



CONNECTED CITIES WITH
SMART TRANSPORTATION 

A USDOT University Transportation Center

New York University

Rutgers University

University of Washington

University of Texas at El Paso

The City College of New York

SEMI-ANNUAL PROGRESS REPORT

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I. Accomplishments

A. Goals and Objectives

C2SMART is the first Tier 1 University Transportation Center (UTC) in New York City, led by the New York University (NYU) Tandon School of Engineering. The mission of C2SMART is to build a solution-oriented research center that uses resources from consortium members' cities as a decentralized but comprehensive living laboratory. The Center brings together a unique combination of strengths and resources in urban informatics, connected technologies, behavioral informatics, and city partners. Its research approach is based on a system-of-systems (SoS) perspective that integrates roads, transport services, energy grids, financial information, and other urban networks.

Research — C2SMART studies challenging transportation problems and field tests novel solutions in close collaboration with end-users, city agencies, policy makers, private companies, and entrepreneurs. We are focused on developing innovative solutions based on emerging disruptive technologies and their impacts on transportation systems. Our three main research areas are: Urban Mobility and Connected Citizens; Urban Analytics for Smart Cities; and Resilient, Secure, and Smart Transportation Infrastructure.

Education — As an academic institution, C2SMART is focused on training the workforce of tomorrow to deal with new mobility problems in ways that are not covered in existing transportation curricula.

Dissemination and Outreach — C2SMART aims to overcome institutional barriers to innovation and hear and meet the needs of city and state stakeholders, including government agencies, policy makers, the private sector, non-profit organizations, and entrepreneurs. The Center is also working to make it possible to safely share data to equip transportation decision-makers with the best information available.

B. Accomplishments Under These Goals

1. Center Administration

Center leadership and staff continued to meet regularly to monitor the status of projects and activity.

2. Research

Projects completed during this reported period:

Digital Twin Technologies Towards Understanding the Interactions between Transportation and Other Civil Infrastructure Systems – The team used The University of Texas at El Paso (UTEP) campus as a living lab by creating a Digital Twin (DT) model focused on a single building and the surrounding transportation network. The research studied the impact of construction-related activity on the surrounding transportation infrastructure and developed a visualization of the impact analysis. The team integrated the project with the Senior Design Capstone course at UTEP to expose civil engineering seniors to emerging technologies like LiDAR for reality capture, BIM modeling, Traffic Simulation, and DT. The project concluded with a stakeholder engagement workshop focused on the El Paso region.

Development and Evaluation of Collaborative Ramp Metering Control for Congested Urban Freeways –

Two ramp metering scenarios were designed for urban and highway settings. The simulations were tested in SUMO for performance measured in terms of congestion reduction and fuel economy. The response of the Eulerian and Lagrangian based ramp metering control was tested under various disruption conditions. The effectiveness of CV based results show that a small percentage of CAVs on the highway congested area will be able to smooth the traffic flow efficiently.

Deployment and Tech Transfer of a Street-level Flooding Platform: Sensing and Data Sharing for Urban Accessibility and Resilience –

The team designed, tested, and built two new ultrasonic prototypes for flood sensing, designed and implemented plans for manufacturing design, deployed 23 prototypes across all five boroughs in New York City, and collected a total of 744 days of data. The team also logged multiple flood events and their profiles, including the highly impactful floods accompanying the storms Henri and Ida in August 2021. The work led to attracted interest for continued funding sources, including a

commitment for \$7million from the City of New York’s Department of Environmental Protection to deploy an additional 500 sensors over the next 5 years.

Work Zone Safety III: Calibration of Safety Notifications through Reinforcement Learning and Eye Tracking

– The first component of this project focused on monitoring construction workers’ attention while the second focused on creating a calibrated notification delivery mechanism optimized to send alarms which grabbed the maximum attention of workers using reinforcement learning (RL). The research outcomes showed that on average it takes 2.5 seconds for a worker to react to an alarm. Data also showed that participants were more responsive to acknowledging alarms that were received with multiple stimuli (vibration + sound vs. only vibration). Results also indicated that the RL agent outperforms random alarm actions after a small number of training episodes.

Automated Lane Change and Robust Safety – This project proposed a data-driven optimal control algorithm to solve the lane-changing problem of AVs which is inspired by reinforcement learning and adaptive dynamic programming. Researchers developed a lane change decision-making algorithm to ensure safe and efficient lane change. The lane change risk index (LCRI) is used to evaluate the AV lane change safety which is obtained by using the proposed data-driven optimal control algorithm. They have combined the data-driven optimal controller with the lane change decision-making algorithm by using control barrier functions (CBFs). Lastly, they developed an experimental setup that includes prototypes of AV and highway lanes, finding that the AV was successful in changing lanes despite the noise in the measurement data and uncertainty in the system parameters.

Ongoing research projects during this reporting period:

Exploring AI-based Video Segmentation and Saliency Computation to Optimize Imagery-acquisition from Moving Vehicles

– “Mapping the walk: A scalable computer vision approach for generating sidewalk network datasets from aerial imagery,” a journal article resulting from this project, was published in Computers, Environment and Urban Systems, Volume 101. The paper explores solutions for the lack information about the location and connectivity of city sidewalks, which makes it difficult to implement research on pedestrian infrastructure. To address this gap, the authors designed and implemented an end-to-end open-source tool— Tile2Net —for extracting sidewalk, crosswalk, and footpath polygons from orthorectified aerial imagery using semantic segmentation.

Quantifying and Visualizing City Truck Route Network Efficiency Using a Virtual Test Bed – C2SMART and NYCDOT hosted a Smart Truck Routing Hackathon event to crowdsource the remaining component of the Smart Truck Routing application, a visualizer that the driver would use while the truck was in motion. The hackathon produced output for the app under development, promising connections and conversations between people interested in improving the New York City freight ecosystem.

Field Application of a High-Power Density Electromagnetic Energy Harvester to Power Wireless Sensors in Transportation Infrastructures

– The team completed a field test of the device on three sample bridges on the Passaic River in NJ: Hillery St Bridge, De Jessa Bridge (Kingsland Avenue Bridge), and Main Ave. Bridge. The EMEH’s dynamic characteristics, such as tip mass and spring stiffness (cantilever beams lengths), were modified to resonate with the bridge by matching their natural frequencies, demonstrating the feasibility of the proposed DR-EMEH to power sensors that regularly monitor the structural integrity of materials and components of highway bridges, such as acceleration and temperature sensors.

Exploring Cost-effective Computer Vision Solutions for Smart Transportation Systems – The team researched data fusion methods that were used to generate safety indicators from different types of traffic data. The development of the work zone element detection model and work zone identification model were completed. To improve the detection accuracy, the team used a novel approach that incorporated three different training image sources which included CCTV, free stock, and synthetic 3D

work zone images. Spatiotemporal analysis was performed on near-miss data to investigate its relationship with crash records and other risk factors. A fishnet approach and spearman's rank correlation statistical test were performed to investigate the relationship between crash records and ME8 and OEM data, with a positive correlation found between them.

Cost-effective Approach Towards Building a Traffic Sign Data Inventory Using Open Street Images – The team is working on developing a machine learning based automatic traffic sign detection and recognition model. The model consists of two components: traffic sign detection (TSD) and traffic sign recognition (TSR). The former focuses on the localization of the target in a frame, while the latter performs a fine-grained classification to identify the type of the detected target. The team trained both TSD and TSR models with the sample data collected, and the key accomplishments can be summarized in three points: develop a traffic sign detection (TSD) model focused on extracting the region of interests (i.e., traffic sign) from the background; develop a traffic sign recognition (TSR) model performing a fine-grained classification to identify the type of the detected target; train a TSD model with the sample data.

