

SEMI-ANNUAL PROGRESS REPORT

Submitted to the U.S. DOT Office of the Assistant Secretary for Research and Technology

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Project Title	Connected Communities for Smart Mobility towards Accessible and Resilient Transportation for Equitably Reducing Congestion (C2SMARTER) Tier I University Transportation Center
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Signature: *Kaan Ozbay*

1. Accomplishments

Goals and Objectives

Reducing Congestion is the main research area of the Connected Communities for Smart Mobility towards Accessible and Resilient Transportation for Equitably Reducing Congestion (C2SMARTER) Center.

C2SMARTER's goal is to solve two key problems related to urban congestion: (1) untangling the broad system-of-systems interdependencies facing congested urban systems that not only include multiple modes, but many interrelated sectors, and (2) understanding the system-wide impacts of congestion. We propose to develop new technologies, operational policies, and strategies towards ensuring system-level congestion reduction for all users. C2SMARTER focuses on all three topic areas under reducing congestion, framing our three research thrusts as: on demand management technologies, system-operational control, and data-driven analyses. Throughout our planned activities, we seek to follow the principles of the US DOT strategic goal of transformation – heavily relying on experimentation, with the goal of using evidence-based decision making to turn research into transformative and equitable solutions that take advantage of emerging technologies such as artificial intelligence (AI)/machine learning (ML) and connected and automated vehicles (CAVS).

Accomplishments of Goals and Objectives

The Center selected nineteen projects for Year 2 US DOT funding, kicking off in October 2024. Described below, these projects are underway in parallel with ongoing Year 1 projects during this reporting period.

Research

The following projects were completed during this period, with reporting closeout underway:

- **Enhancing Transit Access and Safety Through Equitable Micromobility Solution.** The team made design recommendations for bus stops that will function as micromobility hubs in two communities in El Paso, TX. The team proposed a micromobility system concept of operations, under which the city owns e-scooters and e-bicycles and loans them to low-income users. Ambassadors from the City download usage data, perform vehicle maintenance, and award incentives.
- **Equitable Flood Impact Analysis Integrating GeoAI and Digital Twin Modeling.** The team completed macroscopic and microscopic analyses of traffic patterns during floods, demonstrating impacts of flood-induced lane closures and revealing correlations between flood severity, traffic demand, and travel time.
- **Multimodal Multiscale Urban Traffic Control in Connected and Automated Cities.** The team completed field tests of the developed multiscale signal-vehicle coupled control algorithm at Mcity's 2.0 NSF-funded testbed in Ann Arbor, MI across CAV penetration rates. Findings show that the algorithm offers significant advantages over traditional fixed-time and actuated signal timing control methods.

The following projects are ongoing during this reported period, with updates as follows:

- **An AI-Reinforced Traffic Digital Twin for Testing Emergency Vehicle Intervention (Year 1) and What is the New Baseline: Helping FDNY Understand Emergency Response Needs (Year 2).** The team developed an interpretable, explainable boosting machine model for predicting FDNY emergency vehicle average speed. They investigated optimal dispatch locations and worked with FDNY to determine which interventions to focus on and identify citywide data sources that could help expand the AI model.
- **Development of a Vision-Based Landside Traffic Management System at Airports.** The team refined performance metrics for two use cases: automatic queue length detection and frontage curb lane management. The team tested video samples for JFK airport Terminal 4 with two computer vision models, improving detection accuracy for large vehicles, e.g., shuttle buses.

- **Development of Guidelines for Implementing the Flipped Left Diamond Interchange (FLDI) Design.** The team analyzed their driver occupancy survey results to determine acceptance of the new design. The team also developed and refined implementation guidelines.
- **Multi-Horizon Urban EV Charging Infrastructure Planning.** The team tested an optimal power flow model under various scenarios and integrated the two main components: the location model and the OPF/activity model. The team is currently addressing the computational burden of very large regions.
- **A Cost-Efficient Digital Twin Approach Using Pan-Tilt-Zoom (PTZ) Cameras to Enhance Urban Mobility Situational Awareness.** The team designed a cooperative PTZ camera control approach to manage multiple cameras with a Multi-Agent Proximal Policy Optimization (MAPPO) algorithm and tested the model in a simulation network with 37 cameras. They evaluated the capability and found PTZ cameras can capture nearly 70% of vehicles, compared to only about 45% when using random tilting.
- **A Data-Driven Approach to Transportation Equity.** The team performed indoor pilot data acquisitions to test sensors and completed the first version of an open-source data pipeline to automatically extract information from video footage. The team established computational steps to process the data and began selecting optimal intersection locations to deploy the sensors.
- **Amplifying Congestion Reduction by Integrating Macro and Local Traffic Control.** The team began a literature review of macroscopic fundamental diagram (MFD)-based perimeter control and local traffic signal control and began work on the optimal conversion of the perimeter control method into signal timing. The team is conducting testing and validation, fine-tuning the MFD regions for Seattle.
- **Impact of WIM-based Direct Enforcement on the Service Life of Bridges (Year 1) and Assessment of Infrastructure Damage Cost and Compliance of Truck Weight Limit (Year 2).** This effort implemented weigh-in-motion (WIM)-based direct enforcement of overweight trucks on the Brooklyn-Queens Expressway. The team observed that while truck traffic volume remains the same, the number of overweight trucks has reduced from 6-7,000 to 2-3,000 between January 2023 and May 2024. Additional decreases were observed for trucks over 88 KIP (weight in kilo pounds).
- **Digital Twins of Work Zones: Integrating Multi-Simulators to Quantify the Impact of Work Zones and Their Features on Traffic Congestion.** The team created three types of animated roadway worker behaviors using full-body motion capture data. These animated workers were placed in work zone scenarios in CARLA simulation. The team developed a VR-based driving simulator that allows the capture of gaze behavior; participants showed heightened physiological engagement during the tests.
- **Enhancing Urban Micromobility Safety and Adoption through Biometrics and Mobile Sensing Technologies.** The team established an experimental framework for safety assessment including pilot-testing a survey, administering pre- and post-survey instruments, and setting up smartwatch and smartphone sensors and eye-tracking devices. The team enhanced the design of the e-scooter experiment framework and developed a processing pipeline for biometrics data.
- **Equity Issues in Electronic Vehicle (EV) Adoption.** The team conducted a literature review, began collecting data, and conducted preliminary analyses regarding socio-economic disparities, infrastructure accessibility, policy analysis, and solutions to foster inclusive EV adoption.
- **Estimating Daytime Population for Data-Driven Urban Planning.** The team conducted a literature review of how agencies use traffic cameras (CCTVs) and screened over 900 CCTVs in NYC based on cameras' ability to capture pedestrian, bicycle, and parking activity. The team developed a camera tilting detection module to ensure the reliability of extracted data, which is being collected every 30 seconds.
- **Improving Congestion Impact Estimation.** The team made progress on the design of simulation agents, approaching near the state-of-the-art in collision avoidance. A human motion model, known as the versatile behavior diffusion model, was integrated into the simulator. The team is now working to combine training games with an invitation model to make human-like but capable agents.

