SEMI-ANNUAL PROGRESS REPORT

Submitted to the Office of the Assistant Secretary for Research and Technology

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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 test 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

Following university guidance, many C2SMART students, faculty, and staff have returned to on-campus work. In person events are planned for the end of spring and summer. With additional funding from authorization of two new projects as part of the C2SMART Center's research agreement with NYSDOT, the Center is aiming to hiring two additional postdoctoral associates.

2. Research

Table 1: Projects Completed During this Reporting Period

Urban Mobility and Connected Citizens	Lane Changing of Autonomous Vehicles in Mixed Traffic Environments, NYU	This project introduced an optimal data-driven control algorithm to solve the lane-changing problem of AVs using approximate/adaptive dynamic programming (ADP). Existing approaches in the literature of lane changing do not guarantee optimal control of AV, and require solving an optimization problem at each step, whereas this approach only requires learning at specific time intervals with a smaller number of data points when longitudinal velocity changes. Also, due to the fast convergence of the proposed methodology, it is suitable for real-time applications.
	Modeling and Optimizing Ridesourcing Services in Connected and Automated Cities UW	This project developed a general equilibrium modeling framework for an integrated, multimodal CAV ridesourcing and transit system to study customers' mode choices and resulting congestion patterns. The proposed framework and the modeling results are expected to provide useful insights to ridesourcing companies, transit agencies, and city managers about integrating ridesourcing and transit to better solve issues related to urban commuting. Results showed that the demand for shared rides and transit is affected by the relative costs of different types of travel modes in the integrated system. The model can help systematically investigate the mode choices of customers and measure resulting congestion effects in the network.
Resilient, Secure, and	Equitable Access to Residential	This project developed metrics to measure equity and social justice in existing EV charging infrastructure in NYC. The metrics, based on statistical and machine learning techniques, were incorporated in the development of an equity-centric decision support tool for designing public EV charging tariffs. The framework incorporates energy justice

	(EQUATOR) EV Charging, NYU	considerations and ensures that the economic, environmental, and public health impacts of electrified transportation are equitably distributed. They also developed a GUI-based dashboard that visualizes injustices in access to EV charging infrastructure.

Table 2: Updates on Ongoing Center-funded Research Projects

Urban Mobility and Connected Citizens	**A MultiScale Simulation Platform for Connected & Automated Transportation Systems,** UW	The project team completed the SUMO-MATSim-Unity control system, created a traffic environment in Unity, deployed synthesis of traffic signals between SUMO and Unity, simulated a traffic scenario in the Greater Seattle area using the platform, and configured activity parameters in MATSim and Unity. They will fine-tune the unity traffic environment and explore the features of macroscopic fundamental diagrams using VTD simulation results.
	Autonomous Vehicle Good Citizenry Standard, NYU	Three autonomous vehicle stakeholder workshops were held on the topics of governance, integration with transit, safety, data, and equity and accessibility, with 20 attendees from government, private industry, non-profits and advocacy groups per session. The Co-PIs progressed a districting algorithm which aims at generating a zoning system for a given set of demographic datasets to achieve tolerable sampling errors. The algorithm was tested on 62 census tracts in lower Manhattan.
	Evaluating Remote Repositioning for Shared Scooters, UW	This project is on hold due to COVID-19-related supply chain issues that affected scooter shipments by industry partner Spin, which would be evaluated as part of this project's scope. In the wake of Spin's acquisition by Tier Mobility, the project is being rescoped to entail an evaluation of another pilot.
	Collaborative Driving, Ramp Metering & Mean-field Controls, Rutgers	Researchers designed a control algorithm working with several modes and tested in simulations on a highway without on and off ramps. Testing simulations were conducted with heterogeneous traffic. The team identified ramp metering cases of interest towards decreasing congestion and increasing safety. They will extend the mean field model to different levels of heterogeneous traffic and conduct initial simulations in SUMO to test the control algorithms.
Urban Analytics for Smart Cities	**C2SMART COVID-19 Data Dashboard,** NYU, Rutgers, UW	The research team enhanced the user interface, visualizations have been redesigned to accommodate a larger date range, and a feature request form has been added on the home page to collect user feedback. The team has also generated a data overview on the dashboard homepage that automatically summarizes and updates weekly changes for multiple mobility and safety indicators.
	Quantifying & Visualizing City Truck Route Network Efficiency Using a Virtual Test Bed, NYU	The team continued to refine and update the network of the routing app to meet the requests of NYCDOT. They analyzed and refined the freight data collected from various open NYC sources and wrote a script to generate complete truck tours. They will continue to add requested features (tolls, time of day, etc.) and will host a hackathon with NYCDOT to finalize the app's navigation interface.
	Utilizing Social Media Data for Estimating Transit Performance Metrics in a Pre- & Post-COVID-19 World, CCNY	Researchers have conducted social media data analysis, building a model to classify tweets by content category. They are improving the model performance and have conducted preliminary comparison of sentiment and transit performance for the pre-COVID-19 period. Analysis shows a correlation between tweet frequency and public transit events when there are delays or problems on subway lines, or a significant event (such as derailment) for commuter rail. Seasonality was exhibited pre-COVID but this trend has not carried forward.
	Calibration of Safety Notifications through Reinforcement	35 participants participated in user studies where they placed cones on mobile work zones on an urban street in the PI's VR platform. Statistical analysis was conducted on the data and observed a habituation effect of workers to alarms. The team developed machine learning algorithms to generate statistical data, selecting RL