Evaluation of Integrated Overweight Enforcement System using High Accuracy WIM System and Non-Proprietary ALPR System – The team worked with NYCDOT and its contractors to build the new BQE smart roadway testbed. The team collected and processed WIM data from the testbed to validate the reliability of the sensor installation and reviewed all the OW trucks identified by the WIM and ALPR systems to determine the statistics of the overweight truck states. An agent-based model (ABM) was developed and applied on storm water infrastructures to evaluate both the main benefits and co-benefits of storm water mitigation technologies, in particular green infrastructures. The model was applied in Newark, NJ, and it was found that increasing the number of GIs beyond a certain threshold does not enhance community resilience, and that executing a well-thought out plan is preferable.

Digital Twin Technologies Towards Understanding the Interactions between Transportation and other Civil Infrastructure Systems: Phase 2 – The team collected LiDAR point cloud data on additional sites, and have implemented the developed vehicle sensing algorithm on an edge device for real-time vehicle detection. Team members continued exploring and training to use the Bentley iTwin platform which provides a robust solution to create and stream live data to a cloud-based digital model. They have also developed an approach to incorporate vehicle detection results via edge computing on the campus. They have conducted a preliminary scenario analysis extending the previous work on the digital model, and the flow rates obtained from the video detection were used for co-simulation in CARLA and SUMO.

Work Zone Safety: Virtual Reality-based Traffic Co-simulation Platform for Workforce Training and Pedestrian Behavior Analysis – The experiment design, location, and final approval from the IRB board for testing were completed to begin recruiting participants and conduct the experiment during the month of January 2023. A total of three dry runs were performed on campus to ensure the safety of participants and the smooth running of procedures for both participants and administrators. The implementation of pedestrian integration was developed by revising the codes used in SUMO to recognize the participant location as pedestrian behavior in the system. The final recruitment plan was carried out in collaboration with the ASCE undergraduate student chapter at NYU to participate in the experiment.

One-to-Many Simulator Interface with Virtual Test Bed for Equitable Tech Transfer – The NYU team has finalized the actual mechanism of integrating MATSim with a Mobility-On-Demand simulator design and successfully ran it using a subset of NYC-MATSIM population. To further showcase the capability of the API, they ran the simulator with a self-defined NYC population with two sub-groups categorized by income level to evaluate the equity effect of different MOD service setting to the population. The UW team mainly focused on studying the micro/macro-scale traffic dynamics and interactions using the integrated models. A “double queue” type of modeling approach (a micro-scale traffic dynamics model) has been developed first to capture the interactions of two regions (macro-scale traffic dynamics). The

developed model can be used in macro-level traffic control and subsequently multiscale traffic control for a large urban network. Using the SUMO model for downtown Seattle, the UW team also studied the region partitioning and MFD (macroscopic fundamental diagram) calibration for Downtown Seattle.

NY Statewide Behavioral Equity Impact Decision Support Tool with Replica – The team developed an estimation method to obtain heterogeneous parameters for mode choice. The deliverables accomplished were Group-level agent-based mixed logit model (AMXL) datasets, NY statewide mode choice parameters, a Value of time (VOT) distribution in NY state and NYC, and Statistical and spatial distribution of social welfare (consumer surplus calculated using AMXL).

Developing a Framework to Optimize FloodNet Sensor Deployments Around NYC for Equitable and Impact-based Hyper-local Street-level Flood Monitoring and Data Collection – During the workshop hosted in November 2022, the team compiled a list of metrics from the participants. The team selected the final datasets to be used in the model, according to the outcomes of the workshop: the MTA turnstile data set and NYSDOT Traffic Data Viewer. They updated risk metrics previously selected based on the outcomes of the workshop, and estimated the number of buildings located in flood-prone regions built (or had their most recent renovation) before 1961. For 5 of the 8 Equity metrics and for 6 of the 8 Risk metrics previously identified, they were able to define proxies and identify relevant data to quantify them. A list of desired locations was provided by the NYC Department of Environmental Protection, assessing how current and planned locations target relevant aspects for different stakeholders. The goal is to provide a set of 100 future locations that are relevant to the FloodNet team and to other stakeholders, in accordance with the multi-stakeholders identification process approach.

An Artificial intelligence (AI) Based Overheight Vehicle Warning System for Bridges – The team looked for many camera options and selected HXVIEW PTZ Security Camera after considering the features as well as the cost. The current workflow is: (a) use long focus camera to capture the image clearly in region of interest at a safe stopping distance, (b) identify the object accurately, (c) capture pixel level precise segmentation of the vehicle, (d) create a 3D bounding box, (e) estimate the height referencing an object of known height in the image. The team looked at required components for wireless communications for warning system installation and algorithms to save useful data on vehicles post overheight detection.

Utilizing Social Media Data for Estimating Transit Performance Metrics in a Pre- and Post-COVID-19 World – The CCNY team is writing the final report.

Evaluating the Effectiveness of Computer Vision Systems Mounted on Shared Electric Kick Scooters to Reduce Sidewalk Riding – This project has been rescoped.

Table 1 provides a listing of concurrently funded projects from other sources that have synergistic goals or a high degree of overlap with C2SMART-funded projects.

Table 1: Matching or Complementary-funded Projects to C2SMART-funded Projects

Urban Mobility and Connected Citizens	Statewide Open-Source Advanced Traffic Management System Software Pilot	NYSDOT
	Statewide Mobility Services Program Strategic Procurement Planning	NYSDOT
	Intersection Safety Improvement Program Phase 2	City of El Paso
	Utilizing CAT Data to Enhance Freeway Operational Strategies	NCHRP
	AI-based Modeling and Control for Traffic Flow Systems	DOE
	ITS Deployment Evaluation	ITSJPO
	Clean Neighborhoods Challenge: Clean Transit Access Program	NYSERDA
	Multimodal Electric Vehicle demand ReSponsive Transport	FNR
	Tolling Research and Operations	WSDOT
	Traffic Management Center	WSDOT

Urban Analytics for Smart Cities	Utilizing Cooperative Automated Transportation (CAT) Data to Enhance Freeway Operational Strategies	NCHRP/Noblis
	Analytical Support Services IDIQ: Federal Support for Local Decision-Making	BTS
	Development and evaluation of an electric-charging-constrained, non-myopic, dynamic routing algorithm with synchronized transfers	MOIA
	Resilient Edge Networks with Data-driven Model-based Learning	NSF
	An Integrated Reactive and Proactive Adversarial Learning for Cyber-Physical-Human Systems	NSF
	Distributed Optimization-based Control of Large-Scale Nonlinear Systems with Uncertainties and Application to Robotic Networks	NSF
	Learning-based Adaptive Optimal Control Principles for Human Movements	NSF
	Designs and Theory for Event-Triggered Control with Marine Robotic Systems	NSF
	Intelligent Transportation Systems (ITS) Deployment Evaluation Program Data Collection and Information Synthesis Support	FHWA/Noblis
	Promises of Data from Emerging Technologies for Transportation Applications: Puget Sound Region Case Study (Phase I & Phase II)	FHWA/WSDOT
	Scenario Modeling of Return to Work after Covid-19	Challenge Seattle
	Predictive Real-time Traffic Management in Large-Scale Networks Using AI	FHWA
	Bias Modeling and Estimation of Networked Transportation Data	NSF
	Resilient, Secure, and Smart Transportation Infrastructure	AASHTO and NBI Element Deterioration Rates for Bridge Management System
Bridge Resource Program		NJDOT
Capital Program Resource Model		NYSDOT
Overweight Truck Impact Study		NYCDOT
Pilot/Scoping Study to Plan SHM and NDT Systems for BQE		NYCDOT
Design Finite Element Analyses and Crash Testing (SR-21-02 & 03)		NYSDOT
Air Quality Assessment: International Bridge of Americas, El Paso, Texas		NADB
Development and Implementation of FR-HPC and FR-HES-HPC for Capital Improvement Program Bridge Deck Application		NJTA
Bridge Redundancy and Robustness Against Extreme Events		FHWA
Development of a Continuous for Live Load Prefabricated Steel Accelerated Bridge Construction (ABC) Unit for Texas Bridges		TxDOT
Resilience of Power Grid Infrastructure vulnerable to Climate Change and Future Hurricanes		Coal. for Disaster Resilient Infrast.
EASEEbot: A Robotic Envelope Assessment System for Energy Efficiency		Dept. of Energy
FMSG: ARM4MOD: AI-powered and Robot-assisted Manufacturing for Modular Construction		NSF
MRI: Development of Reconfigurable Environmental Intelligence Platform		NSF
Combining Traditional Building Inspection Sensors w/ Deep Learning Robotics		NSF
Center for Collective Impact in Earthquake Science (C-CIES): Building Inclusive Excellence, Diversity, Equity and Community into Earthquake Science		NSF
Principles and Pathways for Public Engagement by NYC Communities with Interpretable, Reliable, and Actionable Flood-Related Data		Alfred Sloan Foundation
EP Water-Research and Collaboration Pipeline		El Paso Water Ut.
Real-Time Flood Monitoring Dashboard		NYSEDF