- **Integrating Personalized Incentives and Virtual Reality Tools for Enhanced Transportation System Management.** The team completed a literature review of integrating personalized incentives with multimodal trip planners to support participatory decision-making and began reviewing available VR platforms and toolkits to assess their potential for simulating travel decisions. The team prepared to launch a stated preference survey on incentives and mode choice for 1,000 participants.
- **Physics-Informed Learning and Control of Connected and Autonomous Vehicles for Congestion Reduction.** The team completed the design of a joint motion planning and control algorithm for CAVs. The Recurrent Predictive Control method was developed and validated and compared in simulations, improving efficiency and performance while reducing steady-state tracking errors.
- **Real-Time Simulation Framework for Coupled Traffic and Power Grid Management During Disaster Scenarios.** The team explored using ML-based methods for link-level and network level reduction in model computation time. The team also developed an initial framework for power system adaptation under natural disasters through Markov Decision Processes (MDP) and reinforcement learning.
- **Understanding Travel Pattern Changes of Transit-Reliant Population.** The team completed a literature review of accessibility measures, heatwaves, and transit users. The team began defining representative trajectories, developing accessibility measures, and quantifying transit accessibility.

Education and Technology Transfer Initiatives

- **A Traffic Educational Hub: Learning by Deploying AI Models with Real Traffic Data.** The team distributed a survey to more than 50 students to gather their needs for an interactive tool when learning ML and other AI techniques for transportation-related purposes. The team developed data fusion algorithms to standardize, clean, and format the diverse datasets for AI model training and validation and created a data repository within the hub, and began testing a few selected models.
- **Workforce Development Pathways via Undergraduate Research.** Students conducted research with eight faculty members in an array of academic disciplines and nine different projects within the discipline of transportation. The Fall 2024 cohort (16 students) presented during the Undergraduate Poster Session and Competition, and 19 students (Spring 2025) are currently engaged.
- **A Knowledge Capture and Deployment Tracking Platform for UTC Research.** The team focused on defining and refining the evaluation metrics and categories of information to be indexed and extracted from transportation research publications, combining automated metrics with human validation. The team continued to develop and refine the interactive chatbot application.
- **The Future of the Bus.** The team completed preliminary research in the form of a landscape scan of existing bus technologies and submitted the findings to project partner Port Authority of New York and New Jersey. The team also prepared for a series of five stakeholder workshops, the first of which is on the topic of “Future-Ready Bus Terminals and Vehicle Design.”

Training and Professional Development

The C2SMARTER Student Learning Hub (SLH) offers free courses taught by doctoral students in consortium schools. The following virtual classes were offered to students during this reporting period:

- Comprehensive Urban Data Collection Using Drones: From Licensing to Advanced Sensor Application. Instructors: Tu Lan and Vivaldi Rinaldi, NYU.
- Where Are All the Robots, and Why Aren't There More of Them? Instructor: Irving Fang, NYU.
- Online Optimization Meets Urban Transportation. Instructor: Tao Li, NYU.
- Causal Inference: Difference in Differences Regression and Its Application in Transportation Research. Instructors: Yanchao Li, NYU.
- Understanding Travel Demand through Passively-generated Mobile Data: A Python-based Mobility Analysis Workshop. Instructor: Ekin Ugurel, UW.
- An Introduction to Multi-agent Driving Simulation with GPUDrive. Instructor: Daphne Cornelisse, NYU.

In addition to the SLH, the following training and professional development events took place:

- Events hosted by the **Institute of Transportation Engineers (ITE) / Intelligent Transportation Society (ITS) Student NYU Chapter** to expose students to transportation infrastructure and facilities: Transit Museum Tour, Penn Station Tour, Long Island: The Game, Networking with YPT-NYC, Civil Engineering Career Fair, Civil Engineering Clubs Welcome.
- **Field Test Demo at Mcity, U of Michigan.** Demonstration of UW's CAV research at Mcity for NSF, USDOT, ITS-America, and industry and public partners.
- **Equitable Transportation Systems Design Data Competition.** Prof. Pandey organized a three-month competition at NCA&T; 61 students developed data-driven solutions for rural communities.
- **Stem Day 2024.** C2SMARTER celebrated STEM Day with Bard High School Early College Bronx and the ITE Met Section for the second year in a row. The students listened to a roundtable of transportation engineers and then learned about computer vision and virtual reality tools in the C2SMARTER lab.
- **NC Section Institute of Transportation Engineers (NCSITE) Annual Meeting.** Three NCA&T students competed in the state-level Traffic Bowl and attended various NCSITE meetings and events.
- **Tri-State Engineering Expo,** White Plains High School. NYU's Dr. Gao presented project videos and introduced transportation engineering to pre-K, middle, and high school students.
- Prof. Pandey designed and facilitated **Writing and Communicating Technical Work: Workshop for Graduate Students** to improve graduate students' skills in technical writing, research communication, and structuring academic work.
- Dr. Gao served as a judge in the **Make It in Brooklyn Future of Transportation** pitch contest.
- In December, NYC College of Technology (City Tech) hosted an **Undergraduate Research Poster Session** for students to present their work.

Dissemination and Outreach

On October 17-18, C2SMARTER hosted **NYC V2X & AI Symposium** in conjunction with FHWA, New York State and New York City Departments of Transportation with over 150 attendees. Speakers came from government, industry, and academia, experienced in vehicle-to-everything (V2X) implementations and artificial intelligence (AI) in transportation. Featured session topics included:

- Lessons Learned from Previous Connected Vehicle Deployments
- AI Implementation in Transportation Systems
- V2X & AI Emerging Technologies, Funding, Standards, and Cybersecurity
- Round Table: Open Discussion with Industry Experts
- Latest Advancements in Smart Cities
- Research in V2X & AI Technologies and Applications

In January, the **Transportation Research Board (TRB) 2025 Annual Meeting** was held in Washington, DC. C2SMARTER's work was highlighted in multiple sessions with over 25 accepted [papers](#), including:

- **Digital Twins as a Highly Responsive Decision Support Tool for Management and Planning of Transportation Systems Operating Under Stochastic Demand and Supply Conditions.** Prof. Ozbay hosted this half-day workshop entitled which was highly attended.
- **Route Choice and Spatio-Temporal Behavior, Joint Subcommittee Meeting.** Prof. Chow, co-chair of the subcommittee on route choice and spatiotemporal behavior, hosted.
- **Inland Waterway Transportation Research Poster Session.** Prof. Azimi served as presiding officer.

In addition, C2SMARTER hosted the following seminars/webinars and presentations:

Event/Presentation Name	Details / Description
NCA&T Civil, Arch., and Environmental Engineering Seminar Series, Fall 2024	Profs. Pandey and Chowdhury presented research on best practices in emerging technologies for transportation systems.
Community Leadership Through Transportation, Oct 2024	Steve Granson, Associate Vice President-Project Development Leader at HNTB was invited as the guest speaker for this event.
Spatio-temporal Adaptive AI for Urban Mobility Modeling, Oct 2024	Zhaonan Wang, Asst. Prof., NYU Shanghai, spoke at the C2SMART Lab at NYU.
Safety Assessment for Autonomous Vehicles, Nov 2024	Dr. Henry Liu, Prof., University of Michigan, Director, Mcity, spoke at the C2SMART Lab at NYU.
Tension Stiffening Related to Cracking and Deflection of Reinforced Concrete, Nov 2024	Peter Bischoff, Honorary Research Professor, Univ. of New Brunswick, presented as part of Rutgers Bridge Resource Program.
Bridging the Gap: Enhancing Infrastructure Safety with Robust Vibration-based Monitoring, Nov 2024	Giacomo Imposa, PhD, Business Development, Kistler Group, presented as part of Rutgers RIME Bridge Resource Program.
I-24 MOTION: An Instrument for Freeway Traffic Monitoring and Control, Nov. 2024	Prof. Dan Work of Vanderbilt presented at the C2SMART Lab at NYU.
Alternative Fuel Vehicle Evacuation and Refueling Infrastructure Location Planning, Nov 2024	Ria Kontou, Asst. Prof., University of Illinois Urbana-Champaign, spoke at the C2SMART Lab at NYU.
ITS, Promoting and Enhancing Public Safety and Community Welfare through Advanced Transportation Technology, Nov 2024	TSU hosted Roma G. Stevens, P.E., PTOE, RSP1, President and Founder, Stevens Technical Services Inc., for a presentation.
Positive Feedback in Transportation Systems, Dec 2024	Prof. Lewis Lehe, University of Illinois Urbana-Champaign, spoke at the C2SMART Lab at NYU.
The MobilityCoin System, Jan 2025	Prof. Klaus Bogenberger, TU Munich, spoke at the C2SMART Lab at NYU and took part in a research exchange afterwards.
A Conversation on Innovation & Planning in The Transportation Field: A Guide to TxDOT Approach, Feb 2025	TSU hosted Catherine McCreight, Director, District Transportation planning of TxDOT.
Gittins Indices for Cost-Aware and Freeze-Thaw Bayesian Optimization, Feb 2025	Qian Xie, PhD Candidate, Cornell, spoke at the C2SMART Lab at NYU.
The Business of Transportation Engineering & Planning, Feb 2025	TSU hosted Darrin Willer, Executive Vice President, DDCM, for a presentation.
Innovation in Transportation, Feb 2025	TSU hosted Kimberly Williams, J.D, Chief Innovation Officer, Metropolitan Transit Authority of Harris County, for a talk.

C2SMARTER members also participated in the following other conferences, symposia, and workshops:

Event Name	Details / Description
The Story of the BQE Screening and Panel, Oct 2024	NYU Prof. Norman hosted a sold-out screening and panel at NYU as part of his Charting Equitable Outcomes project.
Vision Zero Cities Conference, Oct 2024	NYU Prof. Kaufman hosted a fireside chat with Salt Lake City mayor Erin Mendenhall.
The Future of Urban Accessibility: The Role of AI, Oct 2024	UW Prof. Ban presented the Multimodal Multiscale model and its application at the 26th International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS 2024).
KAIST CEE x NYC CUE Research Seminar, Oct 2024	Professors from KAIST's CEE & and NYU's CUE Department participated in a joint session on research collaboration.
Urban Tech Summit, Nov 2024	Prof. Ozbay served as a panelist at this summit that explored how AI can help create more resilient urban environments.

ACI Fall Convention, Nov 2024	Rutgers's Prof. Nassif and Chaekuk Na presented at the semi-annual conference and committee meetings in Philadelphia, PA, focusing on bridge design and structural health monitoring.
The Story of the BQE Community Listening Event, Dec 2024	Prof. Norman hosted a community listening event with oral history facilitators at El Puente in Brooklyn.
Ikos x C2SMARTER: The Future of Railways, Dec 2024	C2SMARTER organized this event in which industry experts explored the innovations and challenges shaping the future of the railway sector.
6 th Infraday East, Dec 2024	Prof. Ozbay served on the Revolutionizing Public Infrastructure: The Impact of AI and Machine Learning panel.
NYU Abu Dhabi Transportation Symposium, Jan 2025	NYU Profs. Ozbay and Chow co-convended the symposium and Profs. Vinitsky and Yabe presented at the symposium.
NCDOT Research and Innovation Summit, Feb 2025	Prof. Pandey's research group participated at this summit; several students presented on various topics.
NYU Schack Institute's Annual Conference on Sustainable Real Estate, Mar 2025	Prof. Ozbay served on The Future of Urban Mobility panel at this annual event. Prof. Wani served on the Rethinking Water: Innovations in Management, Recycling, and Resilience for NY Real Estate panel.
Pioneering Transportation Innovation with Generative AI, Mar 2025	Prof. Ozbay served on a panel at this FHWA cohosted workshop held at the University of Maryland.
ACI Spring Convention, Mar 2025	Prof. Nassif and Chaekuk Na presented at the semi-annual conference and committee meetings in Toronto, ON, focusing on bridge design and structural health monitoring.

Industry and Public Agency Outreach

The following industry and public agency outreach took place during the reporting period:

Industry / Agency	Details / Description
Seattle DOT	Discussion about data needs and signal timing with UW.
CLR Analytics	Discussion about project directions, data support, and possible collaborations with UW.
LJA Engineering	Discussed research results and the FLDI paper developed based on this project with Ali Mozdbar, Senior Project Manager.
Port Authority of NY&NJ	Discussed the Daytime Population research to PANY&NJ for awareness that video analytics can be applied citywide.
New York City DOT	Discussed the Daytime Population research to NYCDOT, as there is a mutual interest in studying freight movements using computer vision.
Port Authority of NY&NJ	Presented and submitted preliminary Future of the Bus research.
Helm.ai	Presented at internal Helm seminar on Congestion Impact project results
Metropia	Partnered to explore the application of personalized incentives. Ongoing discussions focused on data collection and incentive design.
North Carolina DOT	Engaged with staff from the Research and Planning Divisions to share updates on incentive modeling efforts, particularly re: disaster scenarios.
Oak Ridge National Laboratory / U.S. Department of Energy	Profs. Pandey and Jha engaged with ORNL researchers to learn about the RealSim digital twin and advancements in flood modeling.
Federal Highway Administration	Prof. Pandey presented ongoing research to FHWA stakeholders at the Inaugural Dialogue on Transport Research held at NCA&T.
NYC Dept. of City Planning	Discussed the Landside Traffic research to NYC DCP, as there is a mutual interest in studying curbside activities using computer vision.
NSF, USDOT, ITS-America, and other public and private sector partners	Demo at Mcity 2.0 about the joint optimization of CAVs and traffic signals; interact and exchange with participants.
Mitsubishi Electric Research Laboratories (MERL)	The Physics Informed Learning team initiated a research collaboration with Dr. Yebin Wang.
Search and Rescue Common Operating Platform (SARCOP)	The team discussed ways the proposed tool could help SARCOP team members with search and rescue.

Media Coverage and Public Understanding

Entity	Date	Details / Description / Links
U Michigan News	10/08/24	Write up of UW's field-testing case using Mcity remote access (Mcity 2.0).
U Michigan YouTube	10/08/24	YouTube video of remote testing of joint control of AVs and traffic signals demo for UW's collaboration with Mcity.
Tandon News	10/09/24	NYU described Prof. Chow's EV charging research.
Chinese Biz News, Chinese News Weekly	10/18/24	Prof. Jiang's attendance at a Nanjing Institute of Technology conference was featured in two articles published in China.
The Uptowner	10/24/24	NYU's Dr. Zuo was featured in an article discussing how AI and emerging tech can make intersections safer.
Tandon News	10/30/24	NYU posted a recap of the NYC V2X & AI Symposium cohosted by C2SMARTER.
Tandon News	10/31/24	NYU detailed Prof. Ozbay's participation at US DOT's inaugural Future of Transportation Summit.
Tandon News	11/11/24	NYU detailed Prof. Vignon's study of the impact of NYC ride hailing fees.
NY1	12/03/24	Prof. Kaufman was interviewed about congestion pricing and a new bus lane in Manhattan.
Popular Science	12/09/24	NYU's Year 1 FDNY project was included in Popular Science's 50 Greatest Innovations of 2024.
U Michigan News	12/18/24	Write up on UW's selection for testing of network control of CAVs and traffic lights.
NBC's Sunday Today	01/05/25	Prof. Kaufman discussed the implementation of congestion pricing.
Fox 5 NY	01/06/25	Prof. Kaufman discussed the early impacts of congestion pricing.
US DOT LinkedIn	01/15/25	USDOT Research and Technology disseminated NYU's Popular Science award.
City & State NY	01/17/25	Prof. Kaufman wrote an opinion piece on how NYC can prepare for AVs.
Tandon News	01/23/25	NYU publicized Prof. Ozbay and Dr. Bian's NVIDIA award.
Zag Daily	01/29/25	Prof. Kaufman and her team's plans to build a best practice micromobility framework for US cities was publicized.
PoliticsNY	01/30/25	Profs. Ozbay and Kaufman were both named in PoliticsNY & amNewYork's 2025 Power Players in Transportation.
Washington Square News	02/04/25	NYU's university-wide publication noted Prof. Ozbay and Dr. Bian's NVIDIA award.
NYU News	02/11/25	Prof. Kaufman discussed NYC congestion pricing, one month after its kick off.
New York Times	02/26/25	Prof. Kaufman discussed congestion pricing amid today's political landscape.
Interconnects	03/12/25	Prof. Vinitzky was interviewed about his research on self-play for self-driving and the future of reinforcement learning.

