professionals.

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

<u>Accomplishments</u>: Building on previous UTC research into intersection safety tools, this project developed a real-time proactive safety monitoring system based on the trajectory of road users (e.g., cars, pedestrians, and cyclists) collected by video cameras.

<u>ROI</u>: The monitoring system was installed at six NJ intersections collecting real-time data on near-miss collisions, traffic volume, vehicles running red lights, and more. It provides valuable data for policymakers to assess local road safety and implement effective countermeasures.

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

<u>Accomplishments</u>: Assisted FAA with updating its database of landing site information for helicopters. Developed an AI-based algorithm that automates the process of identifying landing sites using video data and Google Earth satellite images — increasing safety and efficiency. <u>ROI</u>: By automating this process, FAA will have a regularly updated and accurate database as the AI algorithm can rapidly scan extensive areas to locate and mark infrastructure. To date, the team has updated FAA's 5010 databases of helipads, heliports, and landing sites using the AI.

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

<u>Accomplishments</u>: Researchers analyzed the potential of an airport-wide Truck Flow Management System at JFK International Airport to coordinate cargo movements, finding significant economic and environmental benefits.



<u>ROI</u>: Identified significant environmental and economic improvements such as reduction of excess truck delay time by an average of 38%, reduction of CO2 emissions annually by 80 to 512 metric tons, and cost savings of approximately \$2.5-\$16M. annually in direct trucking costs.

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)

<u>Accomplishments</u>: This project investigated the performance of different filter types on public transit buses over time to help reduce airborne transmission of COVID-19 and other viruses on these critical public vehicles.

<u>ROI</u>: Findings confirm that MERV-13 filters have better filtration efficiency compared to others, but that filter performance varies depending on age, particle type, and particle properties. This project provides guidelines for transit agencies that are upgrading bus filters to improve safety.

Ongoing Projects

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

<u>Outputs</u>: A non-proprietary final report covering the work performed under this research study. <u>Outcomes</u>: Training and specifications around the new design method 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)

<u>Outputs</u>: This project is developing cost-effective standard open rib SOBD to promote increased implementation of SOBD for short and medium span highway bridges.

<u>Outcomes</u>: New design specifications and companion guidelines expected to be incorporated into the AASHTO Bridge Design Specifications.

<u>Impacts</u>: 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)

<u>Outputs</u>: The primary goal of this project is to evaluate a state-of-the-art technology in roadway surface profiling called Zero Speed Profiling.

<u>Outcomes</u>: 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.

<u>Impacts</u>: 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) <u>Outputs:</u> This project aims to increase safety and minimize the risks of building major underground infrastructure systems by enhancing existing methods for risk assessment. <u>Outcomes:</u> The goal of the project is to develop a framework calibrated for worldwide largescale tunneling projects capable of determining most likely hazards along a tunnel route. <u>Impacts:</u> 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)

<u>Outputs</u>: Deeper understanding of the relative performance of low-carbon concrete systems when exposed to chlorides and deicing salts.

<u>Outcomes</u>: Life-cycle models for various low-carbon concrete mixtures to be developed. <u>Impacts</u>: 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.

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

<u>Outputs:</u> This research will help the Port Authority of NY & NJ reduce the amount of embodied carbon in the concrete mixtures used during their construction activities.

<u>Outcomes</u>: Support the agency wide GHG reduction target of 80% by 2050. <u>Impacts</u>: This project will provide concrete mixtures that can significantly decrease embodied carbon in Port Authority concrete placements. Additionally, the research will improve other areas of sustainability by working to close materials loops in the region.

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

<u>Outputs</u>: A proof of concept for the Port Authority Engineering Dept. providing improved access to and visualization of vital infrastructure assets (wharves, retaining walls, bridges etc.). <u>Outcomes</u>: The prototype application will provide PANYNJ engineers with a collection of visualization and analysis tools that will enhance and support SGR planning. Impacts: These tools will leverage data that may reside in siloed repositories across the agency.

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)

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

<u>Outcomes</u>: Produce a resiliency report with recommendations of climate adaption for the Luis Muñoz Marín International Airport and the surrounding area.

<u>Impacts:</u> 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).

<u>Outputs</u>: Successful implementation and effectiveness of monitoring systems for tunnels requires good understanding of the structure and limitations of the monitoring technology. <u>Outcomes</u>: Extensive review of state-of-the-art technologies for tunnel SHM will be conducted. <u>Impacts</u>: 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)

<u>Outputs:</u> This project will help NJ TRANSIT create a complete roster of the 500-bus capacity Northern Bus Garage and determine critical facility metrics. <u>Outcomes:</u> Several modules for bus dispatching, including data archiving, processing and visualization, will be developed and integrated with the NJ TRANSIT bus scheduling system.



<u>Impacts</u>: 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)

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

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

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

<u>Outputs:</u> This project will enhance the resilience of coastal box girder bridges subject to storm and/or tsunami wave loading through an evaluation of their design geometry. <u>Outcomes:</u> Researchers intend to equip infrastructure designers with resilient strategies for new coastal bridge designs, as well as retrofit strategies of existing T-type and box type decks. <u>Impacts:</u> Advanced knowledge and tools helping coastal bridge owners enhance their assets.