3. Education

- The [C2SMART Learning Hub](#), open to all students attending C2SMART Consortium Universities as well as a network of community colleges in New York City, has offered free courses on applicable skills for students since its launch in September 2020. The classes are taught by doctoral students in transportation programs at Consortium schools, providing teaching and curriculum development experience. The following classes were offered during this period:
 - Diving into open data - What is available and how to use them for transportation research
 - Everything you need to know about digital twins: Building a campus model
 - Machine learning and Deep learning approaches in bridge degradation modeling and forecasting
 - Chatting with ChatGPT: Exploring the Advancements in AI Language Models
 - Unlock the Power of Graph Neural Networks: Understanding the Fundamentals and Knowing When to Implement
 - Unleash Your Creativity with Unity 3D Simulation and Transportation Network Modeling
- C2SMART Center continues to support consortium institution Institute of Transportation Engineers / Intelligent Transportation Society Student Chapters. ITE Met Section hosted a webinar on “Breaking into the Transportation Engineering Field: Student Involvement in ITE.” C2SMART also hosted the ITE MET section Virtual Career Fair and Speed Networking 2023 event.

C. Dissemination and Outreach

1. Training and Tech Transfer Events

a) Conference Presentations and Research Showcases

- C2SMART once again co-sponsored and organized TransportationCamp- NYC, held in October 2022. TransportationCamp, featured hundreds of enthusiastic participants who engaged in networking and user-generated session topics.
- C2SMART hosted a Virtual Hackathon in partnership with NYC DOT from October 15-23, 2022, kicking off with a live introductory session at TransportationCamp. The hackathon sought design for 3D visualizers to help truck drivers navigate the complexities of the city and identify the best route for reaching their destination. 20 attendees participated in a discussion about truck routing and its obstacles in New York City.
- NYU Tandon hosted a Panel Discussion and Networking event with Verizon in October 2022. Students met with Verizon's technology leaders to learn about career opportunities and 5G technologies that Verizon is currently working on.
- “Deluge Data, Data Deluge” was held in October-November 2022 with in-person and virtual sessions that brought critical perspectives from the humanities and arts into dialogue with engineering and data practitioners engaged in flood sensing.
- C2SMART co-hosted and presented at Transit Techies #13: Projects on Bike Safety & Infrastructure with NYU Tandon. C2SMART student Suzana Duran Bernardes gave a live demo of her mountable sensors to improve cyclist safety project.
- New York University and Tongji University hosted the 2nd NYU-TJU Urban Transportation Forum. The topics covered in the virtual event included the future of transportation, sustainability and equity in transportation systems, travel behavior, and safety in urban transportation. This forum provided a platform for experts and students to come together and discuss pressing issues in the field and offer new perspectives on shaping the future of urban transportation.
- Professor Jiang of NYU chaired the session titled "Driver Assistance Systems; Automated Vehicle Operation, Motion Planning, Navigation-11" in the IEEE ITSC in October 2022, and hosted the keynote speech at the 2022 CCDC, attended by about 1000 participants.

b) Workshops

- NYU student Bingqing Liu, in partnership with the Young Members Coordinating Council, helped organize the Early Academic Successful Careers: Resources and Advice workshop. This provides advice on innovative transportation education practices, building research collaboration with communities and industry, and postgraduate researcher careers at the TRB annual meeting.
- C2SMART’s Emerging Leaders in Transportation three-day workshop returned to NYU. The program selected 23 participants and included leadership curriculum where emerging leaders collaborated on long-term leadership goals and developed innovative projects and ideas within an organization. Sessions included talks from professionals in a range of public, private, and nonprofit organizations.
- In conjunction with NYU-ITE student chapter, C2SMART convened the 5th Annual Women in Transportation Discussion Panel, bringing together three leaders across multiple dimensions of transportation and engineering to celebrate Women’s History Month. Over 50 rising transportation professionals attended the hour-long panel discussion focused on gender equity in the workforce and throughout global transportation systems.
- Professor Ceferino and the Floodsense team hosted a workshop in November 2022, inviting experts from different fields and asked them to assign priorities to each available metric on urban infrastructure and calculate a weighting scale to combine them. The team gained input on which priorities should be used to deploy the FloodNet sensors.
- “Where are they now? A catch-up with recent transportation engineering graduates as they start their new careers in industry, government, and academia” was held in October 2022. C2SMART alumni spoke with current students about their journey in transportation after matriculation.

2. Industry and Public Agency Outreach

- The NYU team at C2SMART participated in NYC Town+Gown’s Vision Zero event in November 2022, presenting “AI-Based Video Analytics for Vehicle and Pedestrian Detection, Tracking, and Speed Estimation Using Traffic Cameras: Applications and Opportunities.” The Director of Town+Gown: NYC, who is from NYC Department of Design and Construction, joined the project’s advisory board.
- Updated work was presented by Dr. Jingqin Gao at the Town+Gown: NYC meeting with staff from the NYC Department of Design and Construction and NYC Department of Transportation in January 2023.

3. Seminars and Webinars

- The second installment of C2SMART’s “State of the Field” series was held to take a deep dive on the latest advances in Connected Vehicle technology. The series on Connected Vehicle explored:
 - Improving Safety through Connected Vehicle Technology
 - Assisting Pedestrians with Vision Disabilities in Navigating Urban Streets
 - Simulation-Based Framework for Safety Evaluation of Connected Vehicles
 - A Roundtable on Lessons Learned, Future Research, and Deployment Potential

Additionally, C2SMART hosted the following seminars/webinars during this period:

- Smart Electric Vehicle Charging: Modeling Drivers’ Choices and Autonomous Vehicles’ Strategies presented by Dr. Nicolo Daina
- Roundtable on Traffic Safety Research featuring Dr. Tarek Sayed

4. Media Coverage and Public Outreach

- Professor Piccoli’s work as part of the CIRCLES consortium [was covered](#) highlighting the world’s largest open-track experiment to test AI-equipped vehicles.
- The Palos Verdes-South Bay Sierra Club featured the FloodSense team’s research on the resilience of clean electricity infrastructure systems.
- Professor Rae Zimmerman was featured in Brooklyn Daily Eagle for The Unification for Underground Resilience program at NYU.
- Professor Joseph Chow discussed the challenges of installing EV chargers in NYC to meet the city’s demand for more electric vehicles by 2030 with the Wall Street Journal.

- Sarah Kaufman was quoted in the New York Times last week discussing the impact of crime taking place on the subway and the slow rebound of female ridership.
- C2SMART released its [annual report](#) detailing its research outputs and accomplishments over the 2021-2022 academic year.

