

## SEMI-ANNUAL PROGRESS REPORT

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

<b>Federal Grant Number</b>	69A3551747124
<b>Project Title</b>	C2SMART Tier I University Transportation Center
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<b>Submitting Official</b>	Center Director
<b>Submission Date</b>	April 30, 2020
<b>DUNS</b>	04-196-8306
<b>EIN</b>	13-5562308
<b>Project/Grant Period</b>	Start Date: November 1, 2016 End Date: November 1, 2022
<b>Reporting Period End Date</b>	March 31, 2020
<b>Report Term or Frequency</b>	Semi-Annual

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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 will study 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

##### a) Facilities & Staffing

C2SMART is scheduled to move into its new office space at NYU Tandon School of Engineering in June 2020. The new center space includes a state-of-the-art visualization lab, secure data room and servers, and office/desk space for all of the Center's researchers, faculty, and staff. C2SMART has also hired a new Project Manager partially funded by the Center to assist Center administration in meeting requirements.

##### b) Data Management

C2SMART has worked to become compliant with the Center and USDOT's data management requirements, including uploading datasets, code and other outputs to the center's Data Repository and submitting all products from completed projects to the National Transportation Library. The most-viewed repository is on the "Freeway Inductive Loop Detector Dataset for Network-wide Traffic Speed Prediction" project which has 197 views and 56 downloads at the time of reporting.

##### c) Advisory Board

C2SMART's advisory board participated in its latest project selection process by reviewing proposals for funding from C2SMART consortium members. Based on their industry/agency experience they were able to select and provide comments/input on proposed projects to help ensure newly selected projects meet C2SMART's goals.

#### 2. Research

Table 1 provides updates on C2SMART's ongoing funded research projects.

**Table 1: Updates on ongoing center-funded research projects**

Urban Mobility and Connected Citizens	<b>Integrative Vehicle Infrastructure Traffic System (iVITS) Control in Connected Cities</b> CCNY, NYU	Calibration of the simulation models in New York City has been completed. A report is being finalized with the calibration results.
	<b>Impact of Ride-Sharing in New York City</b> NYU	Researchers built two models based on testbed simulations and trained the model using different datasets and scenarios. The research will next focus on applying available citywide ridership.
	<b>Increasing Work Zone Safety: Worker Behavior Analysis with Integration of Wearable Sensors and Virtual Reality</b> NYU	Researchers selected three work zone scenarios to simulate and began to develop these environments in virtual reality. They received IRB approval to conduct user tests and will add traffic simulations to the VR environments before testing.
	<b>Simulation and Analytical Evaluation of Bus Redesign Alternatives in Transit Deserts with Ride-Hail Presence</b> NYU	Two webpages were built to serve as user interfaces for the MATSim Transit Planning Tool. Practitioners can submit proposed design through the first webpage, and exhibit results for the Brooklyn Bus Redesign project in the second as an example.
	<b>Research and Field Testing of Vehicle-Traffic Control with Limited-Capacity Connected/Automated Vehicles</b> UW	Researchers designed a reinforcement learning (RL) based algorithm for vehicles considering lane changing. Results show significant improvement on fuel consumption while maintaining travel times. They also assembled a model for a real-world test.
	<b>Improving Representation in Transportation</b> NYU	Three tech transfer workshop events occurring during this reporting period: Emerging Leaders in Transportation, The Accessible Mobility Tech Showcase, and Women Leaders in Transportation.
Urban Analytics for Smart Cities	<b>Sparkman: A Smart Parking Management Tool for University Campuses</b> UTEP	The Sparkman smart parking app was tested and distributed to more than 70 members of the Campus Parking and Transportation Association (CPTA). A submitted final report is being finalized.
	<b>Urban Connector</b> UTEP	NYU partners started to recruit participants at senior centers & UTEP worked with the City of El Paso to recruit at the opening ceremony of the Senior Games.
Resilient, Secure, and Smart Transportation Infrastructure	<b>Crowdsourcing Parking Data for Micromobility Vehicles</b> UW	This project shifted focus to micromobility vehicles, and the research team began designing two apps to retrieve misparked bicycle and scooters. They will begin testing the app in Seattle.
	<b>Design of Resilient Smart Highway Systems with Data Driven Monitoring from Networked Cameras</b> NYU	Researchers worked to improve the computer vision vehicle detection system and completed an analysis of fault-tolerant routing over parallel traffic links. The team also collected data for a section of US I-210.
	<b>Developing Secure Strategies for Vehicular Ad Hoc Networks in Connected and Autonomous Vehicles</b> NYU	Researchers completed risk assessment on monitoring and detection of threats of CAVs, as well as development of alternative illustrative scenarios for the introduction of CAVs and its impact on multimodal patterns. The team is preparing a final report.
	<b>Development of Autonomous Enforcement Approach Using Advanced Weigh-in-Motion (A-WIM) System to Minimize Impact of Overweight Trucks</b> Rutgers	The team developed a dashboard to share Weigh-In-Motion (WIM) data and selected a camera system to capture license plates for weight enforcement. They met with FHWA, NYSDOT, and NYCDOT on legislation on direct weight enforcement and is coordinating with NYCDOT to install additional WIM sensors at the test site.
	<b>Connected Vehicles for Municipal Vehicular Fleets</b> CCNY	This project is on hold subject to data acquisition issues.
	<b>Development and Tech Transfer of Multi-Agent Virtual Simulation Test Bed Ecosystem</b> NYU	The Research Team evaluated the AV scenario tool, simulated effects of congestion pricing, and introduction of a new streetcar. Next they will help build base models in other consortium cities.

C2SMART’s initiative to provide support for student-driven research projects to create inter-disciplinary research opportunities continues. The goal of this effort is to attract students and faculty from different disciplines to create new and unique synergies in a research capacity. The following projects are ongoing:

1. Learning-Based Optimal Control of Connected and Autonomous Vehicles
2. Development of Mountable Sensors to Improve Bicyclist Safety
3. Blockchain for Preserving Privacy in V2X Connected Vehicle Applications in Urban Environments

Over the course of this reporting period, C2SMART issued a request for proposals for its next round of Center-funded research projects. Similar to the previous year, a multi-step peer-review process was employed to ensure high-quality projects with a focus on technology transfer were funded. The RFP call specified projects to address the following key areas of importance for C2SMART, its partners, and USDOT:

1. *Big Data and Urban Analytics in Smart Cities*
2. *Connected and Autonomous Mobility*
3. *Microtransit, Micromobility, and Shared Mobility*
4. *Safety of Pedestrians and Mobility Systems*
5. *Resilient, Secure, and Smart Transportation Infrastructure*
6. *Equity & Accessibility for Under-represented Groups in Transportation*

From the revised submissions, the following projects were awarded funding to commence in March 2020:

**Table 2: Year 4 awarded projects**

Urban Mobility and Connected Citizens	<b>Modeling and Optimizing Ridesourcing Services in Connected and Automated Cities, UW</b>	This project proposes a framework to integrate ride-sourcing services and CAVs with transit to serve different users. Simulation will be conducted on a multimodal network in the Seattle area.
	<b>Learning to Drive Autonomously, NYU</b>	Researchers will develop adaptive learning algorithms to tackle the control of autonomous vehicles and its extension to optimal cooperative adaptive cruise control (CACC) of CAVs.
	<b>Cooperative Perception of Road-Side Unit and Onboard Equipment with Edge Artificial Intelligence for Driving Assistance, UW</b>	This project develops a cooperative perception system that fuses data from on-board and road-side units to solve Advance Driver Assistance Systems (ADAS) perception and understanding challenges.
	<b>Urban Microtransit Cross-sectional Study for Service Portfolio Design, NYU</b>	This project will investigate settings that make microtransit successful in partnership with Via and NYC DCAS, to develop a model relating operational performance to city and service attributes to make microtransit more successful.
	<b>Work Zone Safety: Behavioral Analysis with Integration of VR and Hardware in the Loop, NYU</b>	Phase 2 of this worker safety project adds a Hardware in the Loop (HIL) component to simulate real traffic scenarios. Through wearable sensors and VR simulations, researchers will collect worker responses to improve worker safety.
	<b>Wearables to Command More Access and Inclusion in a Smarter Transportation System, NYU</b>	This project will increase the safety profile and ease-of-use of the VIS4ION platform toward ‘connected’ dynamic navigation in complex urban environments, providing a new level of security to people with visual disabilities moving in urban environments.
Urban Analytics for Smart Cities	<b>Development of Level of Service Analysis Procedures and Performance Measurement Systems for Parking, UTEP</b>	This project will develop the Level of Service (LOS) analysis procedure for parking lots and multistory parking garages to evaluate performance, justify the benefit of ITS for parking, and justify linking smart parking with other smart city services in El Paso.
	<b>Integrated Robust Traffic State and Parameter Estimation and Adaptive Ramp Metering Control System, NYU</b>	Researchers aim to resolve several common issues associated with traffic state estimation algorithms and to develop an adaptive ramp metering control system based on the improved traffic estimation scheme.

<b>Resilient, Secure, and Smart Transportation Infrastructure</b>	<b>Energy Harvesting for Self-Powered Sensors for Smart Transportation Infrastructures, CCNY</b>	This research aims to develop an innovative approach for energy harvesting from transportation infrastructures through the optimization of array of permanent magnets and planar shape of the copper coils to maximize harvested energy.
	<b>Street-level Flooding Platform: Sensing and Data Sharing for Urban Accessibility and Resilience, NYU</b>	This work will develop a publicly-accessible platform that provides real-time flood information and will develop a flood sensor that overcomes common sensor challenges and the digital infrastructure necessary to log, process, and present the data.
	<b>Implementation and Effectiveness of Autonomous Enforcement of Overweight Trucks in an Urban Environment, Rutgers</b>	This research will implement an Advanced Weigh-In-Motion (A-WIM) system for autonomous enforcement of overweight trucks and study its effectiveness in reducing the number of illegal overweight trucks in an urban infrastructure environment.
	<b>Securing Intelligent Transportation Systems against Spoofing Attacks, NYU</b>	This project will develop proactive and reactive mechanisms that protect ITS from cyber attacks and recover ITS from security failures, focusing on dynamic routing via spoofing.

During the reporting period, C2SMART/NYU established a multi-year agreement with the New York State Department of Transportation (NYSDOT) to provide on-call research services in support of the Department’s goals. C2SMART was selected based on its USDOT UTC designation and due to its research portfolio and outputs being aligned with NYSDOT needs. Broadly, C2SMART will assist NYSDOT in:



- Testing, implementation, policy development, and governance of the imminent introduction of connected travelers as well as connected and autonomous vehicles
- Utilize efficient technologies and systems to address planning and operational needs regarding the safe movement of vehicles and travelers, and NYSDOT workforce, throughout the state
- Utilize new technologies to measure and enhance the resiliency of operations and infrastructure
- Modeling and simulation of transportation systems to answer questions that fall beyond standard industry state of practice and that require specialized expertise
- Develop flexible and iteratively designed tools to improve the planning and execution of maintenance and construction activities
- Provide education and workforce development in cutting-edge transportation technologies

Over the following reporting period, several projects funded by NYSDOT are expected to commence.

The following other ongoing projects are used as matching funds for C2SMART or have complementary research aims to C2SMART-funded projects. Combined with C2SMART-funded research, these projects enable larger, more impactful, efforts that have benefits for state/local agencies as well as other users.

**Table 3: Matching or complementary funded projects to C2SMART-funded projects**

<b>Urban Mobility and Connected Citizens</b>	<b>NYC Connected Vehicle Deployment &amp; Mobile Accessible Pedestrian Signal System Application</b>	NYCDOT/JHK Engineering
	<b>Multi-Agency/Multimodal Construction Management Tool to Enhance Coordination Projects City-Wide During Planning and Operation Phases to Improve Highway Mobility and Drivers Experience</b>	NYCDOT/ NYSDOT
	<b>Model Station Project (Accessible Station Lab Evaluation)</b>	MTA NYC Transit
	<b>Real Time Public Transit Route Deviation Operational Policies</b>	FTA
<b>Urban Analytics for Smart Cities</b>	<b>Algorithms to Convert Basic Safety Messages into Traffic Measures</b>	NCHRP/Noblis
	<b>Needs Assessment for the Development of Data-Driven Predictive Non-Recurrent Delay Models for TRANSCOM</b>	TRANSCOM/ Infosenseglobal
	<b>Development of Reconfigurable Environmental Intelligence Platform</b>	NSF

Resilient, Secure, and Smart Transportation Infrastructure	Bridge Resource Program	NJDOT
	Technical Support Services for the Maintenance Department	NJ Turnpike Authority

Finally, in response to the COVID-19 epidemic outbreak in March 2020, C2SMART researchers have launched new initiatives to observe how transportation systems are being affected. Research efforts have focused on:

- Passenger travel trends and long-term changes to mode choice during the recovery
- The effect of social distancing policies on transit use and mobility patterns
- Freight, logistics, and supply chain impacts in response to the pandemic
- Economic impacts on agencies’ revenue collection and operating/capital budgets

The objective is to understand the impact of the pandemic on behavior and travel trends to provide actionable insights to enhance the resiliency of transportation systems in the face of future outbreaks. C2SMART put together [a white paper](#) based on information collected in March 2020, and will be continuing to collect data to monitor these trends and regularly update findings as this crisis unfolds.

### 3. Education

C2SMART undertakes several educational efforts to develop students into transportation professionals.

**Vertically Integrated Projects (VIP)** – This program provides a multi-year approach to learning that emphasizes project-based, innovative, research-active education for undergraduate students. Through VIPs, students interact with the industry partners, have the opportunity to commercialize their ideas, and receive course credit. As students progress through the courses, their seniority on the project demands leadership, management, and mentorship roles that prepare them for the workforce. C2SMART supports NYU VIPs in:

- **Smart Cities Technology** - Student research teams design and prototype technological innovations to address the needs of smart cities outlined in the Report to the President “Technology and the Future of Cities” with an emphasis on transportation.
- **NYU Hyperloop** - This team conducts research on hyperloop pods including propulsion, structures, feedback & control, material science, electronics and electrical systems. The business and civil engineering teams will determine the feasibility of implementing a hyperloop-type system in NY.
- **NYU Self Drive** - Students transformed a golf-cart into a machine built for autonomy, and will focus on wearable technology to improve transportation access as part of a C2SMART-funded project.
- **NYU Urban LiDAR and Remote Sensing** - This team researches solutions to address challenges inherent in converting massive LiDAR point clouds into actionable insights for using this data in transportation systems and smart cities.

**Institute of Transportation Engineers (ITE) and Intelligent Transportation Society (ITS) student chapters** – C2SMART students continue to serve in leadership roles and the center provides space and support for their activities. They hosted several networking events and information session with industry, and the 3rd **Women in Transportation Panel**. In addition, in February 2020, then-president of NYU-ITE, Jingqin Gao, was awarded the competitive ITE Met Section 2019 Dr. Louis J. Pignataro Memorial Transportation Education Award. Members from NYU-ITE participated in the Uni BUILD event in Brooklyn, NY on October 6, 2019,. In the past year, students from the NYU-ITE chapter published 18 conference/journal papers.

