



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 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

C2SMART has resumed conducting in-person events, including webinars, which include a hybrid component. As in-person attendance and meetings continue to pick up, C2SMART plans additional activities, including a return of its seminars and training series at NYU.

2. Research

Table 1 lists projects completed during this reported period. Their final deliverables and outputs have been submitted and made accessible. Table 2 provides updates on ongoing research projects during this reporting period. Finally, Table 3 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: Projects Completed During this Reporting Period

Urban Mobility and Connected Citizens	A Multiscale Simulation Platform for Connected and Automated Transportation Systems, UW	This project developed a multiscale vehicle-traffic-demand simulation platform for connected/automated transportation systems to investigate local/regional traffic flow dynamics.
	Autonomous Vehicle Good Citizenry Standard, NYU	This project developed a Responsible Autonomous Mobility framework of good citizenry for autonomous vehicles entering New York City to incentivize providers toward metrics of equity, sustainability and responsible use of machine learning and data.
	Lane Changing of Autonomous Vehicles in Mixed Traffic Environments: A Reinforcement Learning Approach, NYU	This project introduced an optimal data-driven control algorithm to solve the lane changing problem of AVs and developed an algorithm to ensure safe and efficient lane change, validated SUMO and MATLAB based simulations.
	C2SMART COVID-19 Data Dashboard, NYU, Rutgers, UW	Since the start of the Covid-19 pandemic, C2SMART collected data and investigating the impact of COVID-19 on mobility in around NYC and Seattle. Leveraging open data from multiple

Urban Analytics for Smart Cities		sources, this project developed a publicly-available dashboard to observe the impact of the pandemic on transportation.
	A Comprehensive Analysis of Air Quality in the NYC Subway System, NYU	This project analyzed concentrations of particulate matter in the NYC subway system with realtime and gravimetric measurements inside train cars along 9 subway lines, as well as real-time measurements on 341 platforms from 287 stations. Using particle element analysis, they found the concentration of iron particles in subway stations higher than ambient outdoor levels and a rapid increase of PM concentrations.
	Calibration of Safety Notifications through Reinforcement Learning and Eye Tracking, NYU	This project calibrated optimal timing, frequency, modality of warnings to workzone inhabitants from simulated virtual environments which can be deployed into physical work zones for alarm delivery to notify construction workers about potentially dangerous situations in real-time.
Resilient, Secure, and Smart Transportation Infrastructure	Implementation & Effectiveness of Autonomous Enforcement of Overweight Trucks in an Urban Infrastructure Environment, Rutgers	In this study, the team developed a calibration procedure for Advanced-Weigh-in-Motion system. The calibration and optimization tests provided the accuracy and compliance required in ASTM E1318-09. Analysis showed that direct enforcement would reduce the number of overweight trucks by up to 76.9% for > 10% overweight trucks.
	Advanced Weigh-in-Motion System for Autonomous Enforcement of Overweight Trucks, Rutgers	The project assisted the NYCDOT in establishing legislation to operate an autonomous Overweight enforcement system using advanced weight-in-motion system (A-WIM) and automated license plate recognition (ALPR). Based on this effort, New York State signed the BQE autonomous enforcement bill into law.

Table 2: Updates on Ongoing Center-funded Research Projects

Urban Mobility and Connected Citizens	Work Zone Safety: Virtual Reality-based Traffic-simulation Platform for Workforce Training and Pedestrian Behavior Analysis, NYU	The research team continued working on implementing a traffic simulation environment that can run in parallel with VR and has also tested the implementation of Steam VR, a software interface that connects the Unity 3D game engine and the VR devices. During tests, data was collected from the integrated platform to get initial insights on the participants' reaction time to different alarm notifications sent to the smartwatch. The research team has identified 20 professionals from the construction industry so far as the initial cohort of interviewees.
	Automated Lane Change and Robust Safety, NYU	The team proposed techniques for safe maneuver of AVs for lane changing in the presence of HDVs. They then studied the comparison between the data-driven gain scheduling controller with model predictive control in terms of computation time, where it was found that the proposed data-driven gain scheduling controller is lower than MPC controllers typically used in transp.
	Digital Twin Technologies Towards Understanding the Interactions Between Transportation and other Civil Infrastructure Systems Phase 2, UTEP	The team has completed literature review on digital twin technologies in transportation operations and enhanced the digital model from phase 1 by collecting more LiDAR point cloud data of buildings on campus. Three sites have been identified and they explored and built a more digital models using Open