D. Plans for Next Reporting Period

The following events/webinars are planned for the next reporting period:

- Optimal dispatching of electric vehicles for providing charging on-demand service leveraging charging-on-the-move technology – presented by Dr. Lili Du, University of Florida
- Bridging the Gap in Bureau of Public Roads Functions with A Cross-Resolution Perspective of Theoretical Fundamentals and Emerging Applications – presented by Dr. Xuesong (Simon) Zhou, ASU
- Learning from Big and Small Data for Transportation Planning and Resilience Analysis – presented by Dr. Cynthia Chen, University of Washington

The following Student Learning Hub sessions are planned:

- Stairway Towards Systematic Review: Utilizing Rayyan Software & PRISMA Guidelines
- Python for GIS: An Introduction to OSMnx

Finally, the NYU team will host Korea Advanced Institute of Science & Technology (KAIST) for a multi-day workshop on research collaboration in May 2023, while the Rutgers team will attend and co-host workshops on Weigh-in-motion (WIM) technologies to demonstrate their system.

II. Participants and Collaborating Organizations

A. Partner Organizations

Table 2: C2SMART Active Partnerships with Updates during this Reporting Period

Organization Name	Location	Financial Support	Contribution	
			In-kind Support	Collaborative Research
AirSage	Atlanta, GA		X	X
CarbonCure	Dartmouth, Canada		X	
Camera	Brooklyn, NY		X	
City of Bellevue	Bellevue, WA		X	
City of El Paso	El Paso, TX		X	
Con Edison	New York, NY		X	X
ChargePoint	Campbell, CA			X
Gowanus Canal Conservancy	Brooklyn, NY			X
Gowanus By Design	Brooklyn, NY			X
Hudson River Transportation Mgmt. Center	Hawthorne, NY			X
Intelligent Transportation Society of NY	New York, NY		X	
King County Metro	Seattle, WA			X
Kistler Instrument Corp.	Buffalo, NY		X	
The Lighthouse Guild	US (various)		X	X
National Weather Service	US (various)			X
NEC Labs	Princeton, NJ	X		X
Nexar	New York City, NY			X
NEXT	Silicon Valley, CA			X
NJ Turnpike Authority	Woodbridge, NJ	X		
NJDOT	Newark, NJ	X		
NYC Department of Environmental Protection	New York City, NY			X
NYC Mayor's Office of the CTO	New York City, NY			X
NYC Mayor's Office of Resilience	New York City, NY			X

NYC Mayor’s Office for People of Disabilities	New York City, NY		X	
NYC Dept. of Citywide Admin. Services	New York City, NY		X	X
NYC Dept. of Transportation	New York City, NY	X	X	
NY Metro. Transportation Council	New York City, NY			X
NY State Dept. of Transportation	Albany, NY	X	X	X
NYSERDA	Albany, NY	X		
Oak Ridge National Laboratory (ORNL)	Oak Ridge, TN			X
Port Authority of NY&NJ	New York City, NY	X		
Precast Systems Engineering	Exmore, VA			X
Puget Sound Regional Council	Seattle, WA		X	
Replica	Oakland, CA		X	X
Revel	New York City, NY			X
Science and Resiliency Institute	Jamaica Bay, NY			X
Sloan Foundation	New York, NY	X		
Texas Department of Transportation	Austin, TX		X	
Texas Innovation Alliance	Austin, TX			X
Thermalstare LLC	Leesburg, VA		X	
The Things Network	Amsterdam, Neth.		X	
United Nations	New York City, NY			X
Via	New York City, NY		X	
Voltaic	Brooklyn, NY		X	
Washington State DOT	Olympia, WA		X	X

B. Other Collaborators or Contacts

1. Collaborations with Other Departments and Research Centers

C2SMART continues to promote inter-departmental research projects, renewing collaborations between Depts. of Civil/Environmental Engineering, Computer/Electrical Engineering, Computer Science, Urban Planning & Policy, School of Medicine, and the Center for Urban Science and Progress at NYU.

- For the study “COVID-19 and Older Adults: Understanding the Travel Challenges and Gaps in Urban Areas During the COVID-19 Outbreak,” the NYU team collaborated with Tracy L Chippendale, Associate Professor at NYU Steinhardt School of Culture, Education, and Human Development.
- The UTEP team continues to collaborate on numerous projects with the CTECH UTC led by Cornell and the UW team collaborates with the Region 10 PacTrans UTC, led by UW.

2. Inter-University Collaboration

- NYU hosted a Joint Transportation Research Summit with Tongji University in February 2023.
- Professor Benedetto Piccoli continues to collaborate with other members of the CIRCLES Consortium of UC Berkeley, Vanderbilt University, University of Arizona, and Temple University.
- UW and NYU colleagues have been regularly meeting regarding the use of the vehicle-traffic demand (VTD) model for CAV and EV related research, which is jointly conducted in NYC and Seattle.
- Professor Chow is collaborating with the U. of Luxembourg on M-EVRST (Multimodal Electric Vehicle demand Responsive Transport).
- The UTEP team continues to work with faculty at Czech Technical University who have established similar capabilities for Digital Twin and Augmented/Virtual Reality.
- Prof. Cheu is working with Dr. Lune-Fong to estimate the EV charging demand in Texas, and Profs. Villanueva-Rosales, Mondragon, and Bangert at UTEP to study how seniors adapt to new technology.
- Prof. Ceferino is collaborating with JHU on Compounding Natural Hazards and Cyberattacks on power systems and U College of London on Efficient Plans for Earthquake Emergency Response of Hospitals.

- The NYU team collaborated with Gabriela Gongora-Svartzman, Carnegie Mellon University, on “Assessing Spatial Similarity and Heterogeneity of COVID-19 Impacts on Mobility and Connectivity Using Social Media and Crowdsourced Data.”

3. Other Collaborations

- Prof. Weidner is Co-PI on NSF Track 1: Center for Collective Impact in Earthquake Science (C-CIES): Building Inclusive Excellence, Diversity, Equity and Community into Earthquake Science.
- Prof. Jiang is collaborating on NSF Collaborative Research: CPS: Small: An Integrated Reactive and Proactive Adversarial Learning for Cyber-Physical-Human Systems, EPCN: Distributed Optimization-based Control of Large-Scale Nonlinear Systems with Uncertainties and Application to Robotic Networks, and Designs and Theory for Event-Triggered Control with Marine Robotic Systems.
- UW researchers continue to engage in the CSET/USDOT Drone after school program.

III. Outputs

C2SMART is exceeding its targeted performance metrics in each of the areas identified in its Technology Transfer Plan, identified in Table 3. The following research outputs are produced with C2SMART Center support.