	Learning and Eye Tracking, NYU	model code libraries and setting up the model platform. The team is investigating ways to train a separate worker behavior model using the VR user experiment data
	Exploring AI-based Video Segmentation/ Saliency to Optimize Imagery-Acquisition from Moving Vehicles, NYU	The team improved their current video summarization model by training it with additional driving videos to fine-tune its parameters. They proposed a novel task-specific domain method for video summarization and evaluated both models on large video datasets, showing promising improvements in performance. The team is developing a novel panoptic moving object counting algorithm to predict moving object count and location and will work to improve its robustness and efficiency, especially towards counting cars.
	Digital Twin Tech. for Interactions between Transportation & Other Civil Infr. Systems, UTEP	The team is finalizing the integration of VISSIM and LOD 300 BIM models to integrate simulation and information models with reality capture. They've also developed the capacity to create synthetic digital twin response input (like signal timing, DMS input) to VISSIM, and mapped out scenarios to explore in the digital shadow models. The team will explore the challenges from scaling to city from campus models and develop a community engagement workshop.
Resilient, Secure, and Smart Transportation Infrastructure	Implementation & Effectiveness of Autonomous Enforcement of Overweight Trucks in an Urban Infras. Environment, Rutgers	The team performed verification tests of the automated license plate recognition (ALPR) cameras installed in the BQE testbed in NYC during the previous quarter. The team recorded the live data stream of the weigh-in-motion (WIM) system and the ALPR system to perform verification. The team worked with Kistler and subcontractors to evaluate the pavement condition for the new testbed site. The pavement was visually observed to check the apparent cracks or defects in the roadway. The team continuously collected WIM data of 5 lanes at the testbed and provided them to the NYCDOT data repository.
	Field Application of High-Power Density Electromagnetic Energy Harvester to Power Wireless Sensors in Transp. Infrast., CCNY	The team designed a prototype of a modified electromagnetic harvester (EMEH) which has a smaller design than in the first phase of the project. The PI carried out an optimization study on the analytical model of the device, which will be fabricated in a Machine Shop. A lab study using a vibration shaker will evaluate the performance of the device along with the size and interaction of the dynamic magnifier with a coil moving through permanent magnets. A highway bridge will be identified for field testing of the device.
	Comprehensive Analysis of Air Quality in the NYC Subway System, NYU	A trial campaign in which air was sampled in 9 subway stations was conducted, and data was post-processed. Measurements were conducted at one second intervals on cars and station platforms. Researchers found that concentration of PM 2.5 was higher than the EPA recommended daily average concentration limit. Concentration spiked when trains arrived at the station. The team is developing an interactive visualization portal for these results.
	Deployment & Tech Transfer of a Street-level Flooding Platform: Sensing & Data Sharing for Urban Accessibility & Resilience, NYU	The team continued to fabricate and deploy newly designed sensors, added a community request form for sensor deployments, and developed a new partnership with the Bronx River Alliance, the Red Hook Initiative, and Pioneer Works in Red Hook Brooklyn. The team received blanket permission from NYCDOT to deploy sensors on u-poles around the city and gateway deployment permissions for a rooftop site run by New York City Housing Authority. Additional funds for community engagement activities were awarded from the Alfred P. Sloan Foundation.
	Advanced Weigh-in-Motion System for Autonomous Enforcement of Overweight Trucks, Rutgers	The team calibrated the Structural Health Monitoring (SHM) and Fiber Optic sensors for several trucks measured with WIM sensors on the smart roadway testbed on the Brooklyn Queens Expressway (BQE). The team validated the sensors in laboratory on 5 concrete beams and are analyzing the data. They will keep working with NYCDOT and TCDJV to complete calibration

During this reporting period, C2SMART issued its annual request for proposals for Center-funded research projects and initiatives and authorized 10 new projects for the following research year. The RFP called for four main tracks of proposals to prioritize funding for projects to address the following key areas of importance for C2SMART, its partners, and USDOT:

- Track 1: Research-to-Implementation projects
- Track 2: Student-led projects and initiatives
- Track 3: Workshops, training, and workforce development
- Track 4: Short-term high-impact projects in USDOT priority areas, or synthesizing previous years of C2SMART project activity

Of 15 received proposals, 10 were selected for funding following C2SMART's three step review process. Proposals were screened and then sent to peer reviewers for evaluation and comment. Following received comments, preliminary approved proposers were able to revise and resubmit proposals. Following successful resolution of comments and suggestions, projects were finalized for selection. This process included evaluation on the following criteria:

- Research needs identified by end user
- Concreteness of success criteria
- Feasibility, specificity, and relevance of project deliverables
- Specific, measurable impact metrics
- Defined outreach and workforce development activities built into the schedule of tasks
- Key dependencies built into the schedule of tasks

The following projects were awarded funding for the 2022-2023 academic year:

Table 3: 2022-2023 C2SMART Center Funded Projects

Urban Mobility and Connected Citizens	**Work Zone Safety: Virtual Reality-based Traffic-simulation Platform for Workforce Training and Pedestrian Behavior Analysis,** NYU	Fatalities in US roadway construction work zones are a huge occupational hazard. This project aims to address this pressing challenge by developing a virtual reality-based traffic co-simulation platform for enabling immersive training of construction workers under exposure to danger, and calibrating frequency, sound, vibration, and variation of alarms to promote safe behavior.
	Automated Lane Change and Robust Safety, NYU	This project aims to take a significant step forward towards developing innovative solutions for autonomous lane change maneuvers. C2SMART researchers aim to achieve three major objectives: (1) integrating reinforcement learning and control functions to address safety-oriented constraints; (2) developing robustness analysis and robust redesign for connected and autonomous vehicles in the presence of uncertainties and time delay; and (3) validating the proposed lane changing control algorithms with real-world trajectory data and SUMO testing of different environments in the presence of different vehicle mixes and driver uncertainties.
	Digital Twin Technologies Towards Understanding the Interactions Between Transportation and other Civil Infrastructure Systems Phase 2, UTEP	In the first phase of this project, the research team built a digital shadow of campus civil infrastructure and visualized impacts of construction project schedules on the surrounding transportation infrastructure. Instead of using historical data to build an offline digital shadow, phase 2 of the project will develop a Smart Living Lab, which enables live data streams from three selected sites on campus via sensor instrumentation, data communication, and database design. The goal is to accelerate the understanding and adoption of digital twin technology that will bring positive impacts to the civil engineering industry through efficient data management, visualization and decision making.