		<p>Street Map, CARLA simulator, and osm2gmns python library. Team members have begun exploring and training to use the Bentley iTwin platform which provides a robust solution to create a cloud-based digital model and stream live data to it. Given the challenges with integration and the potential for expansion with iTwin, it is likely this will be the approach to integration adopted moving forward.</p>
	<p>Evaluating the Effectiveness of Computer Vision Systems Mounted on Shared Electric Kick Scooters to Reduce Sidewalk Riding, UW</p>	<p>This project was rescoped due to COVID-19-related supply chain issues. The key activity was the negotiation of a data sharing agreement between Spin and the University of Washington regarding scooter trip data that contains potentially personally identifiable information. The team also worked with the City of Santa Monica and Spin to establish the testing program for the Drover AI equipped scooters. The UW team will analyze how differing levels of rider feedback from the Drover AI system affect sidewalk riding and survey riders on their perceptions and views of the Drover AI equipped scooters.</p>
	<p>Collaborative Driving, Ramp Metering & Mean-field Controls, Rutgers</p>	<p>Researchers familiarized with implementation of a Proportional-Integral-(PI-) type local ramp metering controller. The research team has conducted a thorough literature review on longitudinal car-following control models that are used for ACC and CACC driver assistant systems. The research team has configured a SUMO-flow simulation environment including a ring road testing model and an on-ramp merge area model.</p>
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Urban Analytics for Smart Cities</p>	<p>NY Statewide Behavioral Equity Impact Decision Support Tool with Replica, NYU</p>	<p>The team got the access to a database and a comprehensive understanding of how partner Replica’s data were generated through reading the code of their data pipeline. They checked the consistency between Replica’s data and travel survey data in NYC and found a slight difference in trip mode share. The team developed AMXL model to estimate fixed parameters at individual level and developed a group-level inverse optimization algorithm for group-level mode choice modeling, while dropping the computational time dropped significantly.</p>
	<p>One-to-Many Simulator Interface with Virtual Test Bed for Equitable Tech Transfer, NYU, UW</p>	<p>The UW team completed refining the SUMO simulation calibration and conducted testing using the multiscale simulation platform on CAV-based traffic control, for synthetic networks and a network of downtown Seattle. The NYU team has designed a preliminary interface for the integrated simulator platform integrating MATSim with Mobility-On-Demand simulators. The NYU team is also working on the NYC urban freight delivery algorithm to generate synthetic freight population in NYC for the MATSim simulation.</p>
	<p>Cost-effective Approach Towards Building a Traffic Sign Data Inventory Using Open Street Images, UW</p>	<p>The team have built a data collection system to collect necessary traffic sign images, street images and associated information automatically. Meanwhile, the research team has developed their own data collection devices to capture real-time traffic data. The team installed the sensing system on test vehicles to detect the capture the traffic sign data. The team is</p>

Resilient, Secure, and Smart Transportation Infrastructure		<p>now looking into training machine learning models for traffic sign detection and recognition.</p>
	<p>Exploring Cost-effective Computer Vision Solutions for Smart Transportation Systems, NYU</p>	<p>The PI has completed the preliminary literature review on smart city applications of computer vision related to pedestrian with disabilities, flooding, parking, and work zone detection. A resource list of public traffic camera programs in all the states has been developed. Collecting training images from the CCTV cameras for urban work zones, the development of data acquisition and analytics framework was established and an initial detection model was built with approximately 500 customized work zone training images.</p>
	<p>Quantifying & Vis. City Truck Route Network Efficiency Using a Virtual Test Bed, NYU</p>	<p>For the Synthetic Freight Population that was developed, entropy maximization was devised, tested, and implemented. After discovery that the initial estimates were too large, effort has been to calibration and measuring of flow distributions. For the truck routing app interface, a Hackathon was devised in collaboration with NYCDOT planned for Oct. 2022.</p>
	<p>Utilizing Social Media Data for Estimating Transit Performance Metrics in a Pre- & Post-COVID-19 World, CCNY</p>	<p>The model and research work for this project has been completed. The final report is currently under development.</p>
	<p>Exploring AI-based Video Segmentation/ Saliency to Optimize Imagery-Acquisition from Moving Vehicles, NYU</p>	<p>The team has initiated a collaboration with NEC Labs to create a digital twin of dynamic urban traffic to analyze how stationary intelligent infrastructure plus wireless capabilities can be used to make moving vehicles safer. Three intersections in Brooklyn, NY with diverse demographic, urban fabric, and built environment profiles were equipped with REIP sensors to record the dynamic of pedestrian and vehicle interaction. The team conducted data collection, processing, and synchronizing between the sensors for the three selected locations.</p>
	<p>Digital Twin Tech. for Interactions between Transportation & Other Civil Infrastructure Systems, UTEP</p>	<p>Development has commenced on a biannual stakeholder update newsletter regarding the project and other development in the Digital Twin space towards community engagement. Staff from the Texas Innovation Alliance voluntarily supported the team by facilitating the stakeholder engagement workshop. We have additionally collaborated on Research Needs Statements and an invited talk for the Texas Technology Task Force.</p>
	<p>Developing a Framework to Optimize FloodNet Sensor Deployment Around NYC for Equitable and Impact-based Flood Monitoring and Data Collection, NYU</p>	<p>The team has developed heat maps of Census Tracts (CTs) that contain flood-prone areas to select the most suitable locations to deploy the sensors that will monitor water depth during future flood events. 311 Service Requests, MTA data on subway turnstile entries and NYC Digital Elevation Model (DEM) have been integrated into the process. MTA data on subway turnstile entries have been tested comparing stations inside and outside flood-prone areas for the two days following Hurricane Ida. Six risk metrics have been selected and quantified, taking input values from Map-PLUTO, U.S. Census and CDC/ATSDR Social Vulnerability Index.</p>

	AI Based Overheight Vehicle Warning System for Bridge, CCNY	<p>The team has done literature review on state-of-the-art technology to prevent the collision of overheight vehicles with bridges with low clearance. Most of the literature search have been focused on estimating the vehicle height using Artificial intelligence with cameras to achieve a cost-effective solution.</p>
	Eval. of Integrated OW Enforcement System using High Accuracy WIM and Non-Proprietary ALPR System, Rutgers	<p>The team continuously collected WIM data of 3 lanes at the BQE-NYC testbed near and provided them to the NYCDOT data repository. The team performed a test to investigate whether WIM data would be comparable with acceleration measurements and found that the correlation between GWW and acceleration is not strong. The performance of ALPR still requires further testing; some of the cases have been found to cause a false reading by ALPR.</p>
	Urban - DEPOT: Deploying EV Charging Infrastructure in an Urban Environment, NYU	<p>The NYU team has signed a collaboration agreement with Con Edison, to mutually complete the project tasks. Con Edison has agreed to support this project in a Technical Advisory capacity; by providing suggestions from a utility perspective, providing feedback and relevant information and data when possible, and reviewing the results and progress of the research.</p>
	Field Application of High-Power Density Electromagnetic Energy Harvester to Power Wireless Sensors in Transportation Infrastructure, CCNY	<p>The final design consisting of two copper coils attached to two cantilevered beams moving relative to three linear layers of small permanent magnets has been fabricated. The team is currently setting up a lab testing of the fabricated device. An impact mechanism has been created to magnify the interaction of the moving coil with the permanent magnets. They have setup the experiment for performance evaluation of device and use the collected data for optimization and amplification of output power.</p>
	Deployment & Tech Transfer of a Street-level Flooding Platform: Sensing & Data Sharing for Urban Accessibility & Resilience, NYU	<p>The FloodSense team fabricated and installed 7 new sensors and 2 gateways in Queens and Staten Island, NYC. Further training and fine-tuning the model for flood and anomaly detection has been completed, including new gradient-based data filters. Flood Hotspots Identification Strategy, Deployment, and Maintenance manuals have been implemented and shared on github. The team has made a successful collaboration with Informal to devise Technical Design Plans, BOMs, Production costs and manufacturer analysis for a new sensor design.</p>