A. Publications, Conference Papers, and Presentations

1. List of Journal Publications

- Yang, H., Jiarui, C., Chenxi, L., Ke, R., Wang, Y. “Cooperative Multi-camera Vehicle Tracking and Traffic Surveillance with Edge Artificial Intelligence and Representative Learning.” *Transportation Research Part C: Emerging Technologies*. Vol. 148, 2023.
- Wang, H., Hong, W., Meixin, Z., Wang, C., Li, W., Tao, G., and Wang, Y. “Network-Wide Traffic Signal Control Using Bilinear System Modeling and Adaptive Optimization.” *IEEE Transactions on Intelligent Transportation Systems*. Vol. 24(1), 79-91, 2023.
- Ke, R., Cui, Z., Chen, Y., Zhu, M., Yang, H., Zhuang, Y., and Wang, Y. “Lightweight Edge Intelligence Empowered Near-crash Detection Towards Real-time Vehicle Event Logging.” *IEEE Transactions on Intelligent Transportation Systems*, 2023.
- Yang, H., Liu, C., Ling, Y., Kopca, C., Ricord, S., and Wang, Y. “Cooperative Traffic Signal Assistance System for Non-Motorized Users and Disabilities Empowered by Computer Vision and Edge Artificial Intelligence.” *Transportation Research Part C: Emerging Technologies*. Vol. 145, 103896, 2022.
- Ke, R., Liu, C., Yang, H., Sun, W., and Wang, Y. “Real-time Traffic and Road Surveillance with Parallel Edge Intelligence.” *IEEE Journal of Radio Frequency Identification*. Vol. 6, 693-696, 2022.
- Yan, Z., Zhang, D., Lu, X., Liu, Q., Wang, Y., and Sun, J. “Saturation Flow Rate at the Work Zone–Straddled Intersections with Interweaving Movements: Lane-Based Modeling Study.” *Journal of Transportation Engineering, Part A: Systems*. Vol. 148(10), 04022088, 2022.
- Zhou, Y., Zhang, Y., Yuan, Q., Yang, C., Wang, Y. “The Smartphone-Based Person Travel Survey System: Data Collection, Trip Extraction, and Travel Mode Detection.” *IEEE Transactions on Intelligent Transportation Systems*. Vol. 23(12), 23399 – 23407, 2022.
- Liu, C., Yang, H., Ke, R., Wang, Y. “Toward a Dynamic Reversible Lane Management Strategy by Empowering Learning-Based Predictive Assignment Scheme.” *IEEE Transactions on Intelligent Transportation Systems*. Vol. 23(12), 23311-23323, 2022.

Table 3: Output Performance Measures

Performance Measures	Annual Goal	Achieved (current period)
Peer-reviewed papers	20	58
Conference presentations	10	43
Joint proposals/projects with industry/agency partners	10	45
Website analytics	5,000 views	10,726

- Sha, D., Gao, J., Yang, D., Zuo, F., & Ozbay, K. "Calibrating Stochastic Traffic Simulation Models for Safety and Operational Measures Based on Vehicle Conflict Distributions Obtained from Aerial and Traffic Camera Videos," *Accident Analysis & Prevention*, 179, 106878, 2023.
- Nassif, H., Habib, M., Obeidah, A., Abed, M. "Restrained Shrinkage of High-Performance Ready-Mix Concrete Reinforced with Low Volume Fraction of Hybrid Fibers," *Polymers* 14, 4934, 2022.
- Lou, P., Yang, C., and Nassif, H. "Live Load Multiple Presence Factors for Design and Evaluation of Short to Medium Span Highway Bridges," *Transportation Research Board*, 2023.
- Ke, R., Azfar, T., Li, J., Yu, H., Cheu, R., Lv, Y., "Deep Learning based Computer Vision Methods for Complex Traffic Environments Perception: A Review", *IEEE Transactions on Intelligent Transportation Systems*, 2023.
- Ke, R. "Lightweight Edge Intelligence Empowered Near-crash Detection Towards Real-time Vehicle Event Logging," *IEEE Transactions on Intelligent Vehicles*, 2022.
- Ceferino, L., & Lin, N. "Hurricane Risk of Solar Generation in the United States," *Natural Hazards Reviews*, 2022.
- Avraam, C., Ceferino, L., Dvorkin, Y, "Operational and Economy-Wide Impacts of Compound Cyberattacks and Extreme Weather Events on Electric Power Networks," *Applied Energy*, 2022.
- Arora, P., Ceferino, L., "Probabilistic and Machine Learning Methods for Uncertainty Quantification in Power Outage Prediction Due to Extreme Events," *Natural Hazards and Earth System Sciences*, 2023.
- Ceferino, L., Lin, N., & Xi, D., "Bayesian Updating of Solar Panel Fragility Curves and Implications of Higher Panel Strength for Solar Generation Resilience," *Reliability Engineering and Structural Safety*, 229, 108896, 2023.
- Alisjahbana, I., Ceferino, L., Kiremidjian, A., "Prioritized Reconstruction of Healthcare Facilities After Earthquakes Based on Recovery of Emergency Services," *Risk Analysis*, pp. 1-16, 2022.
- Mota, R., Ferreira, N., Silva, J. D., Horga, M., Lage, M., Ceferino, L., Alim, U., Sharlin, E. & Miranda, F. "A Comparison of Spatiotemporal Visualizations for 3D Urban Analytics," *IEEE Transactions on Visualization and Computer Graphics*, 2022.
- Gao, J., Lee, C., Ozbay, K., Zuo, F., Chippendale, T., "Understanding the Travel Challenges and Gaps for Older Adults during the COVID-19 outbreak: Insights from the New York City Area." *Transportation Research Interdisciplinary Perspectives*: 100815, 2023.
- Sha, D., Gao, J., Yang, D., Zuo, F., & Ozbay, K., "Calibrating Stochastic Traffic Simulation Models for Safety and Operational Measures Based on Vehicle Conflict Distributions Obtained from Aerial and Traffic Camera Videos," *Accident Analysis & Prevention*, 179, 106878, 2023.
- Yang, D., Ozbay, K., Gao, J., Zuo, F., "A Functional Approach for Analyzing Time-Dependent Driver Response Behavior to Real-World Connected Vehicle Warnings." *IEEE Transactions on Intelligent Transportation Systems*, 2022.
- Li, H., Chen, X., Agrawal, A.K. and Ettouney, M., "Performance-Based Retrofits of Long-Span Truss Bridges for Collapse Resistance through the Alternate Load Paths," *ASCE Journal of Bridge Engineering*, Vol. 28(2), pp. 04022141, 2023.
- Zou, Z., Ergan, S., "Towards emotionally Intelligent Buildings: A Convolutional Neural Network Based Approach to Classify Human Emotional Experience in Virtual Built Environments," *Advanced Engineering Informatics*, 2023
- Nassif, H., "A Perspective on Quantifying Resilience: Combining Community and Infrastructure Capitals," *Science of The Total Environment*, 2023.
- Jiang, Z., "Exploring a COVID-19 Endemic Scenario: High-Resolution Agent-Based Modeling of Multiple Variants," *Advanced Theory and Simulations*, 2022.
- Rath, S., Liu, B., Yoon, G., Chow, J., "Microtransit Deployment Portfolio Management Using Simulation-Based Scenario Data Upscaling," *Transportation Research Part A: Policy and Practice*, 2023.

- Zou, Z., & Ergan, S. “Towards emotionally intelligent buildings: A Convolutional neural network-based approach to classify human emotional experience in virtual built environments.” *Advanced Engineering Informatics*, 55, 1–13, 2022.
- Yu, X., & Ergan, S. “Estimating power demand shaving capacity of buildings on an urban scale using extracted demand response profiles through machine learning models.” *Applied Energy*, 310, 2022.
- Ergan, S., Zou, Z., Bernardes, S. D., Zuo, F., & Ozbay, K. “Developing an integrated platform to enable hardware-in-the-loop for synchronous VR, traffic simulation and sensor interactions. *Advanced Engineering Informatics*, 51, 2022.

2. Books or Other Non-Periodical, One-Time Publications

- Ph.D. dissertation by Fan Zuo, NYU, Rethinking of learning mechanism in mobility context: A human and artificial intelligence mixture approach. December 2022.
- NCHRP Research Report 997: Algorithms to Convert Basic Safety Messages into Traffic Measures, a result of joint work by Noblis and NYU's C2SMART Center, has been published by The TRB National Cooperative Highway Research Program.
- Benitez, M., Weidner, J., Kreinovich, V., “How to Select Typical Objects”, a chapter in *Decision Making Under Uncertainty and Constraints*, Studies in Systems, Decision and Control, 2023.