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)

<u>Outputs:</u> A structured approach to help DOTs make Project Delivery Method decisions. <u>Outcomes:</u> Develop a data-driven decision-support system to help DOTs select the best project delivery method for each bundled contract by leveraging Machine Learning algorithms. <u>Impacts:</u> Assist DOTs in utilizing alternative, innovative contracting methods in developing project bundling programs to reduce costs and streamline construction activities.

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

<u>Outputs</u>: This project identifies career pathways in transportation for people from historically underserved NJ communities, helping them find careers in the growing transportation sector. <u>Outcomes</u>: By identifying highly localized transportation-related positions in and around Camden NJ, this project will develop data points that support future job placement efforts. <u>Impacts</u>: 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)

<u>Outputs:</u> An evaluation technique to assess and maintain equity principles in transportation planning and construction processes, and further incorporate them into decision-making. <u>Outcomes:</u> Indicators for transportation agencies to better consider equity in projects. <u>Impacts:</u> 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)

<u>Outputs</u>: 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.

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

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

<u>Outputs</u>: 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)

<u>Outputs</u>: 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.

<u>Outcomes</u>: Guidelines for implementing the newly developed concrete mix in field applications. <u>Impacts</u>: 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.

Education and Workforce Development Activities

The consortium has trained more than 1,390 professionals during this period.

• Classes, Seminars, and Educational Opportunities

CAIT launched the North American Regional Training Center with UITP and NJ TRANSIT — providing high-level courses on electric bus planning, rail operations, and maintenance for North American transit agencies.



 On International Women's Day, CAIT hosted women researchers from UTC partner schools for a seminar celebrating their accomplishments. They shared research on bridge monitoring, building fire-resilient communities, and improving water quality.

• Technology and Tools

An innovative electrified-pavement design was developed by CAIT UTC research that can enable efficient Electric-Vehicle charging. Testing shows the new design provided a 1.5% to 13.3% wireless-charging efficiency improvement compared to conventional pavements.

Technology Transfer

• Presentation and Events

CAIT researcher Dr. Hao Wang presented on sustainable transportation at the Mobility For All Conference, a forum addressing Safe, Sustainable and Equitable Transportation hosted by the Middlesex County Regional Chamber of Commerce and Keep Middlesex Moving.

• The CAIT Seminar Series hosted technology transfer webinars highlighting developments from the BEAST Lab, The DataCity Smart Mobility Testing Ground, and best practices in construction safety. These three webinars reached more than 230 attendees.

• Research and Publications

CAIT's Rutgers Pavement Lab was featured in ASCE's Civil Engineering Source for work investigating the use of plastic waste in asphalt. With NYC DOT, CAIT is monitoring the performance of two Staten Island roads paved using an asphalt mix with waste plastic.

• CAIT Students Win Awards

Rutgers CAIT doctoral student Xiao Chen was 1 of 8 students nationally to win an Airport Cooperative Research Program Graduate Research Award, which is run by FAA and TRB. His research analyzes the impact of sea-level-rise on airfield pavements in coastal areas.

- Geoffrey Vega, a Ph.D. candidate from the Polytechnic University of Puerto Rico, was named CAIT's Outstanding Student of the Year and recognized at the 2023 CUTC Awards Banquet. Geoffrey has been investigating infrastructure damage following Hurricane Maria.
- For his work on the NJDOT project "Innovative Pothole Repair Materials and Techniques," Rutgers CAIT student Xiao Chen won the Outstanding University Student in Transportation Research Award at the 24th Annual NJDOT Research Showcase.

How have the results been disseminated?

CAIT established the Consortium internet site: <u>https://cait.rutgers.edu/</u>. 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:



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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.



CAIT Update

February 2023

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





Highlights from Year 1 of CAIT's Rutgers Youth Success Program (RYSP)

During the past year, CAIT's Rutgers Youth Success Program has engaged over 120 justice-impacted and other vulnerable young people from the Camden, NJ area in activities heiping them get back to school, land jobs, seek apprenticeship and career opportunities in transportation and infrastructure, and overcome barriers to success.

Read more

RU Student Wins National Award for Airfield Pavement & Sea Level Rise Research

TRB's Airport Cooperative Research Program (ACRP) announced the winners of its annual Graduate Research Awards. The prestigious awards focus on applied research on airport issues to continue improving the reliability, safety, and security of the U.S. civil aviation system. Rutgers doctoral student Xiao Chen won an award for his work studying the impact of sea level rise on airfield pavement performance in coastal areas.

Read more

Meet CAIT's 2022 CUTC Outstanding Student of the

Year: Geoffrey Vega When Hurricane Maria struck Puerto Rico the effects were devastating. In the aftermath of the storm, UTC partners at the Polytechnic University of Puerto Rico

CAIT Seminar Series



International Women's Day

Celebrating International Women's Day and Women Leaders in Transportation

Transportation is undergoing a period of transformative investment that has the potential to modernize our infrastructure and make it more resilient, safer, and equitable.