Table 3: Matching or Complementary-funded Projects to C2SMART-funded Projects

Urban Mobility and Connected Citizens	NYC 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 Analyst	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	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
	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
	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
	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:
 - Getting Started with Android Development
 - Ramp metering: Control Strategies and New Insights
 - Computer Vision: Object Detection & Tracking, Build Your First Interactive Data Dashboard Using Dash Plotly
 - Hands-On Tutorials for Amazon Web Services (AWS)
- The Institute of Transportation Engineers (ITE) student chapter at NYU, supported by the C2SMART Center, won both the Northeastern District Student Chapter Award (repeated victory) and the Northeastern Traffic Bowl (for the 3rd year in a row). They placed second at the 2022 Grand Championship Traffic Bowl. NYU's Intelligent Transportation Society's student chapter also presented at the ITS-NY Annual Meeting.
- C2SMART student and NYU PhD candidate Farnoosh Namdarpour was granted the Infratech Graduate Scholarship, awarded to an enterprising young woman who reflects those qualities regardless of obstacles and difficulties.

C. Dissemination and Outreach

1. Training and Tech Transfer Events

a) Conference Presentations and Research Showcases

- Four C2SMART projects were selected for presentation at NYU Tandon’s Research Excellence Exhibition in April 2022.
- C2SMART Director Dr. Kaan Ozbay, participated in a discussion on how new developments and innovations in Transportation Equity can help make our system safer and more equitable for all users on Wednesday, May 4, 2022 for "ITS America Webinar: Creating Access Through Equity in Transportation."
- NYU PI Sarah Kaufman moderated a discussion at 2022 CoMotion Miami on her projects related to improving transportation through technology: Intelligent Paratransit, to rethink how we transport seniors and the disabled; and Emerging Leaders in Transportation Fellowship, a program to enhance innovation at all levels of transportation planning and policymaking; and Job Access, a comparative study of how livelihoods are affected by level of access to mass transit in New York City.
- Asheque Rahman, a member of the advisory board on C2SMART’s project “Exploring Cost-effective Computer Vision Solutions for Smart Transportation Systems” presented about the work at the National Travel Monitoring Exposition and Conference on "Traffic Monitoring: Implementing Equipment and Tools - Video Data Collection, Processing, and Tools Exploration." In his presentation, Rahman shared the collaborative work between NYC DDC, NYC DOT and C2SMART on traffic data collection and tools exploration.
- Prof. Andrea Silverman presented as an invited seminar at George Washington University on March 4, 2022 on “FloodNet: low-cost, real-time sensors for hyperlocal, street-level flood monitoring in New York City.” She was also an invited panelist “It Will Rain Again: Data Needs and Opportunities in a Post-Ida New York City” as part of NYC Open Data Week on March 8, 2022.

b) Workshops

- C2SMART Center in conjunction with NYU-ITE student chapter convened the 4th Annual Women in Transportation Discussion Panel, bringing together three leaders across multiple dimensions of transportation and engineering:
 - Susie Lai, Staff Services Traffic Engineer at the Port Authority of New York and New Jersey
 - Kristy Tu, Transportation Engineer and Planner at Arup
 - Sofia Duran, Traffic Designer at VHB
- Sarah Kaufman was a panelist on Women in TransitTech: Solutions to the Pink Tax on Transportation, where she led a conversation with three transit experts on the paper’s findings, its implications for equitable transit strategy and planning, and the solutions panelists have explored to minimize women’s additional transportation costs.
- C2SMART hosted What's the Chatter? with MobilEye, where we were joined by Mark Davis, Data Services Lead of Mobileye North America, to discuss smart roadways, vehicle data, and the future of urban mobility.

2. Industry and Public Agency Outreach

- The Noblis Autonomous Systems Research Center recently held a virtual event to share demonstrations from the Autonomy lab and host a panel discussion of leading government and academic leaders who addressed the challenges and opportunities of systems of autonomous machines. C2SMART Director Kaan Ozbay served as one of the panelists.

3. Seminars and Webinars

C2SMART hosted the following webinars during this period:

- Collaborative and Adversarial 3D Perception for Autonomous Driving on May 19, 2022.
- Research and Practice: Implementing a Flood Sensor Network for a Resilient NYC on May 27, 2022.
- Individual Path Recommendation Under Public Transit Service Disruptions Considering Behavior Uncertainty and Equity on July 8, 2022.
- Virtual reality and simulation as a tool to investigate the safety of future mobility scenarios: opportunities and limitations in applied research on August 15, 2022.
- New Approaches and Paradigms in Traffic Flow Modeling and Control on August 24, 2022.