Plans for the Next Reporting Period

- The Center is preparing to release its Year 3 request for proposals following receipt of USDOT funding.
- Beginning in April 2025, C2SMARTER will host a **Congestion Pricing Speaker Series** to discuss analysis and perspectives regarding the implementation of congestion pricing in New York City. The events will be a combination of in-person panels and virtual webinars:
 - 4/17/25: in-person panel with Charles Komanoff, Rachel Weinberger, and Brian Fritsch
 - 5/5/25: webinar with Alex Anas, SUNY Buffalo
 - 5/21/25: webinar with NYU researchers on the Center's [congestion pricing dashboard](#)
 - 6/4/25: webinar with Erik Verhoef, VU Amsterdam
 - 6/13/25: webinar with Robin Lindsey, University of British Columbia
- The **Future of the Bus** project will hold the following stakeholder workshops:
 - 4/8/25: Workshop 1: Future-Ready Bus Terminals and Vehicle Design
 - 4/24/25: Workshop 2: Workforce Impacts and Opportunities

- 5/6/25: Workshop 3: Equity, Community Engagement, and Behavior Change
- September (Date TBD): Workshop 4: Safety, Security, and Regulation in the AV Era
- Students will present their findings during City Tech’s Spring 2025 undergraduate research poster session.
- NYU student researchers will take part in the annual **Tandon Research Excellence Exhibit** on April 25.
- The Center will participate in **NYU’s Global Urban Summit** on April 25. This year’s theme is “Urban Underground,” and Prof. Masoud Ghandehari will present his research on air quality in the subway system, along with representatives from Columbia University, the MTA, and Transport for London.
- In June, C2SMARTER researchers will present at **ITS-NY’s 32nd Annual Meeting** in Saratoga Springs, NY.
- In October, NYU’s Dr. Frank DarConte will present on bridge deck and highway design at the **New York State Highway Safety Symposium** in Oswego, NY.

2. Participants and Collaborating Organizations

Organization Name	Location	Contribution
AirSage	Atlanta, GA	financial support, in-kind support, collaborative research
AIWaysion	Seattle, WA	personnel exchanges, collaborative research
BAYTRAN	Houston, TX	collaborative research
City of Arlington	Arlington, TX	collaborative research
City of Bellevue	Bellevue, WA	in-kind support
City of El Paso	El Paso, TX	collaborative research
City of Madison	Madison, WI	collaborative research, personnel exchange
City of Seattle	Seattle, WA	collaborative research
City of Westport	South Beach, WA	collaborative research
ClearMotion	Billerica, MA	collaborative research
D.C. DOT	Washington, DC	collaborative research
El Paso MPO	El Paso, TX	collaborative research
GLIDE Scooter	El Paso, TX	collaborative research
Institute for Public Architecture	New York, NY	in-kind support, personnel exchange
King County Metro	Seattle, WA	collaborative research
Kistler Instrument Corp.	Buffalo, NY	in-kind support
LJA Engineering	Austin, TX	collaborative research
MCity	Ann Arbor, MI	collaborative research, personnel exchange
Mitsubishi Electric Research Lab	Cambridge, MA	in-kind support, collaborative research
National Renewable Energy Lab	Golden, CO	collaborative research
NJ Office of Weights and Measures	Avenel, NJ	collaborative research
New Jersey Bike Walk Coalition	NJ (statewide)	In-kind support
Noblis	Reston, VA	collaborative research
NC Dept. of Transportation	Raleigh, NC	collaborative research, personnel exchange
NYC Dept. of Cultural Affairs	New York, NY	financial support, in-kind support
NYC Dept. of City Planning (DCP)	New York, NY	in-kind staff support
NYC Dept. of Transportation	New York, NY	financial support, in-kind support
NY Dept. of Agriculture and Markets	Brooklyn, NY	collaborative research
NYS Dept. of Transportation	Albany, NY	financial support, collaborative research
NYC Fire Dept. (FDNY)	New York, NY	financial support, collaborative research
Ocosta Junior HS After School Prog.	Ocosta, WA	collaborative research, personnel exchange
Old Dominion University	Norfolk, VA	collaborative Research
OR Dept. of Agr. Weights & Measures	Salem, OR	collaborative research
Port Authority of NY & NJ (PANYNJ)	New York, NY	financial support, in-kind support
Replica	Oakland, CA	collaborative research
Robin Hood Foundation	New York, NY	financial support

Sun Metro	El Paso, TX	in-kind support
Texas Dept. of Transportation	Austin, TX	collaborative research
Universidade Federal Fluminense	Niteroi, Brazil	collaborative Research
Veo	Santa Monica, CA	in-kind support
Via	New York, NY	collaborative research
Virginia Tech	Blacksburg, VA	collaborative Research
Washington State Parks	Olympia, WA	in-kind support
Westport Maritime Museum	Westport, MA	personnel exchange

Other Collaborators or Contacts: within the Consortium

Collaborator	Description
David Bushek, Richard Riman	Research within Rutgers on low-carbon concrete to develop a shoreline ecosystem.
Quanyuan Zhu, NYU	Collaboration within NYU on research papers regarding the Daytime Population project.
Augustin Guibaud, NYU	Brainstorming proposal ideas related to the FDNY projects within NYU.
Balu Gokaraju, Jag Shankar	Collaboration within NCA&T on grants and projects, specifically the Steps4Growth program.

Other Collaborators or Contacts: outside of the Consortium but within the US

Collaborator	Description
Calspan	Research on the crashworthiness analysis of NYS barrier and transition hardware with Henning Olsson and Ali Atahan.
Michael Baker Int.	Research on the effect of truck platooning on bridge performance.
HNTB Corp.	Research on the development of guide plates and standard drawing for NJDOT.
Dewberry	Research on evaluating structural behavior during concrete pouring.
University of Nevada, Reno	Dr. Aobo Wang helped to develop a simulation model to test traffic signal timing for The Flipped Left Diamond Interchange project at TSU.
Center of Excellence	NCA&T and the Center of Excellence for Innovation in Affordable Housing are submitting grant proposals to various agencies.
CR2C2	NCA&T collaboration on research and outreach with the Center for Regional and Rural Connected Communities Region 4 UTC.
Google Deepmind	NYU collaboration for the Congestion Impact Estimation project.