## C. Dissemination and Outreach

### 1. Training and Tech Transfer Events

- **Improving Representation in Transportation** is a Center-funded series on transportation policy and how to foster representation of diverse groups. The discussion workshops generate recommendations for

policymakers to improve mobility for underserved groups and areas. 25 early-career urban planning professionals for the seventh annual **Emerging Leaders in Transportation** Program. The **Women Leaders in Transportation Panel** featured a presentation and panel discussion highlighting female leaders in transportation. C2SMART collaborated with the Transit Tech Lab to hold the **Accessible Mobility Tech Showcase** focused on mobility technologies for people with disabilities.

- On October 12, 2019, **TransportationCamp NYC 2019** returned to C2SMART/NYU Tandon to foster open conversations and collaborations on mobility and the ongoing radical changes global in transportation globally – in cities and between them. NYU-ITE student volunteers served as moderators and helped the more than 300 attendees with the check-in process and directed attendees to presentations.
- On November 6, 2019, **Talk from the Top – Life Cycle Cost for Infrastructure Investments**, co-hosted with the Institute of Asset Management, was a public-facing event on the life cycle costs for infrastructure investments. A panel featured Tom Prendergast, former MTA Chairman, Dr Michael Horodniceanu, former President of MTA Capital Construction, Craig Stewart, former Senior Director of MTA Capital Programs, Michael Salvato, former Director for Enterprise Asset Management at the MTA.
- **Managing Urban Parking and Mobility** was held on November 12 – 13, 2019. The International Parking & Mobility Institute and C2SMART convened select leaders from the largest cities across the country including New York, Seattle, Detroit, Columbus, Philadelphia, Chicago, Denver, and San Francisco for a two-day discussion about the evolving mobility landscape and its effects on transportation and parking in cities. C2SMART researchers Kaan Ozbay and Jingqin Gao presented their research on double-parking.

**a) Conference Presentations and Research Showcases**

C2SMART researchers were highly represented at the **99th Annual Meeting of the Transportation Research Board** on January 12th - 16th, 2020, through a total of **53 workshops, presentations, and posters**. A full list can be found on the [C2SMART website](#). C2SMART research on work zone safety was also presented at **USDOT OST-R's** exhibition booth in the convention's exhibit hall. The demonstration used virtual reality to simulate the experience of construction/maintenance workers on active roadways. Additional activities include:



- PacTrans Region 10 UTC hosted a seminar on Oct. 23 at University of Washington, featuring C2SMART Director Kaan Ozbay, with a presentation called “Towards a Safer Urban Transportation System in the Era of Connected & Autonomous Vehicles and Big Data.” At the U. of Pittsburgh, Dr. Ozbay presented “Traffic Incident/Emergency Planning, Management and Operations for Networks under the Threat of Natural and Man-made events” on Oct. 25. He gave a plenary talk on proactive safety management in smart cities at the 24th Hong Kong Society for Transportation Studies conference in Dec, 2019, and was also an invited speaker at the Istanbul Transportation Congress to give a seminar at the Istanbul technical University “Smart Cities and Urban Mobility in the Era of Big Data and Artificial Intelligence.”
- PI Li Jin presented “Building resilient-by-design intelligent transportation systems: Theory and applications,” at the KTH Royal Institute of Technology School of Electrical Engineering on Dec. 16, and at the Shanghai Jiao Tong University on Dec. 27, 2019. At the INFORMS Annual Meeting on Oct. 23, Jin also presented “Risk evaluation for route guidance under recurrent and randomized sensing attacks”
- PI Chow, a current nominee for the INFORMS Transportation Science & Logistics Chair, presented three papers at INFORMS: “Dynamic on Demand Ride-sharing Trip-vehicle Matching with Pricing,” “Sequential Line Planning Problem With Integrated Learning For Emerging Mobility Routes” and “Online Rebalancing Algorithms For Electric Car-sharing Systems.” He and Kaan Ozbay organized the Data-driven Modeling and Simulation of Connected and Autonomous Vehicles session at INFORMS. Dr. Ozbay presented Use of Vehicle Trajectory Data-based Calibration of Microscopic Simulation Models For Evaluating Connected Vehicle Technologies at INFORMS.



- PI Jeff Ban was invited to present “Equilibrium modeling of e-hailing services on a transportation network” at the Smart Mobility Workshop, at Hong Kong University of Science and Tech in May 2019.
- UTEP PhD student Raul Alejandro Vargas Acosta presented the paper “Smart Mobility for Seniors through Urban Connector” at the 5th International Smart Cities Conference on Oct. 14-17th, 2019.
- PI Sarah Kaufman presented to a visiting group from Shanghai about New York City’s subways and spoke at the American Planning Association’s conference about technology equity in planning.
- Dr. Hani Nassif, presented research outcomes related to advanced concrete material for infrastructure resilience at the ACI Fall Convention in Oct. 2019. Dr. Nassif and C2SMART Director Dr. Ozbay and other researchers presented “Exploring the Impact of Truck Weight on Injury Severity using State-wide Disaggregate Weigh-in-Motion Data” at Roadway Safety and Simulation 2019 on Oct. 14-17, 2019.
- Dr. Stan Sobolevsky participated as a panelist on the Macro Mobility Ecosystem panel of SAE Innovations In Mobility on Oct. 31, 2019.
- Dr. Zimmerman presented “Multimodal Networks Interconnecting Transportation Technologies: CAV and other Mode Innovations” at the 2019 Transport-Tech Summit and presented “A data-driven framework for user, provider, and community behavior toward infrastructure services risks,” at the SRA 2019 meeting. Drs. Zimmerman and Zhu presented “Integrating New Transportation Technologies into Existing Travel Modes: The Case of Autonomous Vehicles,” and “The Challenge of Achieving Urban Resilience with Interdependent Infrastructures and Extreme Events”, at NYU Urban Research Day.
- Sruthi Rath and Mina Lee, C2SMART students working with Professor Joe Chow, presented their work at the New York Transportation Technology Symposium on Nov. 1, 2019 on Forecasting E-scooter Competition with Direct and Access Trips by Mode and Distance in NYC and Air Taxi Skyport Location Problem for Airport Access.

b) **Workshops**

- C2SMART hosted a follow-up two-day **Traffic Fundamentals workshop for NYCDOT employees**. This Level 2 course was a continuation of the 2-day course offered in October 2018 intended for experienced engineers. Covered topics included: Travel Demand Modeling, Traffic Control and Operations, Transp. Economics, Connected and Autonomous Vehicles, and drew 30 employees from across NYCDOT.
- C2SMART also hosted the **Greater New York City Chapter of Young Professionals in Transportation (YPT)**, who led a LinkedIn profile workshop as part of their professional development efforts.
- On March 6, 2020, Dr. Hani Nassif, presented his work on the Smart Urban Testbed during the **New Jersey Smart Mobility Workshop**. 31 university faculty and researchers along with 34 external stakeholders from company and local governments attended this workshop. Rutgers team organized an event at NJDOT HQ in Trenton, NJ to provide a training to NJDOT engineers and consultants on the use of the NJ Scour Evaluation Model (SEM). 76 engineers attended this training.
- Dr. Stan Sobolevsky led a workshop on Prediction of Human Mobility (PredictGIS) at the 28<sup>th</sup> annual **ACM SIGSPATIAL International Conference** on Advances in GIS on Nov. 3-6, 2020.