4. Media Coverage and Public Outreach

- C2SMART Director Kaan Ozbay, along with Senior Research Associate Jingqin Gao, were interviewed by IEEE Spectrum's Dexter Johnson for an article in IEEE's June 2022 issue in an article titled [C2SMART Researchers Develop AI Tool for COVID Monitoring and Offer a Solution for Urban Congestion](#).
- C2SMART PI [Sarah Kaufman was featured in 9to5Mac as she helped develop a new kids app, Pok Pok Town](#).
- Sarah Kaufman was also featured in an article for Smart Cities Dive entitled, "[7 ways cities can make transportation safer for women](#)", where her work regarding the Pink Tax on Transportation was highlighted.
- Sarah Kaufman was featured on [Autonocast's weekly podcast](#) for her discussion on why AVs are good for citizens of New York City.
- Sarah Kaufman was also featured in an American Journal of Transportation article titled, "[To reduce traffic, this company wants cargo e-bikes to replace delivery vans](#)."
- At a climate resiliency press conference on September 1, 2022, the anniversary of Hurricane Ida Mayor Eric Adams highlighted the expanding [FloodNet project](#), which includes the new dashboard and 500 new sensors. "This is more than infrastructure; it's how we are going to protect our city and people from rising sea levels and stronger storms," he said.
- NY1 detailed the latest updates to the [C2SMART-supported FloodSense project](#) and its impact on New York City.
- C2SMART's panel discussion, Research and Practice: Scaling a Flood Sensor Network for a Resilient NYC, was featured in an NYU Tandon article titled, "[It takes a village ... or an innovative university-city partnership](#)."
- Professor Elizabeth Hénaff was quoted in an article for Greenroofs titled "[Developing Design Criteria for Active Green Wall Bioremediation Performance](#)" for her work which measured CO2 concentration changes driven by differing plant and growth media (organic vs. hydroponic) treatments within a semi-sealed chamber.
- Professor Elizabeth Hénaff was featured in a [Brooklyn Daily Eagle article](#) for her work exploring the extremophiles living in the bottom of the Gowanus Canal, a 1.8-mile waterway known for its inhospitable and grotesque waters from a century of environmental damage.
- NYU researcher Charlie Mydlarz's recent paper on his work with Ohio State on a new generation of energy harvesting noise sensors with embedded machine learning for automatic sound source ID was featured on [Edge Impulse](#).
- Professor Semiha Ergan was featured in [CIDCI Salon](#) discussing tools available in the architecture, engineering & construction (AEC) industry responding to infrastructure & building needs.
- Professor Jeff Ban was [quoted in a King 5 story](#) exploring commuter traffic's return to pre-pandemic levels. When asked how long traffic will remain light during peak commuting hours, he said, "For some length of time. However, transit is likely to remain in real trouble."

- C2SMART PI Don Mackenzie was recently featured in a Seattle Times article titled "[Seattle-area demand for Uber, Lyft still not back up to speed, an outlier in the U.S.](#)"

D. Plans for Next Reporting Period

- The second installment of C2SMART’s “State of the Field” series will be launched during the next period to take a deep dive on the latest advances in Connected Vehicle technology. The planned series on Connected Vehicle technology will explore four key elements:
 - Improving Safety through Connected Vehicle Technology
 - Assisting Pedestrians with Vision Disabilities in Navigating Urban Streets
 - Simulation-Based Framework for Safety Evaluation of Connected Vehicles
 - And will conclude with a Roundtable on Lessons Learned, Future Research, and Deployment Potential
- C2SMART’s Emerging Leaders in Transportation three-day workshop will return to NYU. This workshop aims to enhance the toolkit of early-career employees to make transportation more efficient, effective, and people-oriented. In this competitive fellowship program, participants will learn from top transportation and management professionals to enhance leadership skills, communication techniques and policy work to bring innovative ideas into practice.
- C2SMART will host a Virtual Hackathon in partnership with NYC DOT from Saturday October 15th, 2022 through Sunday, October 23, 2022. Students will design 3D visualizers to help truck drivers navigate the complexities of the city and identify the best route for reaching their destination.
- The NYU team at C2SMART will participate in NYC Town+Gown’s Vision Zero event scheduled for November 2022.
- Professor Ceferino and the Floodsense team are hosting a workshop in November, inviting experts from different fields, asking them to assign priorities to each available metric and calculating a weighting scale to combine them together.

II. Participants and Collaborating Organizations

A. Partner Organizations

Table 4: C2SMART Active Partnerships with Updates during this Reporting Period

Organization Name	Location	Contribution		
		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
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.

- On May 18, 2022 NYU hosted a Joint Transportation Research Summit bringing together faculty, students, and researchers from NYU's three global campuses in New York, Abu Dhabi, and Shanghai to share their transportation research and discuss future opportunities for collaboration.
- Members from UTEP's Digital Twin team met with partners from NYU regarding implementation of the FloodSense system developed through C2SMART. The UTEP team intends to procure and connect a small network of flood sensors on campus to measure water levels in the arroyo which runs through campus. This represents a different application of FloodSense to that of New York, given the different rain fall patterns and flood concerns in El Paso, TX.
- The UTEP digital twin team also collaborated with staff from the Texas Innovation Alliance, who voluntarily supported the team by facilitating the stakeholder engagement workshop. They additionally collaborated on Research Needs Statements and an invited talk for the Texas Technology Task Force.

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
- 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.
- Professor Chow was awarded a grant from MOIA (<https://www.moia.io/en>), the mobility fleet division of Volkswagen, to develop an enhancement to their electric fleet dispatch algorithm to integrate en-route transfers, a feature his team initially developed as part of NSF’s EAGER grant (CMMI-2022967) in collaboration with University of South Florida to study modular automated vehicles.
- 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. As partners, the team from CTU has expertise, tools, and software that will be leveraged for this project. Dr. Svitek is an international expert in smart cities and data visualization, while Dr. Horak has an operational DT model for the city of Prague in his laboratory.