Urban Analytics for Smart Cities	NY Statewide Behavioral Equity Impact Decision Support Tool with Replica, NYU	Replica has developed a consistent, nationwide activity-based synthetic population that can be used by local agencies across the country. In partnership, C2SMART researchers will build out a behavioral response decision support tool designed to measure impacts on equity for different transportation systems design change. The tool will identify underserved communities in rural areas that would best benefit from introducing new mobility services under a fixed statewide deployment budget.
	One-to-Many Simulator Interface with Virtual Test Bed for Equitable Tech Transfer, NYU, UW	C2SMART researchers will develop a broad API to handle interfacing any simulation with a multi-agent demand simulator, and they'll test this interface on the existing simulations, considering equity impacts on different population segments such as by income, ability, and age. Successful implementation will help existing simulations to evaluate new transportation policies and scenarios.
	Cost-effective Approach Towards Building a Traffic Sign Data Inventory Using Open Street Images, UW	In partnership with Washington State DOT, the team proposes a cost-effective AI-based approach to build a traffic sign data inventory using open street maps. The outcome can support asset management plans with respect to life cycle planning, performance measurement, risk consideration, and help automate the traffic sign detection process using open street data while saving labor for manual labeling and makes the process more efficient. Certain areas, including Rural, Isolated, Tribal, or Indigenous (RITI) communities, often lack information about the distributions and conditions of their assets and this project aims to address this equity issue.
	Exploring Cost-effective Computer Vision Solutions for Smart Transportation Systems, NYU	The project will develop a deep-learning-based data acquisition and analytics tool using vision-based sensors (e.g., cameras) to understand cities with machine eyes. The team will assess the maturity of various smart city applications using computer vision and object detection (e.g., pedestrian detection, work zone identification, curb lane usage, connected and automated vehicles (CAVs)) to match the given needs of agencies. This project aims to deploy two computer vision smart city applications based on stakeholder feedback that are customized for New York City (NYC).
Resilient, Secure, and Smart Transportation Infrastructure	AI Based Overheight Vehicle Warning System for Bridge, CCNY	Overheight vehicles cause extensive damage to lower-lying infrastructure and lead to frequent traffic issues. This research aims to develop a very low-cost AI-based overheight vehicle warning system using cutting-edge camera technology, augmented reality and an AI based height detection approach. Implementation of the research might significantly reduce the impact on bridges by overheight trucks, improve bridge safety and traffic, and save millions of dollars of damage to bridges.
	Developing a Framework to Optimize Flood Net Sensor Deployments Around NYC for Equitable and Impact-based Flood Monitoring and Data Collection, NYU	C2SMART's research produced FloodNet, a hyperlocal flood detection system poised to improve the resilience of New York City. This year, the project will develop a framework and define metrics with feedback from the NYC Mayor's office to ensure the project's successful implementation. The project will build a risk–informed digital twin of NYC integrating multiple data streams to guide the deployment of the FloodNet monitoring system in NYC. This deployment of sensors will provide real-time warnings for hyper-local flooding, allowing for critical life – saving mitigation measures that protect the most vulnerable populations, as well as data that can be used for risk management e.g., distribution of recovery efforts.
	Evaluation of Integrated Overweight Enforcement System using High Accuracy Weight-In-Motion System and Non-Proprietary ALPR System, Rutgers	Partnering with NYCDOT, researchers have developed an urban structural health monitoring testbed on the Brooklyn Queens Expressway to extend the life of this roadway by applying the latest infrastructure resiliency research. The team will work to establish the second testbed for overweight truck enforcement. The team will develop the site-specific sensor layout, install the Quartz sensors and ALPR cameras to measure the truck weight data and identify the license plate and/or USDOT number, and evaluate the performance of the overweight truck enforcement system. The team will also estimate the impact of an extreme event using collected data for

		infrastructure resilience. This implementation will help extend the service life of the roadway and provide safe infrastructure for road users.
	Urban - DEPOT: Deploying EV Charging Infrastructure in an Urban Environment, NYU	The proposed research effort develops tools for forecasting electric vehicle charging demand and for placing and siting electric vehicles charging stations in an urban environment, while considering transportation, electric grid, and urban-space constraints. The project engages two private-sector organizations which are directly associated with the proposed effort: Consolidated Edison, one of the largest private energy providers in the United States, and ChargePoint, which operates the largest online network of independently owned EV charging stations.

Table 4: Matching or Complementary-funded Projects to C2SMART-funded Projects

Urban Mobility and Connected Citizens	NYC Connected Vehicle Deployment – Mobile Accessible Pedestrian Signal System Application	USDOT/ NYCDOT/JHK Engineering
	NYC Connected Vehicle Deployment – Cooperative Driving	
	NYCDOT Off-Hour Deliveries	NYCDOT
	Multi-Agency/Multimodal Construction Management Tool to Enhance Coordination Projects City-Wide During Planning and Operation Phases to Improve Highway Mobility and Drivers Experience	NYCDOT/ NYSDOT
	Statewide Open-Source Advanced Traffic Management System (ATMS) Software Research and Pilot	NYSDOT
	Statewide Mobility Services Program Strategic Procurement Planning	NYSDOT
Urban Analytics for Smart Cities	Utilizing Cooperative Automated Transportation (CAT) Data to Enhance Freeway Operational Strategies	NCHRP/Noblis
	Analytical Support Services IDIQ	BTS
	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 University of California	NSF
Resilient, Secure, and Smart Transportation Infrastructure	AASHTO and NBI (National Bridge Inventory) Element Deterioration Rates for Bridge Management System	NYSDOT
	Bridge Resource Program	NJDOT
	Capital Program Resource Model	NYSDOT
	Pilot/Scoping Study to Plan SHM and NDT Systems for BQE	NYCDOT
	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
	Surveillance for SARS-CoV-2	NYCDEP
	Principles and Pathways for Public Engagement by NYC Communities with Interpretable, Reliable, and Actionable Flood-Related Data	Alfred Sloan Foundation
	Research and Development Projects to Optimize Wastewater Treatment Plant Operations – SARS-CoV-2 Surveillance	NYCDEP

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 following classes were offered during this period:
  - o Build Your First Interactive Data Dashboard Using Dash Plotly
  - o Hands-On Tutorials for Amazon Web Services (AWS)
  - o Natural Language Processing Methods for Textual Similarity using Python
  - o Introduction to Cybersecurity and Its Application in Transportation
  - o Get Started with Blockchain: Distributed Ledgers for Real Use Cases, using Hyperledger Fabric
- C2SMART launched and hosted a **Fireside Chat** featuring *Laura Fox*, General Manager of Lyft's CitiBike program, New York City's bike share program, in conversation with C2SMART doctoral student Suzana Duran Bernardes, who is researching micromobility safety and equity. The event, Cycle Speak with Laura Fox: Citi Bike & Urban Mobility, was designed to expose students to industry leaders and discuss relevant work and career opportunities. It was held on November 18, 2021.
- On October 16, 2021, C2SMART sponsored the annual TransportationCamp NYC "un"-conference in which conference sessions are designed by event attendees. This day-long transportation event featured a keynote talk by Chris Pangilinan, Head of Global Policy, Public Transportation at Uber, and Clarrissa Cabansagan, Director of Programs at TransForm, moderated by C2SMART Managing Director Shri Iyer.

C. *Dissemination and Outreach*

1. Training and Tech Transfer Events

a) **Conference Presentations and Research Showcases**

- PIs on the "Autonomous Mobility: Good Citizenry Standard" project, Sarah Kaufman and Joseph Chow, with research assistant Bingqing Liu, participated in a webinar, "NYC 2025," on March 28, 2022 hosted by the NYU Wagner. The event focused on pandemic recovery initiatives around mobility.
- Sarah Kaufman also participated in a webinar with PAVE: Partners for Automated Vehicle Education, "AVs and the City of Tomorrow: The City as a System" on February 9, 2022.
- Kaufman also hosted "Excellence in Transportation," for the NYU's Rudin Center for Transportation Policy and Management, on March 3, 2022. The event was an online version of the annual fundraising event hosted by the Center, and included several key speakers, including:
  - o Polly Trottenberg, Deputy Secretary, U.S. Department of Transportation
  - o Kathryn Garcia, Director of Operations, New York State
  - o Janno Lieber, Chair and CEO, Metropolitan Transportation Authority
  - o Meera Joshi, Deputy Mayor, New York City
- Professor Zhong-Ping Jiang was session chair at the 60th IEEE International Conference on Decision and Control (DCD 2021).
- Three C2SMART PIs and two students presented on their ongoing projects at NYU's Urban Research Day on March 8, 2022.
- On February 24, 2022, the USDOT hosted a video forum featuring the latest innovative research in artificial intelligence in transportation from UTCs. C2SMART's entry showcased our work in Big Data in Smart Cities via our COVID-19 Data dashboard and our Safety in Transportation Systems research area through innovative use of VR in roadway workzones.