3. Other Publications, Conference Papers, and Presentations

- C2SMART was well-represented at The Transportation Research Board’s (TRB) 102nd Annual Meeting this year, with 39 affiliated students and researchers [presenting ongoing work](#).
- McQuade, S.T., Denaro, C., Mahmood, M., Lee, J., Sprinkle, J., Work, D., Piccoli, B., Seibold B., Bayen, A.M., “Small-scale to large-scale implementation of cyber-physical human experiments on live traffic”, submitted to 4th IFAC Workshop on Cyber-Physical & Human-Systems, CPHS 2022.
- Chakraborty, S., Gao, W., Cui, L., Lewis, F.L., Jiang, Z.P., “Learning-Based Adaptive Optimal Output Regulation of Discrete-Time Linear Systems,” to be presented at the IFAC World Congress, Yokohama, Japan, July 2023.
- Chakraborty, S., Cui, L., Ozbay, K., Jiang, Z.P., “Automated Lane Changing Control in Mixed Traffic: An Adaptive Dynamic Programming Approach”, 25th IEEE International Conference on Intelligent Transportation Systems (ITSC), pp. 1823—1828, Macau, China, 2022.
- Nassif, H., Na, C.K., "Weigh-In-Motion Systems used for Vehicle Enforcement Screen," SWMA Interim Meeting, Raleigh, NC, and NEWMA Interim Meeting, Online/Virtual, on October 2022.
- Azfar, T., Weidner, J., Raheem, A., Ke, R., Cheu, R.L., “Efficient Procedure of Building University Campus Models for Digital Twin Simulation,” 2nd IEEE Digital Twins and Parallel Intelligence (DTPI) Conference, October 2022.
- Azfar, T., “Efficient Procedure of Building University Campus Models for Digital Twin Simulation,” C2Smart Student Learning Hub, November 2022.
- Azfar, T., Wang, C., Ke, R., Weidner, J., Raheem, A., Cheu, R.L., “Incorporating Vehicle Detection Algorithms via Edge Computing on a Campus Digital Twin Model,” ASCE International Conference on Transportation Development, accepted, 2023.
- Qin, J., Lu, D., and Ergan, S., “Towards Increased Situational Awareness at Unstructured Work Zones: Analysis of Worker Behavioral Data Captured in VR-based Micro Traffic Simulations,” 19th International Conference on Computing in Civil and Building Engineering (ICCCBE), Cape Town, South Africa, October 2022.
- Ke, R., “Incorporating Vehicle Detection Algorithms via Edge Computing on a Campus Digital Twin Model”, ASCE International Conference on Transportation Development, 2023.
- Ke, R., “Real-time traffic and road surveillance with parallel edge intelligence,” at 2nd Macao Conference on Smart City Technologies, and “Real-time traffic and road surveillance with parallel edge intelligence,” at IEEE DTPI, 2022.

- Ceferino, L., “Multi-hazards Risks of Large-scale Hospital and Power Systems,” Blume Center and SURF Affiliates and Alumni Meeting at Stanford University and Stony Brook University, November 2022.
- Chow, J., “A stable matching analysis framework for Mobility-as-a-Service platforms as two-sided markets” invited talks at the U. Connecticut and U. Buffalo, October 2022, and invited talks at U. Luxembourg, TU Delft, TU Munich, and TU Dresden, March, 2023.
- Ozbay, K., Systems, Signals & Devices”, IEEE International Multi-Conference, February 2023.
- Ozbay, K., “Stochastic Multi-Objective Optimization-Based Life Cycle Cost Analysis for New Transportation Technologies,” TRB 2023 AKB50(2) Subcommittee on Bridge Life Cycle Cost Analysis, January, 2023.
- Gao, J., “AI-Based Video Analytics for Vehicle and Pedestrian Detection, Tracking, and Speed Estimation Using Traffic Cameras: Applications and Opportunities,” NYCDDC and DOT Town+Gown Vision Zero Research on the Road, Part 5, November, 2022.
- Ozbay, K., “Data-driven Determination of the Impact of Truck Traffic on Traffic Safety using Weigh-In-Motion Data,” NYCDDC and DOT Town+Gown Vision Zero Research on the Road, Part 5, November 2022.
- Kiper, B., Lin, X., Owoborode, M., & Ergan, S. “An approach to generate point cloud-based defects for automated façade inspections” International Conference on Construction Applications of Virtual Reality, CONVR2022
- Park, K., & Ergan, S. “Toward Intelligent Agents to Detect Work Pieces and Processes in Modular Construction: An Approach to Generate Synthetic Training Data” Construction Research Congress 2022: Computer Applications, Automation, and Data Analytics - American Society of Civil Engineers.
- Lu, D., Ergan, S., Mann, D., & Lawrence, K. “The Need for Responsive Environments: Bringing Flexibility to Clinic Spaces” Construction Research Congress 2022: Computer Applications, Automation, and Data Analytics - Selected Papers from Construction Research Congress 2022, American Society of Civil Engineers (ASCE).
- Ergan, S., & Kiper, B. “Generative Adversarial Network (GAN) based data augmentation for enhancing DL models on façade identification,” ASCE International Conference on Computing in Civil Engineering, i3CE, 2022.
- Shi, Z., Lee, Y., & Ergan, S. “Model-based checklist generation for façade safety inspection guidance”, ASCE International Conference on Computing in Civil Engineering, i3CE, 2022.
- Ergan, S., Dai, F., Du, E., & Akhavian, R. “Launching successful datathons: lessons learned from recent ASCE VIMS datathons,” ASCE International Conference on Computing in Civil Engineering, i3CE, 2022.
- Ban, J. “Optimal Location and Sizing of Layover Charging Stations for Battery Electric Vehicles” at the Department of Civil and Environmental Engineering, Utah State University, in March 2023.
- Ban, J. “Multiscale Control of Urban Traffic Networks” at the Department of Civil Engineering, EPFL, February 2023.
- Ban, J. “Drone Technologies for Safety, Emergency Preparedness, and Resilience of RITI Communities” at the Center for Safety Equity Transportation (CSET) Tier 1 UTC, University of Alaska, Fairbanks, January 2023.
- Ban, J. “Sustaining American Transportation: Building Targeted, Resilient, Socially Just, and Forward-Looking Transit Infrastructure for All Americans, Scenario modeling for post-Covid return to work and transit usage,” Public Policy Exchange, The International Centre for Parliamentary Studies, October 2022.
- Ban, J. “Multiscale Urban Traffic Control with Connected and Automated Vehicles,” Dept. of Civil and Environmental Engineering, University of Michigan, October 2022.

B. Websites

The [C2SMART website](#) disseminates information about the Center’s activities and research, with 2,317 unique page views during this reporting period. The data produced from the Weigh-in-Motion (WIM) sensors on the Brooklyn Queens Expressway (BQE) Urban Roadway Testbed is saved to [NYC’s Open Data Portal](#). The [CIRCLES consortium site](#) and [El Paso Data Dashboard](#) continue to be highly trafficked.

C. Technologies or Techniques

- The Electromagnetic Energy Harvester team developed and successfully field tested the developed EMEH device on bridges in New Jersey. The configuration is shown in Figure 1.