3. Other Collaborations

- C2SMART continues to participate as part of is part of a project team led by Dollaride, which was 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.
- The team led by Professor Claudio Silva initiated a collaboration with NEC Labs America in Princeton, NJ, as part of the “Exploring AI-based video segmentation and saliency computation to optimize imagery-acquisition from moving vehicles” project. NEC staff participated in several discussions and helped to frame use cases. They have also provided financial gift to support related work at NYU.
- The FloodSense team has established new collaborations with Drexel University for flood sensor fabrication, Technical support and guidance for technology transfer, Informal for Sensor DFM(Design for Manufacturability), and Senet a private network provider, for coverage in all 5 boroughs of NYC. These collaborations build on their ongoing collaborations with CUNY ASRC; Science and Resiliency Institute at Jamaica Bay; Data visualization team at Pratt Institute; NYCDOT asset management and special projects; NYC Mayor’s Office of Climate Resiliency (MOCR); NYC Mayor’s Office CTO (MOCTO); The Things Network; New York City Department of Transportation; New York City Department of Environmental Protection (DEP; NYC DEP Bureau of Water and Sewer Operations; NYC Emergency Management; National Weather Service; and 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

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 5: Output Performance Measures

Performance Measures	Annual Goal	Achieved (current period)
Peer-reviewed papers	20	34
Conference presentations	10	9
Joint proposals/projects with industry/agency partners	10	16
Website analytics	5,000 views	24,754

A. Publications, Conference Papers and Presentations

1. List of Journal Publications

- [Worldwide city transport typology prediction with sentence-BERT based supervised learning via Wikipedia](#), authored by Joseph Chow, proposes a supervised machine learning approach to predict a city's typology given the information in its Wikipedia page and was published in Transportation Research Part C: Emerging Technologies.
- [Combined Longitudinal and Lateral Control of Autonomous Vehicles based on Reinforcement Learning](#), authored by Leilei Cui, Kaan Ozbay, and Zhong-Ping Jiang, proposed a data-driven optimal control approach in order for the autonomous vehicle to keep a desired distance from the preceding vehicle and stay in the lane. Published in: 2021 American Control Conference (ACC).
- [Efficient Procedure of Building University Campus Models for Digital Twin Simulation](#) authored by Talha Azfar, Ruimin Ke, Jeffrey Weidner, Adeeba Raheem, and Ruey Long Cheu explores different tools and resources to assemble an efficient and convenient procedure to create a 3D digital model of a university campus that can support digital twin applications. Published in: IEEE Journal of Radio Frequency Identification (Early Access).
- [Serviceability of Beams Prestressed with Hybrid \(Steel/Carbon Fiber-Reinforced Polymer\) Tendons](#), authored by Adi Obeidah and Hani Nassif focuses on the serviceability performance of hybrid beams prestressed using a combination of bonded and unbonded steel and carbon fiber-reinforced polymer (CFRP) tendons. It was published in ACI Structure Journal.
- [Deep Learning-Based Downscaling of Temperatures for Monitoring Local Climate Change Using Global Climate Simulation Data](#) by Firas Gerges, Michel C. Boufadel, Elie Bou-Zeid, Hani Nassif and Jason T. L. Wang provides an overview of GCM downscaling with machine learning and present a case study that leverages deep learning to downscale weekly averages of the daily minimum and maximum temperatures in the Hackensack–Passaic watershed in New Jersey. Published in World Scientific Annual Review of Artificial Intelligence.
- [Efficiency in wholesale electricity markets: On the role of externalities and subsidies](#), authored by Burçin Ünel, uses an analytical model of energy-and-capacity markets that allows for prediction of the price and resource mix effects of generation-based subsidies and was published in Energy Economics.
- [Paratransit Shared-Ride Capacity Design With Infectious Disease Contact Exposure](#), authored by Joseph Chow, applies an estimate of disease contact exposure to actual data from New York City's Access-A-Ride (AAR) paratransit system to evaluate design changes during the coronavirus pandemic and was published in Transportation Research Record.
- [A Simulation Sandbox to Compare Fixed-Route, Semi-flexible Transit, and On-demand Microtransit System Designs](#), authored by Joseph Chow, developed an open-source simulation sandbox is developed that can compare state-of-the-practice methods for evaluating between the different types of public transit operations, and was published in KSCE Journal of Civil Engineering.
- [Development of An Analytical Method for Design of Electromagnetic Energy Harvesters with Planar Magnetic Arrays](#), authored by Mohsen Amjadian, Anil Agrawal, and Hani Nassif, proposed an analytical method for the modeling of electromagnetic energy harvesters (EMEH) with planar arrays of permanent magnets and was published in Energies.
- [Safety Analytics at a Granular Level Using a Gaussian Process Modulated Renewal Model: A Case Study of the COVID-19 Pandemic](#) authored by Yiyuan Lei, Kaan Ozbay, and Kun Xie, proposes an efficient Gaussian process modulated renewal process model for safety analytics that does not suffer from information loss due to data aggregations and was published in Accident Analysis and Prevention.
- [Making Waves: Uses of real-time, hyperlocal flood sensor data for emergency management, resiliency planning, and flood impact mitigation](#), authored by Andrea Silverman, Tega Brain, Brett Branco, Praneeth Challagonda, Petra Choi, Rebecca Fischman, Kathryn Graziano, Elizabeth Henaff,

Charlie Mydlarz, Paul Rothman, Ricardo Toledo-Crow, uses flood profile data to aid emergency response, storm recovery and resiliency planning and was published in Water Research.