Other Collaborators or Contacts: International

Collaborator	Description
Indian Institute of Science	NCA&T research collaboration with Dr. Tarun Rambha on transportation modeling and optimization techniques.
Universidade Federal Fluminense	NYU collaborative research with Marcos Lage.
Chalmers University of Technology (Gothenburg)	Lab visit and exchange at UW with Prof. Balazs Kulscar in Oct/Nov 2024; students presented their research (MFD regions partition/calibration of Seattle, etc.).
University of Sydney	Meeting with Prof. Mohsen Ramezani in Jan 2025. Presented UW project research and gained insights into MFD generation and perimeter control.
EPFL (Swiss Federal Technology Institute of Lausanne)	Meeting with Prof. Nikolas Gerolimisin in Feb 2025. Presented UW project research and discussed details in network segmentations, MFD generation, etc.

3. Outputs

Journal Publications - Published

- Y. An, J. Chow, S. Woo, J. Lee. “Urban public charging infrastructure planning for electric vehicles: A continuum approximation approach.” Transportation Research Part D: Transport and Environment, 141.
- Z. Bian, D. Zuo, K. Ozbay, J. Gao. “Adaptive prediction of traffic incident duration using change detection and Bayesian networks.” Transportmetrica A: Transport Science, 1-26. Federal funding acknowledged.

- P. Bischoff, W. Nasreddine, H. Nassif. “Proposed ACI 318 Equations for Immediate Deflection of Prestressed Concrete Members.” *ACI Structural Journal*, 2025.
- S. Chakraborty, L. Cui, K. Ozbay, Z-P Jiang. “Automated lane changing control in mixed traffic: An adaptive dynamic programming approach.” *Transportation Research Part B*, 187. Federal funding acknowledged.
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- J. Zhou, Z. Li, H. Nassif, D. Coit. “A Two-stage Weibull-gamma Degradation Model with Distinct Failure Mechanism Initiation and Propagation Stages.” *Reliability Engineering & System Safety*, Vol. 256, 2025.

Journal Publications – Under Review

- P. Agarwal, D. Bagchi, T. Rambha, V. Pandey. “A Bi-Criterion Steiner Traveling Salesperson Problem with Time Windows for Last-Mile EV Logistics.” *Computational Operations Research*.
- OB Alaka, V. Pandey, A. Khattak. “Investigating Automated Shuttle Readiness for Rural Areas.” *Transportation Research Record*.
- S. Chowdhury, M. Sultana. “Digital Twin in Participatory Urban Design: A Scope Review of Utilizing Extended-Reality (XR) Instruments in Collaborative Urban Design Strategies.” *Journal of Urban Technology*.
- K. Gulati, V. Pandey, N. Manikkavasagam, A. Reginato Jr, A. Lidbe, S. Nagarajan, “A Comparative Analysis of Macro and Micro-Level Measures of Healthcare Access in Urban and Rural Areas.” *Transportation Research Record*.
- S. Naderian, Q. Guo, J. Ban. “Multimodal Multiscale Signal-Vehicle Coupled Control (M2SVCC).” *ISTTT 2025* extended abstract.

- X. Ren, J. Chow, V. Pandey, L. Yuan. “Integrating an Agent-Based Behavioral Model in Microtransit Forecasting and Revenue Management.” Transportation Research, Part B.
- D. Sha, Z. Bian, F. Zuo, K. Ozbay, J. Gao, Y. Tang. “Graph Neural Network-Based Clustering for Enhancing Traffic Pattern Identification in Traffic Simulation Calibration and Validation.” Transportation Research Record.
- R. Tashnia, V. Pandey, DN Hridoy, MS Hasnine, H. Park. “Express Lane Route Choice Under Real-Time Information: A Joint Revealed and Stated-Preference Study.” Transportation Research Record.
- R. Tashnia, V. Pandey, D. Hridoy, MS Hasnine. “A Review of Mileage-Based User Fees for Sustainable Transportation Funding.” Transportation Research Record.
- R. Tamiyu, V. Pandey. “Sequential Day-To-Day Mobility Credit Spending Model for Express Lanes.” Transportation Letters.

Conference Papers

- H. Davis, J. Chow. “Single-Charge Feasibility Evaluation of Synthetic Electric New York City Truck Tours.” Conference on Sustainable Urban Mobility.
- N. Dewberry, I. AlHmoud, K. Benton, D. Suarez, Y. Chen, V. Karkariab, Y. Tsai, M. Brock, N. Alazzawi, S. Chowdhury, W. Chen, J. Cao, B. Gokaraju. “A Real-Time VR-Enabled Digital Twin Framework for Multi-User Interaction in Industry 4.0.” Manufacturing Letters.
- S. Kazemkhani, A. Pandya, D. Cornelisse, E. Vinitzky. “GPUdrive: Data-driven Multi-Agent Driving Simulation at a Million FPS.” Neural Information Processing Systems.
- X. Li, K. Ozbay, ZP Jiang. “Physics-informed Machine Learning for AV Control.” 2025 TRB Annual Meeting.
- X. Li, Y. Wang, K. Ozbay, ZP Jiang. “Physics-informed Machine Learning with Heuristic Feedback Control Layer for Autonomous Vehicle.” 2025 IEEE Intelligent Vehicles Symposium (IV).
- W. Nasreddine, H. Nassif, C. Na. “Crashworthiness of NYSDOT Median Barrier Guardrail.” 2025 TRB Annual Meeting.
- H. Nassif, C. Na. “Modeling, Field Testing, and Evaluation of a 75-Year-Old Concrete Cantilevered Bridge Structure.” ACI Spring Convention 2025.
- S. Zhang, F. Zuo, S. Ergun, K. Ozbay. “Improving Work Zone Safety: Integrating VR-CARLA Co-simulation and Eye Tracking for Behavior Analysis of Drivers around Work Zones.” Road Safety & Simulation Conference 2024.

Presentations

- C2SMARTER researchers presented over 25 [papers and posters](#) at TRB’s 2025 Annual Meeting.
- Dachuan Zuo, Dr. Bian, Dr. Zuo, Prof. Ozbay, NYU. Toward an Enhanced Risk Assessment Sensitivity for Autonomous Vehicles with the Safety Potential Field Approach. 09/24/24 – 09/27/24. 2024 IEEE 27th International Conference on Intelligent Transportation Systems.
- Daphne Cornelisse, NYU. Human-regularized PPO for Behavior Modeling in Batched Simulators. 10/08/24. Waymo’s workshop on Computational Models of Human Road User Behavior for AV Evaluation.
- Prof. Vinitzky, NYU. Fixing Evaluation of V2X Systems Using Reinforcement Learning. 10/18/24. NYC V2X & AI Symposium.
- Prof. Ozbay, NYU. Keynote Address. 10/18/24. NYC V2X & AI Symposium.
- Prof. Nassif, Rutgers. Keynote Address. 10/22/24. Brazil Concrete Institute’s 65th Congress.
- Prof. Vignon, NYU. Urban Parking Policy in the Age of Electrification. 10/22/24. INFORMS Annual Meeting.
- Xinyi Zhao, UW. Grid-Aware On-Route Fast-Charging Infrastructure Planning with Equity Considerations: A Case Study in South King County. 10/22/24. INFORMS Annual Meeting.