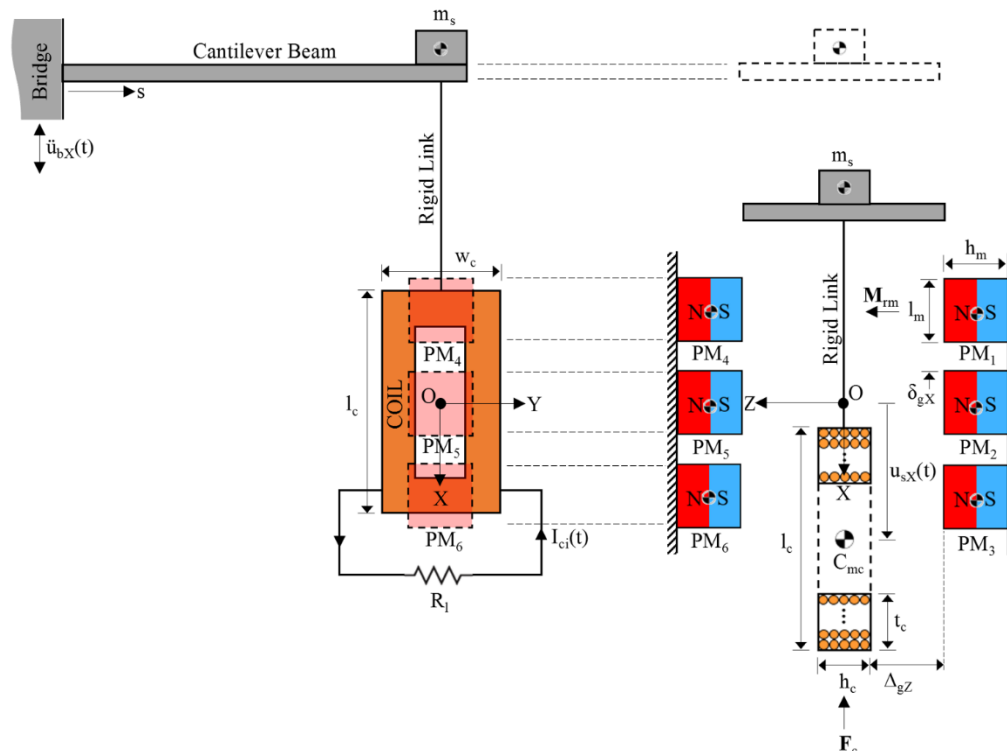


Figure 1: Configuration of the EMEH consisting of a cantilever beam, a thick rectangular air-core copper coil and two layers of three cuboidal permanent magnets

- Prof. Jiang developed a data-driven gain scheduling controller using adaptive dynamic programming.
- Prof. Chow’s project with NYCDOT developed an Android app route visualizer – designed to show the in-route experience of the driver, and a validation methodology for the synthetic freight population.
- Prof. Chow’s project with Replica developed and released the Python packages: AMXL and group-level AMXL model for ubiquitous discrete choice, GLAM Logit model for ubiquitous discrete choice datasets, and an Equity based mobility service design tool.

D. Industry/Agency Partners

Table 2 lists all current active or renewed collaborations with agency and industry partners. In addition:

- C2SMART is actively working with the New York State Department of Transportation (NYSDOT) on six research projects under its long-term consortium agreement.
- Professors Ozbay and Nassif continue to work directly with the NYC Department of Transportation via NYC Town+Gown to study and implement Weigh-In-Motion sensors throughout New York City, as well as on C2SMART’s Smart Urban Roadway Testbed on the Brooklyn Queens Expressway.

- Professor Ozbay’s team continues to work with Noblis on USDOT’s Benefits/Cost Lessons Learned project, as well as on the NCHRP CAT study.
- Professor Nassif is working with NJDOT on the Bridge Resource Program, as well as REEFENSE - A Mosaic Oyster Habitat (MOH) for coastal defense (DARPA).
- The UTEP team has numerous ongoing projects with TTI and Texas agencies, while the UW team is working with local agencies in Seattle and Washington.

E. Other Products

- Prof. Chow’s team released a calibrated Synthetic Freight Population containing all relevant information about the truck tours calculated by the research process.
- A web-based platform hosting the two computer vision applications was developed and hosted on the C2SMART server: <https://urban-intellivision.tandoncsmart.com/work-zone-map>

IV. Outcomes

A. Increased Understanding and Awareness of Transportation Issues

- The Rutgers-NYU team working with NYCDOT on the BQE continues to provide weights, configurations, and license plates of the overweight trucks based on the WIM and ALPR systems at the BQE testbed. Many trucks violated the weight restriction multiple times. The team was able to identify the weights, configurations, and license plates of these multi-violation trucks. The final sensor layout of the BQE WIM testbed is shown in Figure 2.

Table 4: Outcomes Performance Measures

Performance Measures	Annual Goal	Achieved (current period)
Media interviews, mentions, coverage	10	5
Workshops, webinars, and seminars	10	10

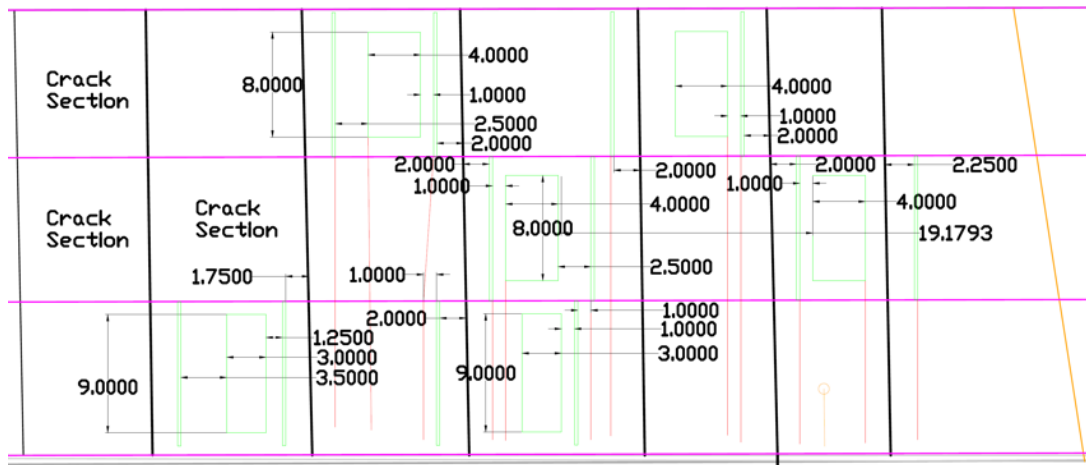


Figure 2: Final BQE-WIM Sensor Layout for the New Smart Roadway Testbed

- Prof. Piccoli’s project has demonstrated how collaborative driving has been shown to reduce fuel consumption and reduce fuel emissions. The gains in fuel economy can be greater than initially expected, as shown in the publication: Stern, Raphael E., et al. "Dissipation of stop-and-go waves via control of autonomous vehicles: Field experiments." *Transportation Research Part C: Emerging Technologies* 89 (2018): 205-221. This will have a tremendous impact on the oil industry.
- FloodNet’s alerting system continues to be useful to city agencies tasked with reacting to flood conditions, and has been integrated into New York City’s long-term climate response strategy.

- The web-based platform developed on PI Jingqin Gao’s project provides a new way for transportation agencies to explore where active work zones are happening in real-time across the city, using data from installed traffic cameras. It also provides an approximation of how many work zones are active, what work zone elements are being used, and the duration of the work zones. This creates a new stream of data and real-time visualization.

B. Increases in the Body of Knowledge

- Prof. Chow’s project utilizing Replica data found that data on population size and sociodemographic information are quite reliable, while the origin-destination flows at the tract level cannot fit perfectly to CTPP data. To this end, models dealing with ubiquitous datasets should be capable to identify bad data points. Coefficients cannot be estimated for infeasible agents (account for 8.25% in NYS), and most of these agents are small trips or trips made by students. A practical use of the developed g-AMXL model is to figure out trips with irregular coefficients. Moreover, the developed equity-based decision support tool provides a data-driven approach for transportation planners and policymakers to consider statewide transportation equity. According to experiments, maximizing total revenue and maximizing total welfare result in similar service regions, which can be explained by the concept of compensating variation. However, they might increase transportation inequities by increasing the welfare disparity. These provide quantitative support for a future system design.