2. **Industry and Public Agency Outreach**

- During this reporting period, C2SMART researchers successfully developed and installed a **Smart Urban Roadway Testbed** on a live section of highway. This new testbed collects real-time data on truck loads using weigh-in-motion (WIM) sensors to measure their impact on the roadway. After the implementation of an Advanced-Weight-in-Motion system, Professor Nassif’s research team met with NYCDOT, FHWA, and NYSDOT to discuss the preliminary results and future plans.
- On Jan. 30, 2020, The Brooklyn-Queens Expressway (BQE) Expert Panel released its Final Report with recommendations to fix a critical section of the expressway. The panel, which included C2SMART Director Professor Kaan Ozbay, Dr. Hani Nassif, and Professor Mitchell Moss, called for immediate actions to be taken owing in part to C2SMART’s contribution. New York City Mayor Bill De Blasio in a

press releasing stated that **“Using data supplied by new state-of-the-art sensors, made by C2SMART to aid DOT in assessing the structure, the BQE Expert Panel noted that many trucks on the roadway are in severe violation of BQE weight restrictions.”** Based on this work the Mayor issued an Executive Order limiting truck usage of the roadway and increasing enforcement. Continuing data collection from the sensors may also provide insights about the real-time condition of the roadway to inform future design decisions regarding, along with measures to limit the prevalence of overweight trucks on the BQE.

- PI Kelvin Cheu and a team of researchers at UTEP have been implementing their research on Senior Mobility with the City of El Paso, which manages the 11 senior centers, and El Paso Community College. NYU partners recruited participants at senior centers to beta test the app in New York.
- As part of a different project, PI Cheu distributed the SPARKMAN Smart Parking App to members of the campus parking (CPTA) for testing and feedback and continued to engage the City of El Paso.
- On Dec. 10th, C2SMART PI Joseph Chow served as a tech pitch evaluator for the Signaling Innovation Summit. Hosted by New York Governor Andrew M. Cuomo, the MTA and the Transit Innovation Partnership, the event brought together innovators, stakeholders, and academic experts to create partnerships that will improve subway safety, performance, and operational efficiency.
- On Jan. 22, 2020 PI Sara Kaufman co-hosted “A Public Future for Sunnyside Yard” with NYC Economic Development Corporation (NYCEDC). The panel discussion covered the potential of a new subway station to develop economic opportunities and to serve as a regional transit connector. Along with NYCDOT, she also moderated “Better Buses: Advancing Social Equity for New Yorkers: How Can Improved Bus Service Transform Economic Opportunity” on Dec. 9, 2019 which focused on the upcoming bus network redesigns led by the MTA and NYCDOT.
- PI Don Mackenzie engaged in talks with several stakeholders including the City of Bellevue, Spokane, Redmond, King County, Seattle Department of Transportation, and UW Transportation Services for a needs assessment for a new crowdsourced micromobility app that reports parking violations. Dr. Mackenzie’s research team will partner with these agencies once the alpha version of the app has been tested. PI Jeff Ban is also using the Puget Sound region as a case study for research funded by the FHWA on “Promises of data from emerging technologies for transportation applications.”

### 3. Seminars and Webinars

C2SMART’s ongoing Distinguished Speaker Series presented talks on advances in transportation. In addition, the center also hosted seminars and webinars presented by center faculty and students and other visiting researchers. All seminars are broadcast live and archived for viewing on the Center’s [YouTube channel](#).

#### a) Seminars

- 10/7/19 - Visually Exploring Massive Urban Trajectories to Enhance Urban Sustainability and Resilience, Dr. Xinyue Ye, Professor, University of California at Santa Barbara
- 10/23/19 - Towards a Safer Urban Transportation System in the Era of Connected & Autonomous Vehicles and Big Data, Dr. Kaan Ozbay, Director of C2SMART Center, NYU
- 11/12/19 - Systems Integration and Innovation in Urban Transportation, Environment, and Health: Models, Tools, and Insights, Dr. Oliver Gao, Director of Cornell Systems Engineering Program, Cornell University
- 11/15/19 - Structure as a Sensor for Indirect Occupant Monitoring through Structural Vibrations, Mostafa Mirshekari, Ph.D. Candidate, Carnegie Mellon University
- 12/9/19 - Towards Weakly-Supervised Visual Understanding, Zhiding Yu, Research Scientist, Carnegie Mellon Univ.
- 12/12/19 - Congestion Pricing in NYC, Dr. Babu Veeregowda, Vice President, HNTB NY Engineering and Arch.
- 1/9/20 - Path Controlling of Automated Vehicles for System Optimum on Transportation Networks with Heterogeneous Traffic Stream, Dr. Zhibin Chen, Professor, New York University Shanghai
- 1/16/20 - E-mission: An Open Source, Extensible Platform for Human Mobility Systems, Dr. K. Shankari, Researcher, University of California, Berkeley

- 1/16/20 - Relationship between Gender and Safety in Public Transport, Laila AitBihiOuali, Postdoctoral Research Associate, Imperial College London
- 1/17/20 - Technologies boosting safety thru Smart Transportation Xiangbin Wu, Research Director of Autonomous Systems Lab, Intel Labs China
- 1/17/20 - Shared on-demand automated vehicles for first/last mile transit and beyond, Dr. Gonçalo Correia, Professor, Delft University of Technology
- 2/10/20 - Mobile Crowd Sensing (MCS) – a First Step Towards Building Collective Intelligence, Dr. Yacine Ghamri-Doudane, Professor, La Rochelle University in France
- 2/12/20 - Optimizing Traffic Signal Control with Connected and Autonomous Vehicles in the Traffic Stream, Dr. Lily Elefteriadou, Director of the UF Transportation Institute, University of Florida
- 2/21/20 - The University of Texas at Austin, Robust Control of Traffic Flow on Networks using Chance Constrained Optimization, Dr. Christian Claudel, Professor

**b) Project Webinars**

- 11/4/19 - Applications of Geographic Information Systems for Urban Mobility in the Czech Republic, Dr. Pavel Hrubes, Professor, Czech Technical University in Prague
- 3/12/20 - Traffic Signal Optimization and Coordination in Connected Cities, Dr. Xuegang (Jeff) Ban, Professor, UW
- 3/26/20 - Installation of a Smart Roadway Testbed in Brooklyn, NY to Measure the Impact of Overweight Trucks on Critical Infrastructure, Dr. Hani Nassif, Professor, Rutgers University

4. Media Coverage and Public Outreach

C2SMART’s email communications achieve consistently high open and click rates, averaging 29% and 9.8% respectively. These results are well above the 23% open rate and 2% click-through rate averages for other mailing lists in education and training reported by MailChimp, the email service used by the center. During this reporting period, the center’s YouTube channel accumulated 1,497 views.

- C2SMART Director Dr. Kaan Ozbay was quoted, along with PI Sarah Kaufman, in a Feb. 5, 2019 Politico article on self-driving vehicle tests by the Port Authority of NY&NJ. The BQE expert panel featuring C2SMART was referenced in numerous outlets including New York Times, Curbed New York, and NY1.
- PI Cheu’s Sparkman project also received coverage in a local ABC News segment on Oct. 9, 2019.
- PI Mackenzie’s work was featured in 11 media outlets including City Lab, Jalopnik, Globe and Mail, NPR/Marketplace and E&E News.

**D. Plans for Next Reporting Period**

Two project webinars are planned for the next reporting period, and C2SMART will continue to move to webinar format in light of the COVID-19 pandemic. C2SMART researchers continue to research the COVID-19 pandemic and have created a section on the C2SMART website for regular updates. A symposium on congestion pricing revenues and NYC’s MTA’s funding shortfall was planned for March, but postponed.

**II. Participants and Collaborating Organizations**

**A. Partner Organizations**

C2SMART has established partnerships with a range of agencies and private companies, outlined in Table 4.