- Shakiba Naderian, UW. Signal-Vehicle Coupled Control with CAVs, Pedestrians, and Cyclists. 10/24/25. The Future of Urban Accessibility: The Role of AI workshop (ASSETS 2024).
- Farnoosh Namdarpour and Prof. Chow, NYU. Non-myopic Dispatch in On-Demand Ride- Pooling Systems Using Reinforcement Learning. 10/24/25. INFORMS Annual Meeting.
- Dr. Gao, NYU. Leveraging Connected and Automated Vehicle Data for Traffic Control and the Safety of Vulnerable Road Users. 10/26/24. International Chinese Transportation Professionals Association Annual Meeting.
- Road Safety & Simulation (RSS) Conference 2024 in Lexington, KY. 10/29/24-10/30/24:
 - Dachuan Zuo, NYU. Safety Potential Fields for Highway Driving Risk Assessment Considering Real-world Risk Perception.
 - Daniel Lu, NYU. Reinforcement Learning-based Optimal Control of Alert Systems to Mitigate Alarm Fatigue for Roadway Worker Safety.
 - Shuo Zhang, NYU. Improving Work Zone Safety: Integrating VR-CARLA Co-simulation and Eye Tracking for Behavior Analysis of Drivers around Work Zones,
 - Prof. Ozbay, Bekir Bartin, NYU. Goodness of Fit Tests for Safety Performance Function Development and Calibration.
- Prof. Vinitzky, NYU. Goal-reaching at Scale for Human Behavioral Modeling. 01/23/25. NSF Workshop on Reinforcement Learning.
- [NCDOT Research and Innovation Symposium, NCA&T](#). 02/11/25.
 - Prof. Pandey. Addressing Accessibility Barriers in Rural and Disconnected Communities.
 - Komal Gulati. Enhancing Traffic Safety and Efficiency in North Carolina: A Framework for Optimized Truck Parking and Reservation Systems.
 - Mohd Ashraf Ali. Enhancing Efficiency and Service Quality at License Plate Agencies in North Carolina.
 - Oladimeji Alaka. Investigating Automated Shuttle Readiness for Rural Areas: A North Carolina Case Study.
 - Ridwan Tihamiyu. User’s Preference for Trip Planner Interface and Factors Influencing Sustainable Transport Choices in Rural and Urban Areas.
 - Rifa Tasnia. Mileage-Based User Fees: Addressing Equity and Behavioral Changes in NC’s Transportation System, Equitable Flood Impact Analysis: Modeling Transportation and Water Infrastructure Interoperability.
- Prof. Kaufman, NYU. Future of the Bus: Current & Emerging Technologies Briefing Document. 2/13/25.
- Prof. Kaufman, NYU. U: Universal. 02/21/25. Museum of Modern Art Pirouette Abecedarium.
- Prof. Vinitzky, NYU. PILAF: An Empirical Foundation for Multi-Agent Reinforcement Learning. 02/26/25. NYU Center for Data Science’s CILVR Seminar series.
- Chaekuk Na, Rutgers. WIM Section 2.26 WIM Used for Vehicle Direct Enforcement – Proposal to Amend:
 - 10/7/24. Southern Weights and Measures Association Annual Meeting.
 - 10/22/24. Northeastern Weights and Measures Association Annual Meeting.
 - 10/29/24. Central Weights and Measures Association Annual Meeting.
 - 1/13/25. National Council of Weights and Measures.
- Prof. Ozbay, NYU. How Do We Transform Traffic Incident Management with Generative AI, Big Data Extracted from Existing Traffic Cameras, and Human Expert Knowledge? 03/13/25 - 03/14/25. Pioneering Transportation Innovation with Generative AI, co-organized by FHWA at University of MD.
- YM Gebregziabher, NCA&T. Flood Inundation Modeling of the Hurricane HELENE Event on Asheville and its Surroundings in NC. 03/20/25. 2025 WRRR Annual Conference, Raleigh, NC.

- Prof. Ozbay, NYU. Towards Smarter Cities by Transforming Urban Mobility through the Use of AI-Enabled Digital Twins. 03/21/25. Invited talk, Carnegie Mellon, Pittsburg, PA.
- Prof. Chow, NYU. Game-Theoretical Applications in Mobility Workshop, U. of Luxembourg. 3/28/25.
- 14th Annual Dr. Bala Ram Graduate Research Poster Competition, NCA&T. 03/21/25.
 - David Quansah. Research on Personalized Incentives for Sustainable Travel Behavior.
 - Mahazarin Sultana. Integrating Eye-Tracking and Immersive Virtual Environments for Informed Co-Urban Design.

Webpages

- **NYU Daytime Population:** Congestion pricing [dashboard](#) density tracker was built using the data pipeline and perspective transformation method developed in this project
- **NYU FDNY Year 1:** Digital Twin workshop [webpage](#)
- **NCA&T Personalized Incentives:** The [StoryMap](#) "Assessing Flooding Impacts on Transportation Networks" illustrates how flooding affects transportation infrastructure
- **NCA&T Personalized Incentives:** The [AR2T Dashboard](#) provides real-time analytics and visualizations for transportation data, facilitating informed decision-making
- **UW Multimodal Multiscale:** [Github](#) for the codes for simulation and optimization model of M2SVCC
- **NYU Using PTZ Cameras:** [webpage](#) for the Digital Twin Workshop at TRB 2025
- **NYU Knowledge Capture:** [webpage](#) of proposed chatbot

New Methodology, Technology, or Technique

- Daytime Population: Developed an **automatic data pipeline** to process video information from all 900+cameras automatically and **perspective transformation** to validate if each camera has similar camera views to ensure the data extracted is comparable.
- Work Zone Digital Twins: Developed **VR-WISE**, a high-fidelity virtual reality driving simulation platform designed to study driver behavior and work zone safety through immersive scenarios.
- FDNY Year 1: Developed an **Explainable Boosting Machine (EBM) AI model** and a **Cross Street Location (CSL) optimization model**, and a **calibrated SUMO model** for EMV behaviors.
- Personalized Incentives:
 - **Virtual reality-based participatory tools.** Tools simulating incentive-based travel behaviors for stakeholder engagement, shared through posters and StoryMap visualization demos.
 - **Random Utility and Random Regret Minimization frameworks.** Behavioral models using RUM and RRM to study incentive impacts on mode choice; methodology integrated into survey design, part of which was presented at TRB 2025.
 - **Geospatial Optimization Models.** Developed to optimize healthcare and transportation access in rural areas.
 - **Reinforcement Learning** for Equitable Toll Design. Developed a framework for optimizing toll strategies with fairness constraints; presented at TRB 2025.
- Landside Traffic Management: Developed **enhanced bus detection** for PANYNJ shuttles and a methodology for **3D-to-2D satellite views perspective transformation**; model performance and visual outputs were shared with PANYNJ via stakeholder meetings.
- Multimodal Multiscale: Developed a **multimodal, multiscale signal-vehicle coupled control (M2SVCC) model**. Based on a Model Predictive Control scheme, the model is shared in Github.
- Physics Informed Learning: Developed **Recurrent Predictive Control (RPC)**, a physics-informed learning-based control method that integrates RNN with MPC, and a **Heuristic Feedback Layer**, which is embedded into the policy network.
- Traffic Education Hub: Developed a **data fusion method** to integrate and map multiple data sources through a uniform data referencing layer.

- Using PTZ Cameras: Developed **AI models**: an encoder-decoder transformer integrated with graph convolution network for traffic state estimation and prediction; a multi-agent Proximal Policy Optimization reinforcement learning method for camera control. Also developed a **calibrated SUMO model** for replicating mobility patterns and driving behaviors along Flatbush Avenue in Brooklyn.
- Knowledge Capture: Developed an **AI model**. This LLM-powered semantic search method allows users to search various keywords for relevant project reports.