- [A New Curb Lane Monitoring and Illegal Parking Impact Estimation Approach Based on Queueing Theory and Computer Vision for Cameras with Low Resolution and Low Frame Rate](#), authored by Jingqin Gao, Fan Zuo, Kaan Ozbay, Omar Hammami, and Murat Ledin Barlas, presents a new computer vision-based data acquisition and analytics approach for curb lane monitoring and illegal parking impact assessment and was published in Transportation Research Part A: Policy and Practice.
- [Efficient and stable data-sharing in a public transit oligopoly as a cooperative game](#), authored by Joseph Chow, proposes a new method of composite coalition to study efficient markets and an alternative continuous model is proposed to handle large networks using simulation and was published in Transportation Research: Part B.
- [Pierce Transit Automated Collision Avoidance and Mitigation Safety Research and Demonstration Project](#), partially authored by [Ruimin Ke](#), reports on research on five parallel tracks to address some of the challenging issues facing transit agencies, bus original equipment manufacturers (OEMs), and technology developers seeking to bring collision avoidance technology to the transit bus industry, and was published on the Federal Transit Administration (FTA) website
- [Development of An Analytical Method for Design of Electromagnetic Energy Harvesters with Planar Magnetic Arrays](#), authored by [Mohsen Amjadian](#), [Anil. K. Agrawal](#), and [Hani Nassif](#), was published in *Energies*, and proposed an analytical method for the modeling of electromagnetic energy harvesters (EMEH) with planar arrays of permanent magnets.
- [Urban path travel time estimation using GPS trajectories from high-sampling-rate ridesourcing services](#), authored by [Kaan Ozbay](#) and Diego Correa, was published in the *Journal of Intelligent Transportation Systems* and explores the use of individual GPS readings to estimate Link-Travel-Time estimation by developing and implementing a novel comprehensive data processing and path-finding methodology.
- The [Mobile Accessible Pedestrian Signal System \(PED-SIG\) Application Test Summary and Evaluation Report](#), authored by Kaan Ozbay, Jingqin Gao, Fan Zuo, Mohamad Talas, Hisham Khanzada, Gary Roth, Robert Rausch, David Benevelli, Samuel Sim, and Keir Opie, was published by the US Department of Transportation. This report details the results of the Mobile Accessible Pedestrian Signal System, which aims to provide pedestrians with vision disabilities navigation assistance at signalized intersections.
- [Understanding and Enabling Cooperative Driving for Advanced Connected Vehicles in New York City](#), authored by Mohamad Talas, Kaan Ozbay, Jingqin Gao, Abhinav Bhattacharyya, Robert Rausch, David Benevelli, and Samuel Sim, was published by the US Department of Transportation. The report explores the applicability of cooperative driving for advanced connected vehicles on urban roadways based on insights, data analysis, and stakeholder feedback documented as a part of the USDOT Connected Vehicle Pilot Deployment.
- [Connected Vehicle Pilot Deployment Program Phase 3 – System Performance Report](#), authored by Mohamad Talas, Keir Opei, Kaan Ozbay, Jingqin Gao, Di Yang, Robert Rausch, David Benevelli, and Samuel Sim, was published by the US Department of Transportation. This report presents the performance measurement and evaluation results and methodology of the New York City (NYC) Connected Vehicle Pilot Deployment.
- Professor Luis Ceferino co-authored three papers: [Probabilistic and Machine Learning Methods for Uncertainty Quantification in Power Outage Prediction due to Extreme Events](#), [Hurricane Risk of Solar Generation in the United States](#), and [Bayesian Updating of Solar Panel Fragility Curves an Implications of Higher Panel Strength for Solar Generation Resilience](#).

- Professor Ruimin Ke co-authored two papers: [Real-Time Traffic and Road Surveillance With Parallel Edge Intelligence](#) and [Efficient Procedure of Building University Campus Models for Digital Twin Simulation](#).
 - Professor Jeff Ban co-authored two papers: [Are Big Mobility Data Reliable for Assessing the Performance of Transit Systems During Covid-19?](#) and [Modeling and Evaluating Impacts of Post-Covid Return-to-Work Plans on Transportation Systems](#).
 - Professor Benedetto Piccoli co-authored [Hybrid multi-population traffic flow model: Optimal control for a mean-field limit](#), [Mean-field limit of a hybrid system for multi-lane multi-class traffic](#), and [Spatial-Temporal Deep Embedding for Vehicle Trajectory Reconstruction from High-Angle Video](#).
 - Professor Hani Nassif co-authored [GIS-based approach for evaluating a community intrinsic resilience index](#) and [Evaluation of Live Load Distribution Factors for Aging Prestressed Concrete Bridges](#).
 - Professor Semiha Ergan co-authored [Estimating Power Demand Shaving Capacity of Buildings on an Urban Scale using Extracted Demand Response Profiles through Machine Learning Models](#).
 - Professor Kelvin Cheu co-authored [Fault Tolerance Analysis of an Adaptive Neuro-Fuzzy Inference System for Mandatory Lane Changing Decisions in Automated Driving](#).
 - Professor Kaan Ozbay, Chuan Xu, and Bekir Oguz Bartin co-authored [Safety Performance Functions for Two-Lane Urban Arterial Segments](#).
2. Books or Other Non-Periodical, One-Time Publications
- C2SMART researchers released a preliminary framework for approaching the wraparound policies concerning the introduction of autonomous vehicles to New York City, published on [the C2SMART website](#).
 - [C2SMART Women Driving Transportation Forward](#) introduced three researchers affiliated with C2SMART to celebrate National Women’s History Month.
 - [Improving Traffic Safety Risk Analysis Through Big Data](#) describes C2SMART’s critical work in evaluating traffic safety risk through the use of the so-called “traffic conflict data.”
3. Other Publications, Conference Papers and Presentations
- C2SMART Center's COVID-19 Data Dashboard was recently featured in [USDOT's Research, Development, and Technology Forum on Artificial Intelligence in Transportation](#).
 - Prof. Joseph Chow participated in a Dagstuhl Seminar on "[Dynamic Traffic Models in Transportation Science](#)" as the only participant from a U.S. university.
 - C2SMART PI Sarah Kaufman published a new report, "[How the Interborough Express Will Impact Local Populations](#)."
 - Professor Ceferino submitted an abstract to the conference ICASP-14, that will be held in Dublin on July 2023. The paper shows the comparative study between NYC Stormwater Flood Maps and 311 data recorded during hurricane Ida. In the same work, they compared regions with high density of 311 complaints with ridership values in MTA subway stations, finding a good correlation between the two metrics. The abstract is under evaluation.
 - Professor Nassif presented "Weigh-In-Motion Systems used for Vehicle Enforcement Screen", at CWMA Interim Meeting, Wisconsin Dells, WI on 8/30/22.
 - Dr. Chaekuk Na, member of the Rutgers team, presented. "Weigh-In-Motion Systems used for Vehicle Enforcement Screen", at WWMA Interim Meeting, Garden Grove, CA on 9/26/22.
 - Xiyuan Ren and Professor Chow’s paper “A random-utility-consistent machine learning method to estimate agents’ joint activity scheduling choice from a ubiquitous data set” was presented at TRISTAN XI.
 - Two papers by the UTEP team “Using Vision-Based Methodology to Create a Traffic Network Asset Inventory for a University Campus for Integration in a Digital Twin” and “Evaluation of 3D