**Table 4: C2SMART partner organizations**

Organization Name	Location	Contribution		
		Financial Support	In-kind Support	Collaborative Research
6-t Bureau de Recherche	Paris, France			X
Abu Dhabi DOT	Abu Dhabi, UAE		X	
Alliance for Downtown New York	New York City, NY		X	

<b>Arcadis</b>	New York, NY		<b>X</b>	
<b>Bestmile</b>	San Francisco, CA		<b>X</b>	
<b>BMW ReachNow</b>	Seattle, WA		<b>X</b>	
<b>Carmera</b>	Brooklyn, NY		<b>X</b>	
<b>Castrol</b>	Various		<b>X</b>	
<b>Central Japan Railways</b>	Tokyo, Japan	<b>X</b>		
<b>City of El Paso</b>	El Paso, TX		<b>X</b>	
<b>Conway Marine Construction, Inc.</b>	Long Island, NY		<b>X</b>	
<b>Cuebiq</b>	New York, NY			<b>X</b>
<b>Daidone Electric, Inc.</b>	Newark, NJ		<b>X</b>	
<b>Drive Engineering</b>	Blue Bell, PA			<b>X</b>
<b>Federal Transit Administration</b>	Washington, DC	<b>X</b>		
<b>Foundation for the Future</b>	Brooklyn, NY			<b>X</b>
<b>Ikos Lab</b>	Europe (various)			<b>X</b>
<b>Intelligent Transportation Society of NY</b>	New York, NY		<b>X</b>	
<b>International Parking &amp; Mobility Institute</b>	Alexandria, VA	<b>X</b>		
<b>King County Metro</b>	Seattle, WA			<b>X</b>
<b>Kistler Instrument Corp.</b>	Buffalo, NY		<b>X</b>	
<b>Nexar</b>	New York City, NY			<b>X</b>
<b>NEXT</b>	Silicon Valley, CA			<b>X</b>
<b>NJ Turnpike Authority</b>	Woodbridge, NJ	<b>X</b>		
<b>NJDOT</b>	Newark, NJ	<b>X</b>		
<b>NYC Mayor's Office</b>	New York City, NY			<b>X</b>
<b>NYCDCAS</b>	New York City, NY		<b>X</b>	<b>X</b>
<b>NYCDOT</b>	New York City, NY	<b>X</b>		
<b>NYS DOT</b>	Albany, NY	<b>X</b>	<b>X</b>	<b>X</b>
<b>Parkofon</b>	Alexandria, VA		<b>X</b>	
<b>Populus</b>	San Francisco, CA			<b>X</b>
<b>Port Authority of NYNJ</b>	New York City, NY	<b>X</b>		
<b>Puget Sound Regional Council</b>	Seattle, WA		<b>X</b>	
<b>Red Hook Initiative</b>	Brooklyn, NY		<b>X</b>	
<b>SHARE NOW</b>	Seattle, WA			<b>X</b>
<b>Sound Transit</b>	Seattle, WA			<b>X</b>
<b>Texas Department of Transportation</b>	Austin, TX		<b>X</b>	
<b>Toyota</b>	Various			<b>X</b>
<b>TrafficCast International</b>	Middleton, WI		<b>X</b>	
<b>Transpod</b>	Toronto, Canada			<b>X</b>
<b>Trust for Governor's Island</b>	New York City, NY		<b>X</b>	
<b>US-China Clean Energy Research Center</b>	Various			<b>X</b>
<b>Via</b>	New York City, NY		<b>X</b>	
<b>Washington State DOT</b>	Olympia, WA		<b>X</b>	<b>X</b>
<b>Zendrive</b>	San Francisco, CA			<b>X</b>

## B. Other Collaborators or Contacts

### 1. Collaborations with other departments and research centers

- C2SMART co-presented with Dr. Oliver Gao from Cornell's Center for Transportation, Environment and Community Health (CTECH) UTC at the IPMI workshop in November 2019.
- Director Kaan Ozbay & Prof. Zhong-Ping Jiang in the NYU Dept. of Electrical and Computer Engineering continue to co-advise graduate students on transportation-related research.

- Dr. Jeff Ban is collaborating with the Center for Safety Equity in Transportation (CSET) UTC on “Drones for Improving Traffic Safety of the RITI Communities in Washington. Dr. Ban is also involved in a project funded by PacTrans called “The impact of shared mobility options on travel demand.”
- Dr. Don Mackenzie is also collaborating on a project for the US-China Clean Energy Research Center alongside colleagues at UW, Carnegie Mellon, Georgia Tech, and San Jose State.
- Researchers from Rutgers and Stevens partnered with the NJDOT Bridge Resource Program to examine the development and implementation of cost-effective ultra-high performance concrete.

## 2. Inter-University collaboration

C2SMART built a new collaborative research platform, **Common Innovation Platform (CIP)**, which allows for greater and increased collaboration between the different members of the research consortium. CIP provides two-way interaction using API capabilities that brings together interconnected data repositories, project and task management tools for expected deliverables and datasets, and a collaborative project workspace. CIP can integrate version control systems as well as project management tools within the collaborative workspace, which allows all participating users to see and manipulate the data simultaneously for centralized research collaboration.

- C2SMART PIs at NYU and Rutgers continue to collaborate extensively on the Brooklyn Queens Expressway (BQE) testbed and analysis of overweight trucks. Rutgers PIs have built a WIM analytical dashboard that allows data to be shared with the consortium members for research purposes.
- UTEP and NYU researchers are collaborating to bring the work on UTEP’s Urban Connector smartphone application to help seniors and their mobility in El Paso, TX, to New York City. UTEP researchers provided the customized beta version of the UC to NYU partners.
- The MATSim research team at C2SMART shared plans with Professor Jeff Ban’s team at UW to implement a similar model in Seattle. Using this collaboration process as a blueprint, a developer tutorial is being prepared to share lessons learned with other members of the research consortium.

## 3. Other collaborations

- The UTEP Campus Parking and Transportation Association (CPTA) agreed to use its membership roster for software testing of Sparkman 1.0. This user feedback was collected and evaluated.
- UTEP researchers continue to work with the City of El Paso Parks & Recreation Dept. and El Paso Community College to recruit participants to complete data collection for the Urban Connector app.
- PI Jin and PI Joseph Chow obtained an agreement from the New York City Department of Transportation to share surveillance camera data towards ongoing research.

## III. Outputs

C2SMART is exceeding its targeted performance metrics in each of the areas identified in its Technology Transfer Plan, identified in Table 5.

### A. Publications, Conference Papers and Presentations

#### 1. List of Journal Publications

- Caros, N., Chow, J.Y.J., Effects of violent crime and vehicular crashes on active mode choice decisions in New York City, *Travel Behaviour and Society*.

**Table 5: Output Performance Measures**

Performance Measures	Annual Goal	Achieved (current period)
Peer-reviewed papers	20	45
Conference presentations	10	51
Joint proposals/projects with industry/agency partners	10	23
Website analytics	5,000 unique pageviews	13,918 unique pageviews