Invention, Patent, or License

- U.S. Patent Application 18/804,316: System and Method for Work Zone Management. Jingqin Gao, Fan Zuo, Kaan Ozbay, Chuan Xu, Liu Yang, and Daniel Zhang. Filed Feb. 20, 2025.

Books or Other Non-Periodical, One-Time Publications: NA

Policy Papers: NA

Other Products: NA

4. Outcomes

Increased Understanding and Awareness of Transportation Issues

- The **FDNY AI-Reinforced Traffic Digital Twin** project estimated quantitative impacts of different types of lane closures; exploring these results enhanced understanding and awareness of the potential magnitude of impact on emergency vehicles. The Year 2 FDNY work is enhancing understanding and awareness of issues affecting emergency vehicle response, including challenges posed by parking-protected bike lanes with double parking, vehicles not yielding to emergency vehicles at red lights, and other related factors.
- The **Landside Traffic Management** research provides visual and quantitative metrics to show the traffic congestion of landside traffic at JFK terminal 4, especially for queues and curb activity.
- The initial **Future of the Bus** research synthesized challenges across PANYNJ facilities and brought to light issues like inadequate data sharing and variables in forthcoming fuel technologies.
- Field testing of the **Multimodal Multiscale** model in Mcity paves the way for evaluating the model in real-world applications, which is needed as the first step in large-scale adoption of CAVs.
- The lane-changing control algorithm of the **Physics Informed Learning** project will allow for more computationally efficient controllers capable of achieving high performance in complex scenarios.
- The integration of the **Knowledge Capture's** LLM-driven framework will help researchers, decision makers, and practitioners understand best practices in ITS project evaluation processes.
- The **Travel Pattern Changes** project is expected to develop new accessibility measures to various cooling places such as green spaces and cooling locations provided by the government.
- The **Traffic Hub** platform will offer students hands-on experience with AI models and real-world transportation data, bridging the gap between theoretical learning and practical application.
- The **Infrastructure Damage** team operating the BQE testbed consolidated data from various sources, which enabled the identification of overweight trucks and the issuance of Notices of Liability (NOLs).
- The camera screening and classification findings of the **Daytime Population** Project have increased the understanding of how camera data can be used for different transportation issues.
- The **Personalized Incentives** project has enhanced awareness of how behavioral nudges can influence individual travel decisions, particularly regarding carpooling and off-peak travel.
- The **Congestion Impact Estimation** simulator is open-source and being used by industry partners.
- The **EV Adoption** project will improve the understanding of equity challenges in EV adoption and lead to the development of equitable transportation policies.

- Transportation agencies have been hesitant to adopt the **FLDI** design due to a previous lack of systematic performance evaluation and design guidelines; the FLDI project results will address this.

New Policies, Regulation, Rulemaking, or Legislation

- Due to the **Infrastructure Damage** work, a proposed amendment to NIST Handbook 44 Section 2.26 was submitted as a voting item at the NCWM Annual Meeting, scheduled for July 2025 in Reno, NV.

Increases in the Body of Knowledge

- The **FDNY projects** shared the AI model results with FDNY and NYU’s research magazine, increasing the body of knowledge about built environment factors in emergency response. The team’s analysis of ambulance dispatch and AVL contributed to a better understanding of existing ambulance operations as well as data gaps in current datasets.
- The initial research of the **Future of the Bus** recommended new technologies to use in buses and terminals, which was shared with PANY&NJ staff.
- The **Multimodal Multiscale** project developed an optimization model based on a Model Predictive Control (MPC) scheme for the joint control of signal phase and vehicle trajectories and shared codes for the model on [Github](#).
- The **Knowledge Capture’s** LLM-driven synthesis framework will accelerate ITS-related knowledge capture and expedite the process of broadcasting key takeaways from ITS projects.
- The dissemination of findings from **Digital Twins of Work Zones** team (via academic publications and NYU research channels) contributes to the growing body of knowledge on how work zone design and roadside activity influence driver behavior and physiological responses.
- The **Personalized Incentives** project contributes to knowledge of integrating behavioral economics with transportation planning, especially through incentive design using RUM and RRM models.
- The **Congestion Impact Estimation** team demonstrated that large-scale reinforcement learning is an effective, efficient way to construct proxies for human driving behavior.
- The **Enhancing Transit Access and Safety** project made their datasets available on [Zenodo](#).
- The **Equitable Flood Impact Analysis** project made their model available on [Github](#).

Improved Processes, Technologies, Techniques, Skills in Addressing Transportation Issues

- The **FDNY projects** provided an innovative digital twin approach to assessing emergency medical vehicle interventions and applied a map matching methodology to reconstruct vehicle paths.
- The **Landside Traffic Management** project’s enhanced bus and queue detection improved detection accuracy and provides a framework in customizing computer vision techniques for traffic management.
- The **Landside Traffic Management** research led PANYNJ to use the proposed method to evaluate the effectiveness of their remote FHV bus shuttle services, for which they currently lack quantitative data.
- **Travel Pattern Changes** project will give policy guidance on cooling needs during heat waves and provide potential legislative support on investing in green spaces and cooling facilities.
- The **Physics Informed Learning** project provides an efficient method capable of realizing combined longitudinal and lateral real-time control for nonlinear vehicle models. It provides a heuristic approach capable of improving tracking accuracy of CAVs using neural network controllers.
- The resulting product of the **Transportation Equity** project will serve as a benchmarking dataset for various machine-learning tasks related to urban tasks.
- The **PTZ digital twin**, integrated with SUMO and PTZ camera sensing and control, offers an innovative approach to assessing mobility and safety risks across road links, improving the process for agencies to accurately monitor traffic conditions across large-scale networks.

- The **Infrastructure Damage** team demonstrated a state-of-the-art WIM system, featuring Piezo-Quartz sensors and a software-based Automatic License Plate Recognition system for identifying overweight trucks, setting the foundation to expand enforcement practices.
- The **Daytime Population** project’s computer vision technique with an enhanced automatic data pipeline and perspective transformation enables comparative analysis using camera data.
- **Personalized Incentives** dashboards and visualizations, such as those featured in the StoryMap and AR2T Dashboard, support better decision-making and scenario-based planning.
- **EV Adoption** results will facilitate the equitable distribution of EV charging infrastructure in all communities, leading to more balanced traffic patterns and reduced congestion in urban centers.
- The **FLDI project** will increase knowledge of the performance of this design, providing performance metrics including the percentage reduction in traffic delay and average queue length.

Enlargement of the Pool of Trained Transportation Professionals

- Multiple projects trained PhD and graduate students on conducting transportation analyses and use of AI tools and models, allowing them to gain hands-on experience and essential job skills (Helping FDNY, Landside Traffic Management, Multimodal Multiscale, Using PTZ Cameras, Traffic Hub, Daytime Population, Digital Twins of Work Zones, Personalized Incentives, EV Adoption, FLDI).
- Multiple projects gave agency staff the opportunity to learn about new methods and applications of tools such as computer vision and digital twins (Helping FDNY, Landside Traffic Management, Using PTZ Cameras, Daytime Population, Infrastructure Damage).
- NCA&T Student Chapter of Institute of Transportation Engineers, advised by Prof. Pandey, was awarded the 2024 Paul F. Cribbins Award for Outstanding Student Chapter at the 2024 NCSITE Annual Meeting.
- The graduate students working with NCA&T Prof. Chowdhury completed the training for the Google AI Essentials Certificate.