C. Improvement and Adoption of Processes, Technologies, Techniques and Skills in Addressing Transportation Issues

- Professor Nassif’s team demonstrated to a number of agency officials and decision-makers that the state-of-the-art WIM sensor (Piezo-Quartz sensor) and software-based ALPR system used to identify overweight trucks for future enforcement practice is tenable and accurate. Prof. Nassif attended the regional National Conference on Weights and Measures (Western, Central, Southern, and Northwest) to propose the amendment of the existing NIST HB 44 Section 2.25 for autonomous OW enforcement. NYCDOT is currently in the process of implementing the system on the Brooklyn-Queens Expressway, where the number of overweight trucks and the extent of overweight tonnage is unknown. The team continues to capture the weights and configurations of the overweight trucks based on the WIM and ALPR systems at the BQE testbed.
- The group-level IO algorithm developed as a result of the data from Replica can considerably reduce the computational time as well as avoid overfitting to some extent. The objective function is convex, which means we can solve the problem using Newton’s method by updating the Hessian and Jacobian matrix. The developed model is quite suitable for datasets with large volume while uncertainty at a fine granularity (like missing values).
- The UW team continues to improve the suite of simulations that work together: MATSim for macro (agent-based) traffic demand simulation, SUMO for microscopic traffic simulation, and Unity for vehicle simulation. Together they model CAVs in different environments and settings.
- Professor Jiang’s research seeks to address the problem of lane changing of AV in mixed traffic. Using reinforcement learning and adaptive dynamic programming, a novel data-driven optimal control algorithm is designed for the lateral/longitudinal control of AV for lane changing. Also, a gain scheduling-based data-driven controller design method is proposed to handle non-linearities in the system dynamics. The technologies in the research have made new contributions to transportation, especially lane changing. The integration of reinforcement learning, and gain scheduling is a promising approach to the development of next-generation vehicle technologies in the era of connected and autonomous vehicles.
- NYCDOT currently relies on inhouse staff to manually provide routing on a hotline for freight trucks. This process will be largely replaced with the faster, more reliable routing app developed under Prof.

Chow’s project. Additionally, the Freight Data visualizer will combine previously separate data sets into one location that can be used to show patterns in freight movement across the city.

- The emerging deep learning method of computer vision developed under PI Jingqin Gao’s project has been adopted with existing ITS infrastructure and publicly available traffic camera data. The web application developed in the project is ready, with a live demonstration of the application planned for the project’s advisory board.

V. Impact

A. Effectiveness of the Transportation System

- FloodNet’s continued flood monitoring is yielding a dataset with minute-to-minute updates from each of the sensors. The alerting system offers an opportunity to warn drivers and city agencies of flooded streets in real time.
- The Rutgers RIME team attended the National Conference on Weights and Measures in Savannah, GA in January 2023 to promote the amendment of the existing NIST HB 44 Section 2.25 for autonomous OW enforcement. The team’s proposed amendment was promoted to “Informational” status to discuss further within the Standard and Tolerance (S&T) Committee to finalize the amendment.
- Professor Chow of NYU was an invited participant in "U.S. Department of Transportation (USDOT) Workshop: Transportation, Mobility, and the Future of Infrastructure" in December 2022.

Table 5: Impacts Performance Measures

Performance Measures	Annual Goal	Achieved (current period)
Instances of software, tools, research results, or guidelines adopted by transportation agencies leading to operational improvements	5	18
Partnerships/collaborative relationships with companies or transportation agencies established or renewed	10	28

B. New Practices or Companies

- Professor Agrawal of CCNY patented the Laser Ranging Over - Height Vehicle Detector System (LARA - OHVD) generated from his C2SMART research project. Patent No.: US 11,487,010 B2, (Nov. 1, 2022).
- Professor Ergan is serving as an advisor to Tall Wall Robotics, Inc., a startup company formed as a spin-off of the collaborative research on the DOE-funded EEASE-bot work on detecting facade energy problems using robotic technologies.
- Professor Ergan was involved in the submission of provisional patent for a Robotic Envelope Assessment system.

C. Body of Scientific Knowledge

- The development of VR-based worker safety training platform for work zone safety is a novel approach to previously available training contents which most often employed web-based interactive learning platforms or simple lecture videos for participants to passively acquire the knowledge. The VR-based platform developed under Prof. Ergan’s project offers an interactive module where participants can interact with different objects that are synced with audio instructions on the module’s learning contents. A user study assessing the effectiveness of the platform will add to the knowledge and implication of the application of VR in the worker safety domain for industry professionals.
- UTEP Professor Ruimin Ke received the Outstanding Paper Award, 2022 IEEE Digital Twins and Parallel Intelligence (DTPI) Conference and the 2023 Best Paper Award, TRB Standing Committee on Information Systems and Technology.

- C2SMART members received a number of other awards at TRB 2023, including two from the International Journal of Science & Technology:
 - Ding Wang, Brian Yueshuai He, Jingqin Gao, Joseph Y.J. Chow, Kaan Ozbay, and Shri Iyer (NYU) won the Most Cited Paper Award for their publication, “Impact of COVID-19 behavioral inertia on reopening strategies for New York City transit.” The article was initially published in the International Journal of Transportation Science and Technology in 2021.
 - Professor Joseph Chow (NYU) was also honored with the Outstanding Associate Editor Award in recognition of his outstanding contribution to the quality of the journal in 2022.
 - Zilin Bian, NYU, was awarded second place in the TRB Artificial Intelligence and Advanced Computing Applications Committee Best Dissertation competition.
 - Chan Yang, Rutgers, was selected as first place in the Long-Term Infrastructure Performance (LTIP) Student Data Analysis Contest.
- Professor Ceferino was re-elected as Co-chair of the Public Health Working Group from the EERI Learning from Earthquake’s Program.
- Prof. Wang of UW was honored as Distinguished Member, American Society of Civil Engineers, Mar. 2023, Fellow, Institute of Electrical and Electronics Engineers (IEEE), Jan. 2023, received the 2023 Francis C. Turner Award, American Society of Civil Engineers, Feb. 2023, the Best Paper Award, AED30 Information Systems and Technology Committee, Transportation Research Board (TRB), Jan. 2023, and the Outstanding Paper Award, 2022 IEEE International Conference on Digital Twins and Parallel Intelligence (DTPI 2022), Smart Cities Conference, Oct. 2022.
- Prof. Agrawal received the 2023 Distinguished Member of ASCE Award, 2023 Raymond C. Reese Research Prize for the paper “Performance-Based Design Framework for Concrete Barriers Subjected to Truck Collision,” and 2022 Research Implementation award for the project “NJDOT UAS/Drone Procedures Manual and Best Practices for Use in New Jersey” by NJDOT.

D. Transportation Workforce Development

- UTEP student Lauren Brown, a Masters student with The Border Intermodal Gateway (BIG) Transportation Laboratory, was selected as C2SMART’s Student of the Year.
- The NYC truck routing Hackathon engaged undergrads and external members who were not aware of or interested in the truck routing problem of NYC. Introducing it at TransportationCamp provided an opportunity for new entrants to engage with the topic.
- The team is providing workshops for high school students on deep learning techniques for image identification and segmentation.
- The UW team also continues to participate in the CSET/USDOT Drone after school program in WA.
- Chan Yang was selected first place in the Long-Term Infrastructure Performance (LTIP) Student Data Analysis Contest. The contest’s goal was to encourage university students to use data from the Long-Term Pavement Performance (LTPP) web portal, LTPP InfoPave™, or the Long-Term Bridge Performance (LTBP) web portal, LTBP InfoBridge™, for the analysis. The intent was to introduce potential future transportation engineering professionals to quality performance data, applying that data by using appropriate research methods to derive recommendations, and using that data to make informed decisions.
- The Rutgers team also received First Place (Bridge) of the Inaugural 2022 Student Data Analysis Contest from FHWA.

VI. Changes/Problems

- Professor Yury Dvorkin’s project was cancelled as the PI moved to a different institution outside of C2SMART. Funds dedicated to the project were repurposed for other Center programming.