- On December 23, 2021, the Equitable Commute Project, of which C2SMART is a core partner, held a kickoff event where e-bikes equipped with C2SMART-designed safety sensors were distributed to essential workers for a pre-pilot data collection and evaluation period.

b) Workshops

- Professor Hani Nassif hosted the Bridge Design Workshop on Dec. 21, 2021, as part of the Bridge Resource Program.
- The FloodNet team hosted 3 data visualizations workshops for community feedback in Dec 2021
- Professor Jiang invited Professor Francesco Bullo from the University of California, Santa Barbara to give a seminar at the Electrical and Computer Engineering department at NYU on Feb 10, 2022.
- On November 11, 2021, C2SMART hosted a workshop for all our current and prospective PIs called "Equity in Transportation Research" to help researchers conceptualize how they might engage with questions of equity and social justice in their projects, and to set guidance around how UTCs can lead the way in solving transportation equity problems. Panelists were Luis Artieda, World Enabled, Amy Fong, US Department of Labor, Office of Disability Employment Policy, Alice Grossman, Texas Transportation Institute, and David Bragdon, Transit Center.

2. Industry and Public Agency Outreach

- Sarah Kaufman led three workshops on the topic of Autonomous Mobility and the policy implications if its introduction to New York City. Individuals from a range of stakeholder organizations participated in the workshops in December, including private sector leaders, local and state government officials and neighborhood representatives.

3. Seminars and Webinars

C2SMART launched the **"State of the Field: Structural Health Monitoring,"** seminar series to highlight important issues in this field during this period. This event series was launched this period to take a deep dive on the latest advances in transportation engineering research through a series of thematically-tied events aimed explicitly at agency and industry audiences:

- Structural Health Monitoring, Erik Zuker, HNTB, October 26, 2021
- Weigh-in-Motion (WIM) Technology, Hani Nassif, Rutgers University, November 23, 2021
- New Fiber Optic Structural Health Monitoring (SHM) Technologies and Recent Case Studies, Terry Tamutus, Structural Monitoring Solutions (SMS), February 24, 2022

The following webinars were also hosted by C2SMART during this reporting period:

- Lane Changing of Autonomous Vehicles in Mixed Traffic Environments: A Reinforcement Learning Approach, Zhong-Ping Jiang, Leilei Cui, Sayan Chakraborty, NYU, March 28, 2022
- Proactive Road Safety Management Techniques, Tarek Sayed, University of British Columbia, February 22, 2022
- Improving Contraflow Left-Turn Lane Design at Signalized Intersections to Decrease Traffic, Yi Qi, Texas Southern University, February 18, 2022
- Context Driven Analytics and AI for Infrastructure and Facility Management, Burcu Akinci, Carnegie Mellon University, February 15, 2022
- Cooperative Perception of Smart Roadside Unit with Edge AI for Driving Assistance, Wei Sun and Chenxi Liu, University of Washington, December 7, 2021
- Listening Session: Equitable Access to EV Charging, Yury Dvorkin, NYU, November 17, 2021
- Roadmap to Cooperative & Automated Transportation: Theory, Modeling and Experiments, Xiaopeng (Shaw) Li, University of South Florida (USF), November 16, 2021
- Using AI to Improve CAV Operations in Mixed Traffic, Sikai (Sky) Chen, Purdue University, Carnegie Mellon University, November 9, 2021
- Proactive Safety Management Empowered by Big Data, Kun Xie, Old Dominion University, October 19, 2021

4.   Media Coverage and Public Outreach

- The FloodSense project was featured in "Sensor Networks Help Fight Floods and Noise Pollution" in IEEE Spectrum, in the Brooklyn Eagle's Good Morning Brooklyn, Digest. FloodNet was also included in New York City's Internet of Things Strategy Progress Report, produced by the NYC Mayor's Office of the Chief Technology Officer: "Based on the demonstrated utility of this data, the City announced a commitment to scale the deployment of flood sensors citywide on September 27th, as a part of a broader landmark plan to protect New Yorkers from dangerous storm events," the report finds.
- Sarah Kaufman was interviewed by Mass Transit in the article, "Nearly half of Bird riders in Atlanta are women" where she discussed the relationship between gender and city infrastructure.
- Crosscut spoke with C2SMART PI Don Mackenzie about the possibility of a high-speed rail in the Pacific Northwest.
- C2SMART Director Kaan Ozbay, Co-PI of the BQE Testbed research projects, alongside Rutgers Professor Hani Nassif, provided comment on the I-40 bridge shutdown in Memphis, Tennessee in *Construction Dive.*
- Charlie Mydlarz, Co-PI on the FloodSense project was been quoted in Bloomberg CityLab's new article, Automating the War on Noise Pollution.
- C2SMART Student Researcher and NYU Ph.D. Candidate Suzana Duran Bernardes' cycling data sensor has been featured in The E-Bike Revolution Comes to the Bronx. Suzana's C2SMART-funded project developed a device that attaches to the downtube of the e-bikes that are being distributed by the Equitable Commute Project.
- Professor Xuegang Jeff Ban was featured in "Commuter study indicates pandemic patterns likely won't change quickly in the Seattle metro area" in King5 local news.
- C2SMART PI Sarah Kaufman was featured in 9to5Mac as she helped develop a new kids app, Pok Town. The Pok team strove to make the Town more engaging, inspiring, and inclusive working with Sarah Kaufman, to expand the Town into an eco-friendly downtown cityscape. She was also quoted in NYMag and the NYTimes during this reporting period in "As E-Scooters and E-Bikes Proliferate, Safety Challenges Grow," "Ahoy! Your Air Fryer May Soon Arrive by Boat," and "A Simple Solution for Getting Cars Off the Road Right Now." Sarah was also featured in Smart Cities Dive in an article titles "7 Ways Cities can Make Transportation Safer for Women: Study" along with her work on the Pink Tax on transportation.
- Professor Andrea Silverman was interviewed in a Science Friday segment produced by WNYC Radio titled "Where does toilet water go?" The C2SMART-funded FloodNet consortium was also featured in the piece.