- Gurbuz, O. and Cheu, R. L. “A survey to explore behavior, intelligent transportation systems needs and level of service expectations for student parking at a university campus, Transportation Research Record.
- He, B.Y., Chow, J.Y.J., Optimal privacy control for transport network data sharing, Transportation Research Part C: Emerging Technologies.
- He, B. Y., Zhou, J., Ma, Z., Chow, J. Y. J., Ozbay, K. Evaluation of city-scale built environment policies in New York City with an emerging-mobility-accessible synthetic population, submitted to TR: part A, under review.
- He, B. Y., Lee, M., Zhou, J., Ma, Z., Chow, J. Y. J., Ozbay, K. Analysis of city-scale policies in New York City with Agent-based Simulation, under preparation.
- Li, W., Ban, X., Zheng, J., Liu, H., Cheng, G., Li, Y., 2020. A deep learning approach for real-time traffic volume prediction at signalized intersection. Journal of Transportation Engineering, accepted.
- Ma, T.Y., Chow, J. Y. J., Klein, S., Ma, Z., A stochastic user-operator assignment game for empirical evaluation of a microtransit service in Luxembourg. arXiv, preprint.
- Pantelidis, T., Li, L., Ma, T.Y., Chow, J. Y. J., Jabari, S. E., Node-charge graph-based online carshare rebalancing with capacitated electric charging, working paper arXiv, preprint.
- Pantelidis, T., Rasulkhani, S., Chow, J.Y.J., A path-based many-to-many assignment game to model Mobility-as-a-Service market networks, arXiv, preprint.
- Su, H., Chow, J.Y.J., Jin, L. V2I Connectivity-Based Dynamic Queue-Jumper Lane for Emergency Vehicles: An Approximate Dynamic Programming Approach, arXiv,preprint.
- Wang, R., Wen, C., Feng, C., Jin, L. and Ozbay, K. Robust Traffic Flow Estimation using Spatial-temporal Graph Neural Network, under preparation for submission to NeurIPS.
- Xie, Q. and Jin, L. Resilience of Feedback Routing over Parallel-Link Networks Facing Stochastic Sensing Faults, under preparation for submission to Automatica.
- Xiong, X., Ozbay, K., Jin, L., and Feng, C. Dynamic prediction of origin-destination flows using gated line graph convolutional networks, Transportation Research Record, accepted.
- Xu, S.J., Xie, Q., Chow, J.Y.J., Liu, X., Empirical validation of network learning with taxi GPS data from Wuhan, China. arXiv.
- Xu, S.J., Chow, Y.J., Online route choice modeling for Mobility-as-a-Service networks with non-separable, congestible link capacity effects, arXiv, preprint.
- Yoon, G., Chow, J.Y.J., Contextual bandit-based sequential transit route design under demand uncertainty, Transportation Research Record: Journal of the Transportation Research Board.
- Yoon, G., Chow, J.Y.J., Unlimited-ride bike-share pass pricing revenue management for casual riders using only public data International Journal of Transportation Science and Technology
- Zhou, S., Pang, J., and Zhu, Q., MUSIC: A High-Capacity Low-Waiting Time Intersection Management System for Connected Autonomous Vehicles, under review.
- Zhou, S., and Zhu, Q., Robust Congestion Control of Connected Autonomous Vehicles, under preparation.
- Zimmerman, R. and Restrepo, C.E., Physical Security: External Applications, In: Encyclopedia of Security and Emergency Management, Springer Nature Switzerland AG.
- Zimmerman, R. Human-made Disasters: Electric Power and Transit Linked Outages, Encyclopedia of Security and Emergency Management, Springer Nature Switzerland AG.
- Zimmerman, R. Historical and Anticipated Changes in Interconnected and Concentrated Infrastructure and Social Networks in Weather, Climate and Human-Initiated Disruptions, Urban Infrastructure: Interdisciplinary Perspectives from History and the Social Sciences, accepted.

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

Nothing to report during this reporting period.

## 3. Other Publications, Conference Papers and Presentations

C2SMART researchers were highly represented at the 99th Annual Meeting of the Transportation Research Board with a total of **53** workshops, presentations and lectures. A full list can be found on the [C2SMART website](#). In addition, the following conference presentations were produced:

- Abu-Obeidah, A., Nassif, H. and Na C., Implementation of Fiber Reinforced High-Performance Concrete (FR-HPC) for Bridge Decks in New Jersey”, March 29 - April 2, 2020, ACI Convention, Chicago, cancelled

- Kieras T., Farooq M. J., Zhu Q., Holistic Risk Analysis of Hierarchical Supply Chain Threats in Connected and Autonomous Vehicles, 2020 IEEE World Forum on Internet of Things, New Orleans, USA
- Li L., Lin D., Pantelidis T., Chow J.Y.J., Jabari S. E., An Agent-based Simulation for Shared Automated Electric Vehicles with Vehicle Relocation, 2019 IEEE Intelligent Transportation Systems Conference (ITSC)
- Vargas-Acosta, R. A., Becerra, D. L., Gurbuz, O., Villanuev-Rosales, N., Nunez-Mchiri, G. G. and Cheu, R. L. (2019). "Smart mobility for seniors through the urban connector". The 5th IEEE International Smart Cities Conference (ISC2), Casablanca, Morocco, Oct. 14-17, 2019.
- Wang, D., Ozbay, K., He, B. Y., Shen, B. Y., Chow, J. Y. J., Traffic flow model calibration for an agent-based traffic simulation model applied in New York City. Extended abstract submitted to the 8th International Symposium on Dynamic Traffic Assignment, under review.
- Xu, C., Xie, K., Ozbay, K., Demiraluk, S., Nassif, H. Exploring the Impact of Truck Weight on Injury Severity using State-wide Disaggregate Weigh-in-Motion Data. Roadway Safety and Simulation (RSS2019) Iowa City, IA
- Zimmerman, R., Challenges of Multimodal Networks Interconnecting Transportation Technologies: CAV and other Mode Innovations, 2019 Transport-Tech Summit, New York, NY November 1, 2019.
- Zhou, S., and Zhu, Q., Intersection Management System for Connected Autonomous Vehicles, 2019 Transport-Tech Summit, New York, NY November 1, 2019.
- Zimmerman, R., A data-driven framework for user, provider, and community behavior toward infrastructure services risks, SRA 2019 annual meeting, Arlington, VA.
- Zimmerman R., Incorporating Public Acceptance into Planning Decisions for Autonomous Vehicles, Transportation group. Association of Collegiate Schools of Planning (ACSP) 60th Annual Conference, November 4-8, 2020, Toronto, Ontario Canada, abstract submitted.
- Zou, Z. Bernardes S.D, Kurkcu, A., Ergan S., Ozbay K., An Integrated Approach to Capture Construction Workers' Response towards Safety Alarms using Wearable Sensors and Virtual Reality, European Group for Intelligent Computing in Engineering, submitted.

## B. Websites

The **C2SMART website** ([c2smart.engineering.nyu.edu](http://c2smart.engineering.nyu.edu)) continues to be used for disseminating information about the Center's activities and research and had 13,918 unique pageviews during this reporting period, exceeding its annual goal of 5,000 pageviews. In addition, the [Sustainable Transportation Lab](#) website is used to disseminate information about research at the University of Washington, including C2SMART-funded work on shared electric vehicle systems. The [Rudin Center](#) website shares information about research and workforce development, and the [Rutgers Infrastructure Monitoring and Evaluation Group \(RIME\)](#) website provides regular updates on the group's activities.

## C. Technologies or Techniques

Researchers at UTEP finalized and tested Sparkman 1.0, the application resulting from their research project that incorporates their developed Level of Service (LOS) criteria for parking search time, giving transportation engineers an evaluation criteria on user experience for any change in parking management policy. Sparkman 1.0 was coded with a new zoning and zone permit pricing (Z2P2) methodology, also developed as a result of this project. As a result of the Urban Connector project, also at UTEP, the research team has developed an iOS version of the Urban Connector app, allowing the team to recruit participants who are users of both Android and iOS smart phones, allowing for a broader understanding the lifestyles and mobility needs of the senior adults.

C2SMART's Multi-agent virtual simulation test bed ecosystem (MATSIM) continued to be expanded during this period, producing simulation outcomes for several scenarios of interest to NYC DOT and including activities that make the test bed accessible to policymakers and consortium partners. The research team implemented automated taxi and dockless bikeshare scenarios to MATSIM, along with different congestion pricing schemes and a module simulating the implementation of NYC's proposed Brooklyn-Queens Connector streetcar connecting Red Hook, Brooklyn and Astoria, Queens (BQX).