Reconstruction Methods from Terrestrial LiDAR Point Cloud Data to Create Digital Twins of Civil Infrastructure Projects” were selected for presentation at the ASCE ICTD 2022 Conference.

- Professor Ozbay and Dr. Gao presented to NYC Town+Gown on July 26, 2022, with a group of agency professionals from NYC Department of Design and Construction and NYC Department of Transportation.
- Professor Ozbay and Dr. Gao presented “Calibrating Stochastic Traffic Simulation Models for Safety and Operational Measures Based on Vehicle Conflict Distributions Obtained from Drone and Traffic Camera Videos” at the 8th Road Safety & Simulation International Conference.

B. Websites

The [C2SMART website](#) disseminates information about the Center’s activities and research, with 39,000 unique page views during this reporting period, exceeding its annual goal of 5,000 pageviews. The [COVID-19 mobility dashboard](#) continues to generate a lot of interest and inquiries and received 3,990 total page views. 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 412 times. The FloodNet project website www.floodnet.nyc also actively disseminates project outcomes.

C. Technologies or Techniques

- C2SMART-related video analytics work was mentioned on USDOT Intelligent Transportation Systems Joint Program Office’s ITS Deployment Evaluation website. The ITS Deployment Evaluation Program presents summaries on the benefits, costs, deployment levels, and lessons learned for ITS deployment and operations. Over 20 years of ITS evaluation studies, research syntheses, handbooks, journal articles, and conference papers tracking the effectiveness of deployed ITS.
- The Electromagnetic Energy Harvester team developed a new device consisting of two copper coils attached to two cantilevered beams moving relative to three linear layers of small permanent magnets. The device is undergoing testing for field deployment.

D. Industry/Agency Partners

Table 4 lists all current active or renewed collaborations with agency and industry partners.

- C2SMART is actively working with the New York State Department of Transportation (NYSDOT) on six research projects under its long-term consortium agreement. These projects are:
 - SR-20-02 Statewide Mobility Services Program Strategic Procurement Planning
 - SR-20-03 Capital Program Resource Model
 - SR-20-04 Statewide Open-Source Advanced Traffic Management System (ATMS) Pilot
 - SR-20-05 AASHTO and NBI Element Deterioration Rates for Bridge Management System
 - SR-21-02 Design Finite Element Analyses and Crash Testing
 - SR-21-03 Finite Element Analyses and Crash Testing of NYSDOT Bridge Railing and Barrier
- The National Science Foundation (NSF) awarded three teams of researchers at the NYU Tandon School of Engineering a combined \$2.5 million to confront wireless telecommunications challenges head on. C2SMART PI Zhong-Ping Jiang is a participant in the projects, each of which are supported by NSF’s Resilient and Intelligent Next Generation Systems (RINGS) partnership.
- C2SMART PI Joseph Chow’s proposal, “Development and evaluation of an electric-charging-constrained, non-myopic, dynamic routing algorithm with synchronized transfers” was selected by MOIA, the mobility division of Volkswagen, in response to their RFP.
- Professors Ozbay and Nassif received a new grant from NYC Department of Transportation via NYC Town+Gown to study and implement Weigh-In-Motion sensors throughout New York City
- Professors Chow and Ozbay of NYU are part of a team led by Arcadis that was awarded a contract from NYCDOT for expanding their Off-Hours Delivery program.

- The Defense Advanced Research Projects Agency (DARPA) awarded Rutgers a \$12.6 million grant for its initiative to create an oyster-based ecosystem that will protect coastlines from storms, flooding and erosion. The initiative, “Reefense: A Mosaic Oyster Habitat (MOH) for Coastal Defense,” aims to develop both biological and engineered oyster reefs on the Gulf Coast to help manage the shoreline as sea level rises and storm conditions continue to put communities and infrastructure at risk. Dr. Hani Nassif joined the project to bring a Civil Engineering perspective to the work.
- Professor Ozbay received a new 3-year grant from USDOT (sub to Noblis) for USDOT’s Benefits/Cost Lessons Learned.
- 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, the largest network provider of independently owned EV charging stations, is 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. The project has assembled a volunteer advisory board. In total, 10 professionals from New York City (NYC) Department of Transportation, NYC Department of Design and Construction, NYC Department of City Planning, and NYC Office of Technology and Innovation will participate
- 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

- Professor Jiang’s lane-changing methodology is being implemented in Simulation of Urban Mobility (SUMO) which is an open source, portable, microscopic and continuous multi-modal traffic simulation package and will be made available at project conclusion.
- The One-to-many Simulator project created a calibrated VTD simulation platform for greater Seattle.
- The FloodSense team released Flood Hotspots Identification Strategy, Deployment, and Maintenance manuals implemented via github.