D. *Plans for Next Reporting Period*

- C2SMART's "State of the Field: Structural Health Monitoring" event series will continue in the next reporting period with at least 2 additional webinars on the topic.
- The FloodSense project will deliver a panel discussion on the culmination of its work with the Mayor's Office of Resiliency in New York City, the challenges and opportunities of scaling research, lessons learned, and what comes next for the project.
- 3 C2SMART students, alongside one Cornell University student, will be participating as panelists in the ITS-NY Annual Meeting as ITS-NY and C2SMART discuss ways for the two organizations to collaborate.
- Professor Joseph Chow is working with NYCDOT to plan a student hackathon to refine and further develop the user interface of the mobile freight routing app being developed to aid in freight navigation in New York City.
- NYU transportation faculty from across its 3 global campuses (New York, Shanghai, Abu Dhabi) will be holding an intercampus symposium to discuss research and further collaboration.

II. Participants and Collaborating Organizations

A. Partner Organizations

Table 5: C2SMART Active Partnerships with Updates during this Reporting Period

Organization Name	Location	Financial Support	In-kind Support	Collaborative Research
CarbonCure	Dartmouth, Canada		X	
Carmera	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
Mobileye	Jerusalem, Israel		x	x
National Weather Service	US (various)			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
Texas Department of Transportation	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.

- The FloodSense project strengthened relationships with FloodWatch which is directed by partners at CUNY (Brett Branco), and run by the Science and Resilience Institute at Jamaica Bay and New York Sea Grant. The team also shares regular project updates and receives feedback from the following community based organizations: Hamilton Beach Civic Association, Gowanus Canal Conservancy, Red Hook Initiative, Pioneerworks Community Sensor Lab, Resilient Red Hook, Rockaway Initiative for Sustainability and Equity, Bronx River Alliance

2. Inter-University Collaboration

- Professor Benedetto Piccoli continues to collaborate with the other members of the CIRCLES Consortium of UC Berkeley, Vanderbilt University, University of Arizona, Temple University
- The UTEP team is leveraging an existing relationship with faculty at Czech Technical University (Miroslav Svitek and Tomas Horak) who have established similar capabilities for Digital Twin and Augmented/Virtual Reality combined with deep expertise in transportation modeling and logistics. Dr. Svitek is an international expert in smart cities and data visualization, while Dr. Horak has an operational digital model for the city of Prague in his laboratory.
- The FloodNet team is collaborating on an NSF funded project on parametric flood insurance involving GuyCarpenter, Wharton, Center for New York City Neighborhoods (CNYCN), and the NYC Mayor's Office of Climate and Environmental Justice to deploy 3 sensors and a gateway in East Brooklyn. The team is also working with a data visualization team at the Pratt Institute for map design.
- UW and NYU colleagues have been regularly meeting on using the vehicle-traffic demand (VTD) model for CAV and EV related research jointly conducted in NYC and Seattle, and finalized a collaborative proposal. Professor Ban is also in conversation with other C2SMART researchers about using the microscopic simulation model of the VTD platform (for the downtown Seattle area) to support a freeway strategy study supported by NCHRP.

3. Other Collaborations

- The Equitable Commute Project (ECP), on which C2SMART is a core partner, has been selected as one of six finalists in NYSERDA's Electric Mobility Challenge. As a finalist, the ECP is eligible to win one of three $7 million awards to help low-income essential workers in transit deserts commute and travel throughout the city by equipping them with subsidized electric bikes.
- C2SMART is also part of the project team led by Dollaride, selected through Phase One of New York Clean Transportation Prizes in the Clean Neighborhoods Challenge for its CTAP initiative, which is being developed in partnership with HEVO, BlocPower, and Build Edison.

III. Outputs

C2SMART is exceeding its targeted performance metrics in each of the areas identified in its Technology Transfer Plan, identified in Table 5. The following research outputs are produced with C2SMART Center support.

Table 6: Output Performance Measures

Performance Measures	Annual Goal	Achieved (current period)
Peer-reviewed papers	20	11
Conference presentations	10	14
Joint proposals/projects with industry/agency partners	10	28
Website analytics	5,000 unique pageviews	9,574 unique pageviews

A. Publications, Conference Papers and Presentations

1. List of Journal Publications

- More than 60 C2SMART Center researchers and affiliates presented at the [Transportation Research Board's 2022 Annual Meeting.](#)
- Bekir Bartin, Sami Demiroluk, Kaan Ozbay, Mojibulrahman Jami, Automatic Identification of Roadway Horizontal Alignment Information Using Geographic Information System Data: CurvS Tool. Transportation Research Record. January 2022. [doi:10.1177/03611981211036364.](#)
- Qian Xie, Li Jin, Stabilizing Queuing Networks with Model Data-Independent Control, IEEE Transactions on Control of Network Systems, [doi: 10.1109/TCNS.2022.3145752](#).
- Di Yang, Kaan Ozbay, Kun Xie, Hong Yang, Fan Zuo, A functional approach for characterizing safety risk of signalized intersections at the movement level: An exploratory analysis, Accident Analysis & Prevention, December 2021, https://doi.org/10.1016/j.aap.2021.106446.
- Ziyi Ma, Joseph Y.J. Chow, Transit Network Frequency Setting with Multi-Agent Simulation to Capture Activity-Based Mode Substitution, Transportation Research Record, November 2021. [doi:10.1177/03611981211056909](#)
- Zhexi Fu, Joseph Y.J. Chow., The pickup and delivery problem with synchronized en-route transfers for microtransit planning, Transportation Research Part E: Logistics and Transportation Review, January 2022 https://doi.org/10.1016/j.tre.2021.102562.
- Bingqing Liu, Theodoros P. Pantelidis, Stephanie Tam & Joseph Y. J. Chow, An electric vehicle charging station access equilibrium model with M/D/C queueing, International Journal of Sustainable Transportation, January 2022 https://doi.org/10.1080/15568318.2022.2029633.
- Xiaotong Dong, Joseph Y.J. Chow, S. Travis Waller, David Rey, A chance-constrained dial-a-ride problem with utility-maximising demand and multiple pricing structures, Transportation Research Part E: Logistics and Transportation Review, February 2022, https://doi.org/10.1016/j.tre.2021.102601.
- Guocong Zhai, Kun Xie, Di Yang, Hong Yang, Assessing the safety effectiveness of citywide speed limit reduction: A causal inference approach integrating propensity score matching and spatial difference-in-differences, Transportation Research Part A: Policy and Practice, March 2022 https://doi.org/10.1016/j.tra.2022.01.004.
- Semiha Ergan, Zhengbo Zou, Suzana Duran Bernardes, Fan Zuo, Kaan Ozbay, Developing an integrated platform to enable hardware-in-the-loop for synchronous VR, traffic simulation and sensor interactions, Advanced Engineering Informatics, January 2022 https://doi.org/10.1016/j.aei.2021.101476.
- Hafiz Anwar Ullah Khan, Sara Price, Charalampos Avraam, Yury Dvorkin, Inequitable access to EV charging infrastructure, The Electricity Journal, April 2022, https://doi.org/10.1016/j.tej.2022.107096.
- Guande Wu, Jianzhe Lin, & Claudio T Silva. ERA: Entity Relationship Aware Video Summarization with Wasserstein GAN. The 32nd British Machine Vision Conference 2021 https://doi.org/10.48550/arXiv.2109.02625.