Rutgers researchers produced the following technologies adopted by public agencies in NY & NJ:

- 1) WeatherEVANT: A real-time weather related event visualization and analytics tool used by the maintenance department of New Jersey Turnpike Authority
- 2) SAVE-T: safety analysis software adopted by the Operations Department of the New Jersey Turnpike Authority for analyzing crash data
- 3) T.R.I.P: Total Roadway Inspection Program, an asset management and maintenance planning tool adopted by the maintenance department of New Jersey Turnpike Authority
- 4) FR-HPC and HES-HPC specifications, adopted by the engineering department of NJ Turnpike
- 5) A web-based app for infrastructure damage cost estimation, adopted by the NJDOT freight dept.
- 6) Live load analysis for the BQE Project, adopted by NYCDOT, along with a direct weight enforcement scheme for implementation at the testbed. The proposed scheme includes the high-accuracy WIM sensors and system, low-budget security camera, a software-based license plate recognition, etc.

#### D. Industry/Agency Partners

Table 3 provides a list of active funded grant projects being conducted by C2SMART PIs, while 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. Some of these include:

- Waterborne Freight Deliveries in NYC, submitted to NYC Economic Development Corporation
- GOALI: Collaborative Proposal: Enable Elastic Capacity for Transportation Infrastructure through a Transmodal Modular Autonomous Vehicular System, submitted to National Science Foundation
- Applications were made by C2SMART researchers to NSF's ARPA-E, EAGER, and CIS opportunities
- MEMENTOS-Blockchain - Privacy Preserving and Scalable Connected Vehicle and Micro-mobility Data Storage and Retrieval on Blockchain using Federated Learning, submitted to FHWA EAR
- Cost-efficient rural-area incident management system: Smart diagnosis and adaptive response, submitted to FHWA EAR
- Community Mobility and Energy Hubs, submitted to New York State Energy Research and Development Authority with ARUP
- CIV:LAB, TechTown, Detroit Urban Solutions, NYU joint proposal to the Knight Foundation
- 2020 FTA Section 5310 Enhanced Mobility of Seniors and Individuals with Disabilities Program Application, submitted to New York State Department of Transportation
- Response to RFP for Academic Institutions to Advise on Best Practices in Traffic Signal Performances, submitted to Port Authority of New York & New Jersey
- An NSF-EPSC proposal with the University of Leeds on the topic of shared transport integration and modelling to support strategically designed urban systems

C2SMART is working with the New York State Department of Transportation on various new research proposals under its long-term consortium agreement to begin next reporting period.

#### E. Other Products

The researchers have produced various datasets, models, mobile applications and summaries during this reporting period, located on the center's Zenodo Data Repository. In addition:

- Professor Jeff Ban and the UW team have produced a hybrid reinforcement-learning-based Eco-Driving algorithm for vehicles driving along signalized corridors considering lane-changing behavior.
- The MATSim project produced two new simulation modules based on congestion pricing and autonomous vehicles, python codes to estimate mode share, a query tool to produce a synthetic population in the simulator, and a revised schedule in XML to simulate the BQX streetcar.



- PI Jin, continuing his research on smart resilient highway systems, produced additional Python codes that process data from highway I210.
- The Impact of Ridesharing project finalized a model to estimate the impact of ride-sharing in New York City based on data provided by the NYC Taxi and Limousine Commission.
- PI Nassif’s team provided technical memorandums to NYCDOT to assist with monitoring and of WIM sensors, along with a direction enforcement scheme using a camera and license plate recognition.
- Results from the Bus Redesign project are being integrated on Tableau Public to create an interactive map where users can query hour-to-hour bus operating strategies, including optimal frequency graphs, route passenger share graphs, and the stop load profile. In addition, two webpages were built to serve as user interfaces for the MATSim Transit Planning Tool. Practitioners can submit proposed design and exhibit results for the Brooklyn Bus Redesign project.
- PI Semiha Ergan’s research, which models worker behavior using wearable sensors and VR to improve construction zone safety, captured scans of the Brooklyn-Queens Expressway (BQE) to create an interactive VR environment with controlled traffic simulation and worker tasks.

## IV. Outcomes

### A. Increased Understanding and Awareness of Transportation Issues

The **Improving Representation in Transportation** series of workshops was launched to help policymakers understand disparities in urban travel behaviors, including for factors like gender and physical ability.

**Accessible Mobility Tech Showcase** – C2SMART, together with the Transit Tech Lab, held an event focused on new mobility technologies for people with disabilities, on February 25, 2020. This program included a panel to discuss new mobility technologies and how they can work best in New York City.

### B. Increases in the Body of Knowledge

C2SMART researchers have taken a multi-pronged effort to address how best to manage and control connected and autonomous vehicles in urban environments and to improve the integration of these technologies into cities as real-world implementation begins. The NYU and CCNY teams continue to work in various capacities with NYCDOT on USDOT’s **NYC Connected Vehicle Project**, including the development of an application for visually impaired pedestrians that uses connected infrastructure to aid them in navigating urban streets. C2SMART researchers calibrated a microscopic traffic simulation model for transportation performance measures such as travel time, volume, and turning movement counts, and are currently calibrating this model for safety measures using image processing and real-world vehicle trajectories from video collected by a drone. Collaborating with the **NCHRP** research panel, initial algorithms for each selected measure were created and development is underway. All generated codes will be made available to the public at the project’s conclusion.

Using available **TRANSCOM** data, C2SMART researchers reviewed existing predictive models in order to identify those that can best predict traffic impacts when a non-recurrent incident occurs. The research team created recommendations using potential operations use cases and provided the system requirements for an ideal predictive tool for non-recurrent traffic incidents.

**The UW team** has completed the design of a hybrid reinforcement learning-based Eco-Driving algorithm for vehicles driving along signalized corridors considering lane-changing behavior. They conducted

**Table 6: Outcomes Performance Measures**

Performance Measures	Annual Goal	Achieved (current period)
Media interviews, mentions, coverage	10	48
Workshops, webinars, and seminars	10	22

simulations to test the proposed algorithm, and found that it could significantly improve fuel consumption performance of vehicles while maintaining acceptable travel times.

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

The Sparkman 1.0 smart parking application has been distributed to more than 70 members of the Campus Parking and Transportation Association (CPTA). The research team anticipates adoption of this application by many more of the 300 university campuses (with enrollment of at least 10,000) within the U.S, expanding the benefits of allocating enough spaces at suitable permit prices—reducing congestion, emissions and students’ frustration in the search of empty parking stalls—to a wider market. In addition, the Level of Service (LOS) criteria designed by the team as a new criteria for evaluating parking search time has been shared with the TRB Committee on Highway Capacity & Quality of Service.

C2SMART researchers plan to apply their Multi-agent virtual testbed simulation (MATSim) to evaluation of the ongoing Brooklyn Bus Network Redesign. They will pay special attention to the presence of ride hail fleets (through analytical models and exploratory consideration of MATSim extensions) in justifying bus stop spacing and route allocations. In addition, two webpages are being built to serve as the user interfaces for the MATSim Transit Planning Tool. MATSim was used in a separate C2SMART project to evaluate the potential impact of the impending implementation of the congestion pricing plan in Manhattan, and of the Brooklyn Queens Connector streetcar (BQX), planned for finalized design.

The Rutgers team’s work on the Advanced Weigh-in-Motion (AWIM) system supported the NYC Mayor’s executive order to create the new NYPD BQE Truck Enforcement Task Force which began to convene during this reporting period. The team collected and processed the WIM data to validate the effectiveness of this executive order on weight statistics. The results showed that the number of overweight trucks, especially extremely heavy trucks, was reduced with the additional enforcement.