Adoption of New Technologies, Techniques, or Practices

- The **FDNY Year 1 project** developed a digital twin that contains both AI models and microsimulation models, providing a new way to simulate EMV behavior.
- The field test of the **Multimodal Multiscale** model supports the use, testing, and advancement of Vehicle-to-Everything technologies toward future integration and widespread adoption of CAVs.
- The **Knowledge Capture** framework demonstrates how to adopt and integrate LLM models.
- The **Using PTZ Cameras** team developed a digital twin that enhances urban mobility management by providing real-time situational awareness of both mobility and safety risks.
- The **Traffic Hub** web tool serves as an innovative platform to foster ML/AI education.
- Via the **Infrastructure Damage** project, NYCDOT approved the deployment of the WIM system utilizing Quartz sensors, along with the ALPR system incorporating non-proprietary cameras.
- The **Digital Twins of Work Zones** team developed the VR-WISE simulation platform, which enables the adoption of new techniques to simulate and analyze driver behavior in work zones.
- The **Personalized Incentives** project is expected to influence platforms like Metropia by integrating findings into app functionality, promoting real-world adoption of incentive-driven mobility tools.

5. Impacts

C2SMARTER’s research is positively impacting the operations and effectiveness of the region’s transportation system, facilitating technology transfer, contributing to the body of knowledge, theory, and research in the field, and offering opportunities and skills training to practitioners and students.

Effectiveness of the Transportation System

- The digital twin developed in the **FDNY Year 1 project** provided a virtual testbed that improved agency efficiency for testing EMV interventions they were not able to test in the real world.

- The performance metrics generated in the **Landside Traffic Management** project are expected to aid data-driven decision making for landside traffic operations for JFK Terminal 4.
- The use of a multimodal optimization model in the **Multimodal Multiscale** project ensures safety and efficiency considerations across all transportation modes.
- The **Physics Informed Learning** method reduces accident probability during lane-changing, contributing to smoother traffic flow and reduced congestion.
- The **Transportation Equity** dataset is quantifying potential disparities regarding intersection accessibility and will enable comparisons across heterogeneous groups.
- The **Knowledge Capture** framework accelerates the process of extracting evaluation results and performance measures from ITS projects, allowing researchers to better understand their effectiveness.
- The **Using PTZ Cameras** digital twin enables agencies to make informed, real-time decisions that improve traffic flow and enhance safety for all road users.
- The number of overweight trucks decreased by over 50% following the initiation of direct overweight enforcement as a result of the **Infrastructure Damage** project. This is expected to lower the risk of fatal accidents, ease congestion, reduce pollution, extend service life, and enhance overall safety.
- The VR-WISE platform of the **Digital Twins of Work Zones** project enables scenario testing that would be impractical in the real world, contributing to potential reductions in work zone-related incidents.
- The **Personalized Incentives** work has focused on real-world applications such as carpooling promotion, laying the groundwork for future congestion reduction and environmental benefits.
- The **FLDI** research will facilitate the implementation of this design, potentially reducing delay and congestion at interchanges and improving the operational efficiency and safety of the entire network.

Technology Transfer

- The **Physics Informed Learning** project has an ongoing collaboration with Mitsubishi Electric Research Laboratories (MERL) for potential technology transfer. MERL engaged in discussions on physics-informed ML methods in autonomous driving, focusing on the stability and safety of learning control.
- Researchers conducted a TRB digital twin workshop with industry partners and other stakeholders worldwide to share findings on the **Using PTZ Cameras** project.
- NYCDOT established a new overweight truck enforcement site per the **Infrastructure Damage** work.
- The **Digital Twins of Work Zones** findings have sparked discussions with agency stakeholders on integrating simulation-based testing into future planning. VR-WISE has been shared with the research community, promoting VR and biometric monitoring in transportation research.
- The **Personalized Incentives** research has influenced conversations with partners such as Metropia around integrating behaviorally driven incentive systems into their platforms. Ongoing discussions focus on data collection and incentive design, building on their pilots in Houston and Virginia.
- The **Congestion Impact Estimation** work was presented to Waymo, Helm AI, and Valeo AI, resulting in changes to their research agendas.

Increase in the Body of Scientific Knowledge

- **Collaboration with FDNY** led to an award from Popular Science and NYC's Hayes Innovation Prize, increasing the body of knowledge of AI solutions for transportation systems. Ongoing data analysis is expected to provide insight on NYC's congestion pricing and its impacts on emergency vehicles.
- Increased efficiency and accuracy in curb usage and queue detection resulting from the **Landside Traffic Management** project will ultimately facilitate data-driven decision making at airports.
- The **Future of the Bus** briefing document has raised several concepts in the areas of bus design.
- The methodology of the **Multimodal Multiscale** model is an example of model-based joint control, where multiple transportation modes are integrated into a unified optimization framework.

- The **Physics Informed Learning** project applies ML, reinforcement learning, and nonlinear control to transportation systems, providing a referable methodology for other transportation issues.
- The dataset the **Transportation Equity** project is producing will help urban practitioners characterize detailed physical activity happening at intersections, increasing the body of resources stakeholders can use to make decisions regarding the next generation of urban regulations.
- The **Knowledge Capture** project’s web-based portal allows access to current UTC reports and provides automated reasoning to help users discover the body of ITS-related knowledge.
- The **Traffic Hub** platform will offer students hands-on experience with AI models and real-world transportation data, bridging the gap between theoretical learning and practical application.
- The **Daytime Population** project is increasing efficiency and accuracy in processing video data.
- The **Digital Twins of Work Zones** project combines eye-tracking, biometric data, and VR simulations. The results have been shared through academic venues and public engagement events, expanding awareness of simulation-based methods in work zone safety.
- The **Personalized Incentives** project has contributed new insights into the use of random regret minimization models, behavioral economics, and digital twin simulations within transportation.
- The **Congestion Impact Estimation** project’s simulator is open-source and widely used as a basis for fundamental research on driving.
- Prof. Nassif’s work on the **Impact of WIM-based Direct Enforcement** and **Infrastructure Damage** projects, among other research, led to the 2025 Arthur J. Boase Award from the American Concrete Institute Foundation, recognizing his contribution to the body of knowledge regarding structural health monitoring and the use of advanced cementitious materials for infrastructure applications.

Transportation Workforce Development

- The NYSDOT Transportation Constructors Inspection program of the **Workforce Development Pathways** project creates a pipeline to increase the pool of qualified transportation professionals for the agency. With exposure to the NYSDOT-TCI program, students learn about various transportation careers.
- The **Infrastructure Damage** project provided technical support to NYCDOT in the implementation of direct overweight enforcement initiatives. The team delivered presentations at regional Weights and Measures Association meetings as well as at the National Conference on Weights and Measures. These sessions educated state personnel on the differences between static scales and dynamic WIM systems and illustrated the potential benefits of direct overweight enforcement for their respective jurisdictions.

6. Changes/Problems

- Final report submission for projects completed during this reporting period have not been completed due to delays with the peer-review process for final reports.
- The Year 2 Red Light Camera Expansion project has not started due to contractual issues with project partner and match source NYCDOT.
- Select Year 1 projects have been extended past their original timeframes (completion by September 2024) due to programmatic challenges such as time lag in receiving data from partners and data sharing agreements, personnel changes and availability caused by disruptions due to campus operations issues, etc.