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

- [Artificial Intelligence in Proactive Road Infrastructure Safety Management](#), based on a roundtable which included [Kaan Ozbay](#), was published through the International Transportation Forum.
- C2SMART Student Haggai Davis wrote about [using MATSim-NYC to simulate a proposed network redesign](#) to improve the level of service for users as well as reduce the operating costs for the MTA.
- C2SMART Center PI Sarah Kaufman co-authored "[The Pink Tax on Mobility: Opportunities for Innovation,"](#) discussing high leverage ways to correct the disparity between women's monthly transportation expenditures as compared to those of men.

3. Other Publications, Conference Papers and Presentations

- C2SMART released its 2021 Annual Report in December 2021.
- C2SMART Center PI Semiha Ergan was featured in CIDCI Salon discussing tools available in the architecture, engineering & construction (AEC) industry responding to infrastructure & building needs
- C2SMART Director Kaan Ozbay was a guest speaker at the GW Civil and Environmental Engineering Departmental Seminar Series presenting "Predictive and Pro-active Traffic Safety Research in the Era of Smart Cities Where Big Data Meets the AI/ML Revolution" on Friday, February 18th, 2022.
- On February 24, 2022, C2SMART, participated in the USDOT Research Development &Technology Video Forum on AI. C2SMART presented on two projects: Work Zone Safety: Calibration of Safety Notifications through Reinforcement Learning and Eye Tracking and C2SMART COVID-19 Data Dashboard with Object Detection and Image Processing from Traffic Cameras.
- C2SMART participated in NYU Urban Initiative's Research Day on March 8, 2022. Professor Yury Dvorkin talked about his work developing modeling and algorithmic solutions to assist society in enabling energy transition and decarbonization by means of economy-wide electrification; Professor Charlie Mydlarz presented on low-cost water level sensors to fill a critical data gap on the presence, depth, and duration of street-level floods by measuring flood profiles in real-time; and Professor Andrea Silverman discussed evaluations of the frequency and impact of hyperlocal, urban floods. Transportation Engineering PhD Candidates Dan Lu and Haggai Davis III presented their projects, "Improving Roadway Construction Safety through Wearable Alarm Systems for Workers" and "Development of a Freight Routing Application", respectively.
- Professor Andrea Silverman gave a Department Seminar at George Washington University on March 4, 2022 titled "FloodNet: low-cost, real-time sensors for hyperlocal, street-level flood monitoring in New York City." Professor Silverman was also a panelist for an NYC Open Data Week panel discussion on March 8, 2022: "It Will Rain Again: Data Needs and Opportunities in a Post-Ida New York City," and presented to NYU's NY Water Environment Association student chapter meeting on March 23, 2022.
- Professors Andrea Silverman and Charlie Mydlarz gave a webinar at IEEE on 10/22/01 titled "How Sensors are Making Better Urban Environments"
- Professor Joseph Chow delivered several presentations during this reporting period, including "Tackling operational inefficiencies toward sustainable Mobility-as-a-Service" hosted by Texas A&M on Mar 3, 2022, "Modeling capacity effects for route choice in multimodal mobility ecosystems", at a Google Workshop on Urban Mobility Simulation and Optimization on Nov. 17, 2021, "Microtransit deployment portfolio management using simulation-based data upscaling" hosted by the University of Toronto on Nov. 12, 2021, "Microtransit deployment portfolio management using simulation-based data upscaling" hosted by Ford Mobility on Oct. 28, 2021, and "Microtransit deployment portfolio management using simulation-based data upscaling", hosted by Via, Oct. 21, 2021.
- Professor Kaan Ozbay delivered a webinar titled "Simulation of Urban Transportation Systems: Past, Present, and Future" hosted by the University of Lancaster on March 15, 2022.

B. Websites

The C2SMART website disseminates information about the Center's activities and research, with 9,574 unique page views during this reporting period, exceeding its annual goal of 5,000 pageviews. 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 and has been downloaded a total of 283 times. The FloodNet project is developing a city-wide portal for the project: www.floodnet.nyc. During this period, the center's YouTube channel accumulated 2,734 views. C2SMART has gained 27 followers to its Twitter account (@C2SMARTNYU), used to promote its research, webinars, and other events and news, since last reporting period. The C2SMART Center LinkedIn page has gained 425 followers during this reporting period.

C. Technologies or Techniques

- 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 by Professor Joseph Chow's team for the project "Quantifying and Visualizing City Truck Route Network Efficiency Using a Virtual Testbed." 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.
- Professor Zhong-Ping Jiang and his team of graduate student researchers successfully developed a lane changing decision model of autonomous vehicles, and have developed a methodology based on the Linear-Quadratic Regulator framework that solves the trajectory planning and trajectory tracking at the same time by the learning-based adaptive optimal control approach.

D. Industry/Agency Partners

Table 5 lists all current active or renewed collaborations with agency and industry partners. C2SMART is actively pursuing new funding opportunities to complement or continue Center-funded research to expand upon the initial research into implementation projects.

- The C2SMART Center finalized its work with NYC-area agencies on USDOT's NYC Connected Vehicle Project, including an application for visually impaired and a cooperative driving task.
- C2SMART is actively working with the New York State Department of Transportation (NYSDOT) on four research proposals under its long-term consortium agreement. These projects are:
    - o SR-20-02 Statewide Mobility Services Program Strategic Procurement Planning
    - o SR-20-03 Capital Program Resource Model
    - o SR-20-04 Statewide Open-Source Advanced Traffic Management System (ATMS) Pilot
    - o SR-20-05 AASHTO and NBI Element Deterioration Rates for Bridge Management System
- C2SMART was awarded the following additional 2 research task orders from NYSDOT:
    - o SR-21-02 Design Finite Element Analyses and Crash Testing
    - o SR-21-03 Finite Element Analyses and Crash Testing of NYSDOT Bridge Railing and Barrier
- The Hudson Valley Transportation Management Center, part of NYSDOT, will provide traffic video footage and feedback in terms of practical implementation for Professor Anil Agrawal's research.
- The NYC Mayor's Office of Climate and Environmental Justice has formally expressed desire to provide feedback and suggestions for datasets and metrics to support the framework developed by Professor Luis Ceferino for his forthcoming project.
- Professor Joseph Chow's project, "NY Statewide Behavioral Equity Impact Decision Support Tool with Replica," will be included as part of Replica's Data for Good initiative. As part of this collaboration, Replica will share the outputs of its Places model, a high-fidelity activity-based travel model that simulates the population's trip-taking activity, with data outputs down to the network-link level, for the New York State regions of interest. Replica is supporting a research intern from Professor Chow's lab and will appoint a Senior Research Scientist to coordinate the research efforts.
- Con Edison, one of the largest energy utilities in the United States, and Charge Point, the largest network provider of independently owned EV charging stations, are collaborating with Professor Yury Dvorkin to develop forecasting tools for EV charging demand and placing and siting EV charging stations for Professor Dvorkin's project.
- Dr. Jingqin Gao, C2SMART senior research associate, is leading a project to address applications of computer vision for NYC Department of Design and Construction (NYCDDC), and NYCDOT that take advantage of the existing public traffic camera network in NYC.
- Washington DOT will serve as a direct user of the research output of Professor Yinhai Wang's project and will meet to incorporate WSDOT's existing traffic sign management practices and requirements.