## V. Impact

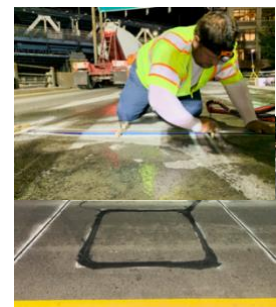
**Table 7: Impacts Performance Measures**

### A. Effectiveness of the Transportation System

Most significantly, C2SMART researchers worked with NYCDOT to develop a new **smart roadway testbed** along the Brooklyn-Queens Expressway in Brooklyn. This new testbed collects real-time data on truck loads using weigh-in-motion (WIM) sensors to measure their impact.

Researchers performed a site evaluation in accordance with ASTM E1318 and chose appropriate segments to maximize accuracy. Installation was conducted in partnership with NYCDOT, and after it was completed, a 5-axle semi-trailer truck (FHWA Class 9) with known axle weights traveled in each lane to determine the sensor calibration factor. Preliminary data collected from the WIM sensors showed that 11.1% of trucks exceeded 80 kips. Higher live loads cause greater stress on the structure and shorten its lifespan. Continuing data collection from may provide insights about the roadway to inform future design decisions.

Performance Measures	Annual Goal	Achieved (current period)
<b>Instances of software, tools, research results, or guidelines adopted by transportation agencies leading to operational improvements</b>	5	9
<b>Partnerships/collaborative relationships with companies or transportation agencies established or renewed</b>	10	27



Principal Investigator, Hani Nassif, and co-Principal Investigator Kaan Ozbay, and PI Mitchell Moss were members of the Brooklyn-Queens Expressway Expert Panel convened by the Mayor of New York City to craft a comprehensive plan for a redesign of the highway. The panel recently used research data including that collected by the researchers' WIM sensors to make several proposals for the long-term longevity and decongestion of the BQE. These recommendations included permanent lane reductions, designated and wide shoulders, and a demand management plan to reduce volumes by 15% or more.

These sensors and resulting data are part of the first phase of C2SMART's planned urban testbed to cover the full stretch of roadway, and others in New York City, while collecting data on the resiliency of structures as well as other valuable data on the critical transportation link and its effects. This testbed will provide significant opportunities for further collaborative research with New York City agencies, with results transferrable to critical infrastructure across the country. The C2SMART research team also plans to bring WIM technology to other NYC roadways for better enforcement of overweight trucks.

## B. New Practices or Companies

Nothing to report in this reporting period

## C. Body of Scientific Knowledge

Though most of C2SMART's work is in applied research, it continues to work in connected vehicles and cities continues to generate significant scientific knowledge in this area prior to full-scale deployment. C2SMART researchers were recognized for their contributions which the following awards:

- On Dec. 10, 2019, Rae Zimmerman was awarded the Society for Risk Analysis 2019 Distinguished Achievement Award for "extraordinary achievement in risk analysis pertaining to the planning and operations of infrastructure systems."
- Ziya Ma, an NYU graduate student, was awarded a Student Designee for the 2019 Dwight David Eisenhower Transportation Fellowship by the Federal Highway Administration (FHWA).
- C2SMART students Hella Alostia-Alnajjar, Wassim Nasr Eddine, and John El-khoury, were awarded 2019 Scholarships by the Tri-State Arab-American Association of Engineers and Architects (AAAEA).
- In addition to the competitive ITE Met Section 2019 Dr. Louis J. Pignataro Memorial Transportation Education Award, Jingqin Gao was awarded the WTS Beverley Swaim Staley Leadership Legacy Scholarship by the WTS Greater New York Chapter.
- C2SMART Ph.D. Candidate Di Sha won the Best Simulation Application Paper Award for "Applying Bayesian Optimization for Calibration of Transportation Simulation Models," which proposes a framework for the high-dimensional calibration problem of transportation simulation models.
- C2SMART selected Alexander Curtis of NYU as its 2019 Outstanding Student of the Year.
- C2SMART Director Dr. Kaan Ozbay was appointed to TRB's Traffic Flow Theory and Characteristics committee. In addition, he served as chair of the TRB joint simulation award subcommittee.

## D. Transportation Workforce Development

C2SMART has made an impact on transportation workforce development through classes taught by Center faculty, support of students involved in transportation research projects, funding for masters and Ph.D. students, and opportunities for undergraduate students. Our efforts in this area also include:

- A two-day Traffic Fundamentals workshop was held for NYCDOT employees at NYU.
- UTEP researchers created a training video to accompany the Sparkman parking application that was distributed to more than 70 Campus Parking and Transportation Association (CPTA) members.
- Three undergraduate students from NYU were recruited to help in the beta testing of the Urban Connector app in New York. They received training on human subject research prior to field work.

- Professor Li Jin of NYU assembled a team of two MS students and one senior undergraduate student studying computer science to attend a public vision-based transportation video analysis competition, closely related to his project using computer vision to design resilient highway systems.

**Emerging Leaders in Transportation** is an annual event open to young transportation professionals. This three-day program brought together 25 early-career urban planning professionals for inspiring panels, lively discussions among participants, and a behind-the-scenes look at JetBlue operations at JFK Airport. Emerging Leaders participated in several networking and leadership activities, and heard from several local industry leaders. The program aims to enhance the toolkit of early-career employees to make transportation more efficient, effective and people-oriented. The two greatest impacts included the expansion of a professional network between transportation startups, students and professionals working to solve mobility issues, and improved understanding of challenges among under-represented groups at the leadership levels of transportation.

The final event in the series of **Women Leaders in Transportation** featured an event aimed at NYU students and planning their careers. The event began with a presentation from Dr. Lily Elefteriadou, Professor and Director, University of Florida Transportation Institute. Dr. Elefteriadou and three other women transportation leaders participated in a panel moderated by C2SMART PI **Sarah Kaufman**:

- Jennifer Strasser, Vice President, Cambridge Systematics, Inc.
- Mary Kay Murphy, Director of Planning and Regional Development, PANYNJ
- Meera Joshi, Principal and New York General Manager, Sam Schwartz

Panelists discussed the challenges faced by women in the transportation industry, including avoiding the “Mommy track” and being simply a representation of diversity rather than a valued voice. They also shared the unique opportunities women have to advance the field, including broadening perspectives in transportation decision-making. The panelists recommended several professional organizations as resources for burgeoning planners and transportation students. Students were able to receive feedback about their career plans from a diversity of perspectives.

C2SMART PIs have planned a webinar in April 25th which will provide training for NYCDOT staff. The webinar will overview large-scale transportation simulation models built with the MATSim and SUMO open-source simulation platforms. In addition to a timely overview of analysis of pandemic recovery effects, the webinar will explore applications such for-hire vehicle caps and congestion/cordon pricing, on-demand taxi, traffic flow modifications to allow for connected vehicles, and dockless bike-share.

## VI. Changes/Problems

Due to the COVID-19 pandemic, all on-campus activities have been cancelled. While most C2SMART research is only minorly affected, projects, particularly involving partners and extensive communication are expected to experience delays. In addition, projects activities such as the Urban Connector Seniors Outreach which require extensive in-person activities are on hold. Finally, planned events and tech transfer activities are postponed indefinitely and new events and activities are not being planned.

The scope of the project “Valuing Vehicle Rebalancing in Free-Float Carsharing Systems” led by PI Don Mackenzie has shifted focus to micromobility vehicles due to data unavailability with the previous electric vehicle partners. Instead, the project will focus on the availability and issues with micromobility fleets and has been retitled “Crowdsourcing Parking Data for Micromobility Vehicles.”

The “Connected Vehicles for Municipal Vehicular Fleets: Applications & Testing Framework” project led by CCNY originally scheduled for completion on February 29, 2020 is indefinitely on hold since the research team was unable to obtain the data necessary for the research.