Throughout history, how we think about and use transportation has been shaped by innovative women leaders. On International Women's Day, **Wednesday March 8th**, CAIT will take the time to highlight some of the women leaders at the Center.

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?

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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	Oneida and	Personnel resources, knowledge exchange
Superintendents Association	Chemung Counties	
New York Association of Town	Canaan, NY	Personnel resources, knowledge exchange
Superintendents of Highways		
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
- Lukai Guo & Hao Wang. (2023). Multi-physics modeling of piezoelectric energy harvesters from vibrations for improved cantilever designs. Energy. 263. 125870. 10.1016/j.energy.2022.125870.
- Hao Wang. (2023). "Towards Sustainable Transportation." Mobility For All Conference. Middlesex County Regional Chamber of Commerce & Keep Middlesex Moving. https://www.mcrcc.org/event/mobility-for-all-conference/.
- Tianya Terry Zhang, Peter J. Jin, Thomas M. Brennan Jr., Kelly McVeigh, Mohammad Jalayer, & Deep Patel. (2023). Arterial Vehicle Trajectory Reconstruction Based on Stopbar Video Sensor for Automated Traffic Signal Performance Measures. Journal of Transportation Engineering, Part A: Systems, Volume 149, Issue Number 4. American Society of Civil Engineers. https://doi.org/10.1061/JTEPBS.0000749.
- Xu Chen, Zihe Wang, & Xuan Di. (2023). Sentiment Analysis on Multimodal Transportation during the COVID-19 Using Social Media Data. Information, 14, no. 2. 113. https://doi.org/10.3390/info14020113.
- Huixiong Qin, Asim Zaman, & Xiang Liu. (2023). Artificial intelligence-aided intelligent obstacle and trespasser detection based on locomotive-mounted forward-facing camera data. Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit. 095440972311563. 10.1177/09544097231156312.
- Nan Hua, Negar Elhami Khorasani, & Anthony Tessari. (2023). Utilizing Advanced Modelling for Fire Damage Assessment of Reinforced Concrete Tunnel Linings. Structural Engineering International.

10.1080/10168664.2022.2161440.

- Amirali Najafi, Gaston A. Fermandois, Shirley J. Dyke, & Billie F. Spencer. (2022). Hybrid simulation with multiple actuators: A state-of-the-art review. Engineering Structures, Volume 276. https://doi.org/10.1016/j.engstruct.2022.115284.
- Abigail Lazofsky, Cathleen Doherty, Patrick Szary, & Brian Buckley. (2022). A surface sampling and liquid chromatography mass spectrometry method for the analysis of quaternary ammonium compounds collected from public transportation buses in New Jersey. Emerging Contaminants, 8, 318-328. https://doi.org/10.1016/j.emcon.2022.06.005.
- James Hughes & David Listokin. (2022). Population Trends in New Jersey. Rutgers University Press. 10.36019/9780813588339.
- Policy Papers
 - Nothing to report
- Website(s) or other Internet site(s)
 <u>https://www.facebook.com/RutgersCAIT/</u>
 <u>https://www.linkedin.com/company/center-for-advanced-infrastructure-and-transportation-cait</u>
- New methodologies, technologies or techniques Incorporated into earlier sections of this report
- Inventions, patents, and/or licenses Nothing to report
- Other products

Outputs	Annual Goal	Semi-Annual Metric
1) a traditional or online training program.	3	7
2) a presentation and/or webinar.	10	8
3) a demonstration and/or pilot project.	3	4
4) a guidebook or similar publication in addition to an academic report.	8	5
5) a new specification.	1	1
6) new software or an app.	3	4
7) a new material and/or tangible product.	1	2
8) a potential patent or otherwise marketable product.	2	1
9) Primary or secondary customers will be tracked.	15	6
10) Implementation stakeholders will be tracked.	15	6
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	3/1
b. Researchers and/or developers	1 / 5	2/2
c. Early adopters and problem owners	5/5	2/5
d. Late adopters that follow the technology's development	3 / 5	0/0
e. Deployment team	3/3	0/5
f. Others, e.g., trade organizations, regulators, suppliers, etc.	1/3	2/4
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	8
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	0
b. Infrastructure: Invest in infrastructure to ensure mobility and accessibility and to stimulate economic growth, productivity, and competitiveness for American workers and businesses.	5	4
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	3
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	Semi-Annual Metric
1)	MOU/letters of commitment indicating a customer's commitment to adopt or that they have adopted/used	5	4
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	2

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	Semi-Annual Metric
1)	cost savings (time, money, or life-cycle performance)	\$280k year one - \$2.575M each subsequent year	\$3,764,263
2)	durability and/or resilience and/or preservation	Zero in year one - 30 years each subsequent year	34 years
3)	workforce proficiency or documented success stories	4 success stories	6

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.

Labor shortages prolonged by the pandemic have at times caused delays in engaging students and changes in external stakeholder leadership. 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