- The New York City Department of Environmental Protection (DEP), and its Bureau of Water and Sewer Operations, provides consultation to Professor Henaff's team on deployment locations in flood-prone areas, key to validating their stormwater models. NYC Emergency Management serves as an end user of the project and provides feedback on sensor data representation, alerts, and data needs. The National Weather Service provides similar feedback.
- Floodnet is collaborating with global engineering firm Arcadis on a planned deployment of a further 6 flood sensors and gateway in the New York City Housing Authority (NYCHA) Jamaica Houses in Queens in May 2022 to monitor the condition pre and post construction of a green infrastructure solution for flood mitigation.
- Professor Joseph Chow's research team meets quarterly with NYCDOT to iterate on a freight routing app and visualization tool. The two teams are planning a hackathon to further develop a user interface for the tool.
- Professor Nassif's team continues to work closely with NYSDOT, its consultants, and industry partners on the BQE roadway testbed as part of the NYCDOT BQE team for long-term structural health monitoring, the Triple Cantilever Joint Venture.

E. Other Products
- NYU-VPR: Long-Term Visual Place Recognition Benchmark with View Direction and Data Anonymization Influences, created by Chen Feng, Diwei Sheng, Yuxiang Chai, and Xinru Li is a newly published online dataset repository website for the NYU-VPR project. Visual place recognition (VPR) is critical in not only localization and mapping for autonomous driving vehicles, but also assistive navigation for the visually impaired population. The NYU-VPR dataset contains more than 200,000 images over a 2kmx2km area near the New York University campus.
- The UTEP team has collected a detailed record of transportation assets from the UTEP campus via vehicle-mounted camera. These assets have been timestamped and a script was developed to extract telemetry information for the assets.
- Professor Jiang's proposed methodology has been implemented in Simulation of Urban Mobility (SUMO), an open source, portable, microscopic, and continuous multi-modal traffic simulation package designed to handle large networks.
- Professor Chow and his research team have developed a truck specific network of greater NYC that can be used to route freight vehicles.

IV. Outcomes

A. Increased Understanding and Awareness of Transportation Issues

- Principal Investigator Sarah Kaufman has been leading research into the gender equity gap in transportation. She recently co-led the release of a white paper which outlines a clear definition of the "Pink Tax on Mobility", as well as opening the door to innovations which can alleviate this problem. The recently released white paper was borne from research and a workshop held in 2021, facilitated by C2SMART and other project partners, to frame the issue for various stakeholders, lay the foundation for systemic change, and gather momentum by identifying high-impact near-term interventions
- Results from the Equity in Transportation Research workshop, held on November 12, 2021, were incorporated into the 2022 C2SMART Center Research Solicitation, which took an industry/ agency-driven approach towards funding new projects and initiatives.

Table 7: Outcomes Performance Measures

Performance Measures	Annual Goal	Achieved (current period)
Media interviews, mentions, coverage	10	14
Workshops, webinars, and seminars	10	28

- Results of Professor Ghandehari's research project might serve as a guide for the retrofitting of subway station platforms, in terms of isolating the platforms from the tunnels to reduce passenger exposure to PM 2.5.
- The multiscale simulation platform being developed by Professor Jeff Ban and his team, will help simulate and understand the behavior and interaction of multiscale traffic flow and to help simulate new technologies and systems in transportation such as electric vehicles and buses, CAVs, new mobility services, and freight deliveries.
- The Brooklyn-Queens Expressway (BQE) has been experiencing a substantial number of overweight trucks. The team led by Professor Hani Nassif provided the weights, configurations, and license plates of the overweight trucks based on the Weigh-In-Motion (WIM) and Automated License Plate Recognition (ALPR) systems at the BQE testbed, in a continued, growing collaboration with NYCDOT.

B. Increases in the Body of Knowledge

- FloodNet, the consortium of universities led by the C2SMART-funded FloodSense project, was a finalist for Gartner's Eye on Innovation Award.
- As compared to the existing literature on lane changing, Professor Jiang's research has proposed a novel optimal data-driven controller technique by integrating control theory with reinforcement learning and adaptive dynamic programming. A novel data-driven optimal control technique 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.
- C2SMART Center NYU transportation engineering doctoral candidates Di Yang and Di Sha proposed a novel calibration framework which combines traffic conflict techniques, including trajectory estimation using aerial drone and traffic camera footage, and multi-objective stochastic optimization to calibrate operational and safety measures simultaneously. Their results show that the calibrated parameters can significantly improve the performance of a simulation model to represent real-world traffic conflicts as well as operational conditions, such as travel time and link volume.

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

- Professor Nassif's team demonstrated distributed fiber optic (DFO) sensors for a large structure to monitor the BQE's cantilever sections to estimate service life. The NYCDOT accepted the FO sensor installation and the team implemented them. The team also demonstrated state-of-the-art WIM sensors (Piezo-Quartz sensors) and a software based ALPR system to identify and enforce overweight trucks, which has also been adopted into the state of the practice in New York City.
- NYCDOT currently relies on in-house staff to manually provide freight routing on a hotline for freight trucks. This process will be largely replaced to the faster, more reliable routing app that Professor Chow and his team are developing. 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.
- Dr. Jingqin Gao is leading two undergraduate student researchers towards providing computer vision methods to validate existing car, and pedestrian counting approaches currently used by these agencies and their subcontractors.
- NYU transportation engineering doctoral student Zilin Bian demonstrated improvements to the Data Driven Work Zone Impact & Conflict Estimation Platform (DWICE) used by NYCDOT, Office of Construction Mitigation and Coordination (OCMC) and NYSDOT. These improvements included interface improvement, addition of an interactive Gantt chart added to Coordination Analysis, a machine-learning model trained for impact analysis, and integration of Waze data.
- Professor Ozbay' team acquired before/after imagery and data to evaluate a road diet in the City of Houston via surrogate safety measures in partnership with Together for Safer Roads.