IV. Outcomes

A. Increased Understanding and Awareness of Transportation Issues

- C2SMART released multiple reports, articles, and webinars on PED-SIG, a phone app which could improve mobility of pedestrians with vision disabilities to navigate safely and independently through New York City using Connected Vehicle

Table 6: Outcomes Performance Measures

Performance Measures	Annual Goal	Achieved (current period)
Media interviews, mentions, coverage	10	43
Workshops, webinars, and seminars	10	18

technology. The reports highlight both the potential for this technology to improve mobility and the obstacles that must be overcome.

- 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 UTEP team collaborated with Texas Innovation Alliance and TxDOT staff to create a Research Needs Statement (RNS) centered on a digital twin adoption strategy for TxDOT. This RNS is under consideration and, if selected, will be competed statewide in Spring 2023.
- FloodNet’s alerting system continues to be useful to city agencies tasked with reacting to flood conditions.

B. Increases in the Body of Knowledge

- The research findings from the Autonomous Lane Changing project have contributed towards the data-driven control of AV where the model and environment uncertainties are taken care by the data driven controller. The proposed data-driven controller enjoys satisfactory performance and guaranteed stability properties for real-time implementation.
- C2SMART-related video analytics work was mentioned on USDOT Intelligent Transportation Systems Joint Program Office’s ITS Deployment Evaluation website. The ITS Deployment Evaluation Program presents summaries on the benefits, costs, deployment levels, and lessons learned for ITS deployment and operations. Over 20 years of ITS evaluation studies, research syntheses, handbooks, journal articles, and conference papers tracking the effectiveness of deployed ITS.

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

- Professor Nassif’s team demonstrated the state-of-the-art WIM sensor (Piezo-Quartz sensor) and software-based ALPR system to identify overweight trucks for future enforcement practice. The NYCDOT accepted using the WIM system using the Quartz sensor and the ALPR system using non-proprietary cameras.
- The UW team has prepared a suite of simulations that work together: MATSim for macro (agent-based) traffic demand simulation, SUMO for microscopic traffic simulation, and Unity for vehicle simulation.
- The NYU team developed a data-driven gain scheduling controller using adaptive dynamic programming; the technique will be shared via research publications in reputed journals and conferences. This research has also addressed the problem of lane changing of AV in mixed traffic; 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.
- The research from the Autonomous Lane Changing project has addressed 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 proposed technologies in this research have made new contributions to transportation especially lane changing.
- Professor Ke’s project is implementing a vehicle detection and tracking on edge device process based on the Nvidia DeepStream SDK which provides a complete pipeline for developing computer vision algorithms and deploying them in edge computing devices. The purpose of this project is to place edge computing devices Jetson Xavier NX and cameras to complete object detection and tracking and

get real-time traffic flow information in all directions including the trajectory of each vehicle. The project is currently in the stage of testing target detection and tracking algorithms and counting the number of vehicles for every type. Some videos shot from Schuster Garage at different times and from different angles are being tested using yolov5 and DeepSORT algorithms.

V. Impact

A. Effectiveness of the Transportation System

- FloodNet’s continued flood monitoring is yielding a dataset with updates every minute from each of the sensors. The alerting system offers an opportunity to alert drivers and city agencies of flooded streets in real time

B. New Practices or Companies

- Nothing to report in this period.

C. Body of Scientific Knowledge

- C2SMART released three evaluative papers regarding the USDOT Connected Vehicle Deployment Pilot: Mobile Accessible Pedestrian Signal System (PED-SIG) Application Test Summary and Evaluation Report – New York City, System Performance Report - New York City, and Understanding and Enabling Cooperative Driving for Advanced Connected Vehicles in New York City.
- C2SMART PI Zhong-Ping Jiang was awarded NYU Tandon's 2022 [Excellence in Research Award](#)
- Professor Joseph Chow was selected by the *Transportation Science* (<https://pubsonline.informs.org/journal/trsc>) editorial board to receive a Meritorious Service Award in appreciation of my efforts as a reviewer for the journal.

D. Transportation Workforce Development

- Two of C2SMART’s labs at NYU welcomed high school students as part of the 2022 [Applied Research Innovations in Science and Engineering \(ARISE\)](#) program. As part of the 5-week program, the students worked to further research in sustainability and COVID-19 economic recovery.
- C2SMAR at NYU hosted two students for this year’s Summer Undergraduate Research Program, where they created 3-4 minute videos about their summer research project geared toward a “non-STEM” audience. Both students placed in the video competition, winning first in the Data Science/AI/Robotics category and third in Urban Studies.
- Professor Chow served as an external examiner for two international PhD student defenses: Jonas Hatzenbuehler (supervised by Oded Cats and Erik Jenelius) at KTH Royal Institute of Technology, and Dang Khoa Vo (supervised by William Lam and Anthony Chen) at Hong Kong Polytechnic University
- The C2SMART Student Learning Hub has presented a total of 30 sessions. These sessions have generated 2,275 total views by almost 500 students from 31 universities across 8 countries.

Table 7: 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	9
Partnerships/collaborative relationships with companies or transportation agencies established or renewed	10	11

VI. Changes/Problems

- Nothing to report in this period.