V. Impact

A. Effectiveness of the Transportation System

- On December 23rd, 2021, Senator Brian Kavanagh and Assembly member Jo Anne Simon announced that their BQE Overweight Truck bill (S2740B/A2316) was signed into law by NY Governor Kathy Hochul. The new law authorizes a pilot program along I-278 in Brooklyn allowing for the installation of state-of-the-art, weigh-in-motion technology to issue violations electronically when trucks exceed the existing legal weight limits. The law comes at the tail end of several years of groundwork, beginning with Mayor De Blasio's Expert Panel, where experts including C2SMART Associate Director Hani Nassif and Director Kaan Ozbay recommended a series of immediate interventions alongside long-term rehabilitation, including the installation of WIM sensors to help monitor the actual truck load on the triple cantilever section of the BQE.

  With this authorization, the team is piloting with NYCDOT an Automatic License Plate Recognition (ALPR) system in combination with the installed Weigh-in-Motion (WIM) system to automatically detect truck weights and match to license plate records to issue violations when over the established weight threshold, as authorized by the legislation. This technology deployment will further help to support the safe operation of the structure.

Table 8: 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	3
Partnerships/collaborative relationships with companies or transportation agencies established or renewed	10	27
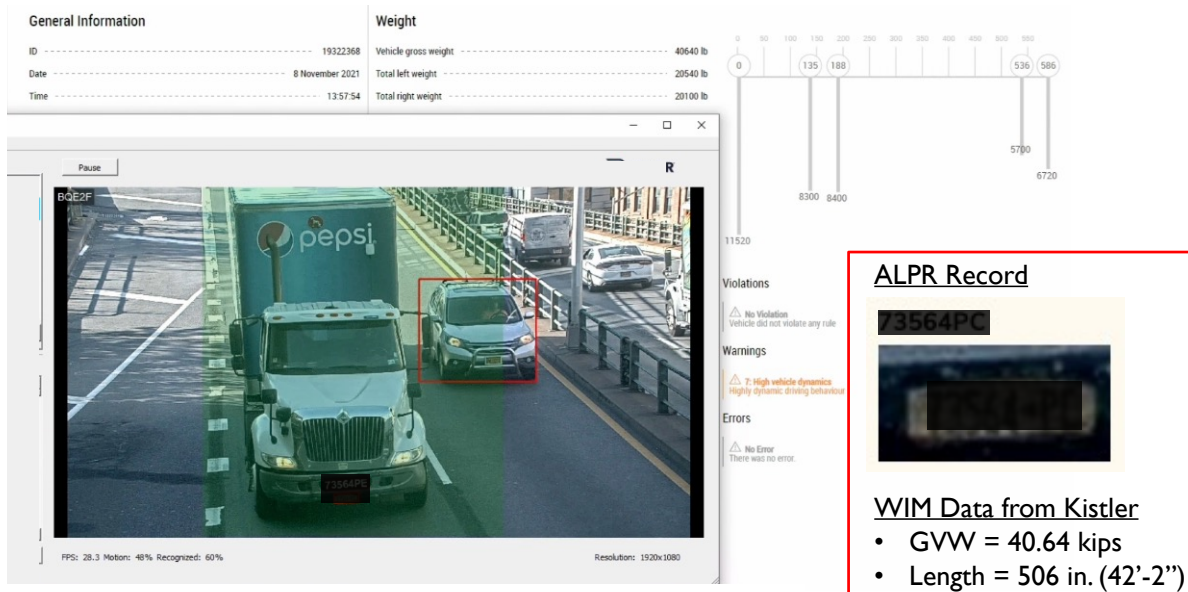
Figure 1: Realtime Data Stream from Automated License Plate Recognition System on BQE

- The NYC Extreme Weather Task Force is working to finalize an investment of more than $7M in FloodNet. This funding for the project, first seeded by C2SMART in 2020, will work to scale flood sensors and a full flood-detection and monitoring system to all of New York City and assist with New York City's resiliency efforts. Continued flood monitoring is yielding a dataset with updates every minute from each of the sensors, and the alerting system continues to be useful to city agencies tasked with reacting to flood conditions.

B. New Practices or Companies
- Nothing to report in this period.

C. Body of Scientific Knowledge
- As part of USDOT's Connected Vehicle Project, C2SMART researchers – in collaboration with NYCDOT and industry partners JHK and Harman – recruited 24 volunteer participants with vision disabilities via local and national organizations to help conduct field tests of a phone application, PED-SIG, which could improve mobility of pedestrians with vision disabilities to navigate safely and independently through New York City. C2SMART Researchers led the safety performance evaluation component of this project. Using both stimulated and observed Connected Vehicles data, they conducted both before and after studies and reported their findings to NYCDOT/USDOT.

D. Transportation Workforce Development
- Daniel Ortiz, Rutgers University, was awarded Student of the Year. Daniel completed a bachelor's degree in Civil Engineering in January 2021 at Rutgers, The State University of New Jersey and is currently a graduate student in the same institution pursuing a master's degree in structural engineering. Daniel has worked closely on the installation of novel sensor technologies including distributed fiber optic (DFO) sensors and wireless sensor nodes for structural health monitoring (SHM) along the corridor of the Brooklyn-Queens Expressway (BQE) in New York City for structure resiliency. Daniel has also contributed to the development of advanced cementitious materials including ferrocement and ultrahigh-performance concrete (UHPC) to improve the service life of the infrastructures, presenting a conference paper at the 13th International Symposium on Ferrocement.
- NYU doctoral candidate Haggai Davis received the Eisenhower Fellowship in December 2021. The proposal he submitted has become the basis for project "One-to-Many Simulator Interface with Virtual Test Bed for Equitable Tech Transfer" led NYU Professor Joseph Chow.
- NYU undergraduates Ruhejami Mustari (Computer Engineering 2022) and Julia Qin (Civil Engineering 2022) assisted Professor Ergan's "Work Zone Safety III: Calibration of Safety Notifications through Reinforcement Learning and Eye Tracking" specifically helping with running the VR user studies and coding for data analysis. They received research course credits for their efforts.
- Professor Hani Nassif and his team continue to provide technical training to NJDOT staff as part of the Bridge Resource Program, including hosting seminars/webinars and other workforce development activities mentioned under the *State of the Field: Structural Health Monitoring* series.

VI. Changes/Problems

Funded Research Projects:

The Evaluating Remote Repositioning for Shared Scooters project led by Professor Don Mackenzie was initially on hold due to COVID-19-related supply chain issues that postponed scooter shipments by industry partner Spin, which would be evaluated as part of this project's scope in the City of Boise. Spin was recently acquired by Tier Mobility, and the City of Boise is no longer conducting a pilot of autonomous repositioning technology. This project is now currently being rescoped to entail an evaluation of another pilot of a remote micro-mobility application with an industry partner.