

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 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 officially moved into its new office space at NYU Tandon School of Engineering in June 2020, though full occupancy is delayed due to New York and NYU’s shelter-in-place guidance during the COVID-19 pandemic. 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.

b) Data Management

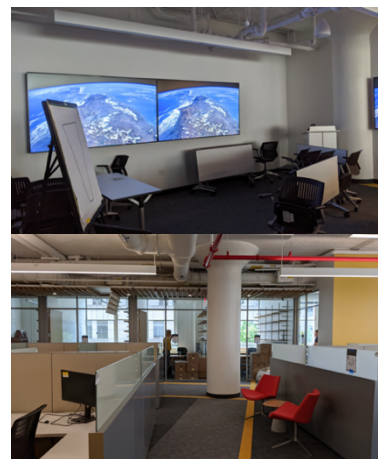
C2SMART has worked to become compliant with USDOT’s data management requirements, including uploading datasets, code and other outputs to the center’s Data Repository and submitting all products from completed projects to the National Transportation Library. The most-viewed repository is again the “Freeway Inductive Loop Detector Dataset for Network-wide Traffic Speed Prediction” project which has 358 views/99 downloads at the time of reporting. The Common Innovation Platform (CIP) developed by C2SMART continues to be used and enhanced. This collaborative research and project tracking now serves as the repository for all datasets, code, publications, and internal reporting documents for center-funded projects.

c) Advisory Board

C2SMART’s directors and advisory board met in August 2020 to review the previous four years’ worth of Center accomplishments and solidify strategic goals for the 2020 and 2021 academic year, including a continued focus on technology transfer and workforce development.

2. Research

The following Center-funded projects were completed during this reporting period.



C2SMART's new facility at NYU Tandon, Metrotech Center, Brooklyn, New York

Table 1: Projects Completed During Reporting Period

Urban Mobility and Connected Citizens	Impact of Ridesharing in New York City, NYU	A mode-choice model for ridersharing in NYC was finalized, and an impact assessment was conducted on a Manhattan congestion surcharge, as well as the introduction of ridesharing. The PI is conducting outreach to agencies and industry to expand the model.
	Increasing Work Zone Safety: Worker Behavior Analysis with Integration of Wearable Sensors and Virtual Reality, NYU	VR-simulated construction workzones for the effectiveness of alarms sent to users in different modes frequencies and durations were finalized. The project was extended to enhance the VR environments and address experiences using hardware-in-the-loop.
	Integrative Vehicle Infrastructure Traffic System (iVITS) Control in Connected Cities CCNY, NYU	This project developed and calibrated simulation models of Connected Vehicle environments in New York City.
	Simulation and Analytical Evaluation of Bus Redesign Alternatives in Transit Deserts with Ride-Hail Presence, NYU	Scenarios were run for the evaluation of the existing MTA Brooklyn bus network, evaluation of a proposed Brooklyn Bus Redesign plan, and the optimization of the proposed plan using C2SMART's MATSim virtual testbed. An interactive user interface on Tableau Public to simulate different bus route redesigns is being deployed.
Urban Analytics for Smart Cities	Sparkman: A Smart Parking Management Tool for University Campuses, UTEP	This project generated the Sparkman App to be used for campus parking needs and the app had been distributed to more than 70 members of the Campus Parking and Transportation Association (CPTA).
Resilient, Secure, and Smart Transportation Infrastructure	Crowdsourcing Parking Data for Micromobility Vehicles, UW	The web application MisplacedWheels, providing a new way of reporting micromobility parking violations, and web portal MisparkedRepo, allowing users to create spatial visualizations and other analysis, are now live for the public, researchers, operators and agencies to use.
	Design of Resilient Smart Highway Systems with Data Driven Monitoring from Networked Cameras, NYU	A video-based vehicle counting software for multiple weather conditions on highway videos was completed, and quantitatively evaluated using public datasets. A graph neural network method to perform robust traffic flow estimation from networked cameras/sensors was implemented and evaluated on simulated data.
	Development and Tech Transfer of Multi-Agent Virtual Simulation Test Bed Ecosystem, NYU	The Multi-Agent Virtual Simulation Test Bed Ecosystem (MATSim) was used to simulate several new scenarios including New York City's phased pandemic reopening plan. Workshops were set up to teach the tool as part of C2SMART's Learning Hub series, and plans to extend to other cities are being prepared
	Developing Secure Strategies for Vehicular Ad Hoc Networks in Connected and Autonomous Vehicles, NYU	A computational/analytical framework was applied to transportation systems using connected and autonomous vehicles (CAVs). A review of guidance for users and developers of safe vehicular systems was produced, along with several peer-reviewed journal and conference papers for research dissemination.

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 student-driven projects were completed during this reporting period:

- Development of Trajectory Planning Systems and Learning-Based Control Methods for CAVs - *Mengzhe Huang, advised by Kaan Ozbay*

- Development of Mountable Sensors to Improve Bicyclist Safety - *Suzana Bernardes, advised by Kaan Ozbay (NYU)*
- Blockchain for Preserving Privacy in V2X Connected Vehicle Applications in Urban Environments - *Kavya Bangalore & Junaid Khan (NYU)*

Table 2 provides updates on C2SMART’s ongoing funded research projects.

Table 2: Updates on ongoing center-funded research projects

Urban Mobility and Connected Citizens	Impact of Ridesharing in New York City, NYU	The team established a Vehicle In the Loop Simulation platform that integrates traffic simulation (SUMO), visualization (Unity 3D), and a fully autonomous scaled-down race car (AWS DeepRacer). They tested the VILS platform on a simple physical track and contacted the Seattle for data and signal timing plans. A GOALI proposal was submitted to NSF CPS with Inrix as industry partner.
	Modeling and Optimizing Ridesourcing Services in Connected and Automated Cities, UW	The team is fine-tuning their proposed modeling framework to account for the possibility of all services (single rides, shared rides, ride-hailing + transit) belonging to the same provider. The team has started data collection and network development of a simulation network in Seattle to test their model on a real dataset of customers traveling from nearby neighborhoods to downtown.
	Urban Microtransit Cross-sectional Study for Service Portfolio Design, NYU	The team collected microtransit commute data from Via in several cities, computed travel time for different modes, and developed a mode choice model with multiple modes (motorized and non-motorized) including from industry partner VIA. The team will develop a portfolio design model relating performance metrics operations to city and service attributes.
	Work Zone Safety: Behavioral Analysis with Integration of VR and Hardware in the Loop, NYU	The team implemented simulation feedback to represent traffic patterns in the VR environment for one of the construction tasks identified as commonly leading to accidents. They started implementing the Hardware in the Loop (HIL) of the data collection platform for work zone safety studies through the use of Internet of Things (IoT) technology.
	Learning to Drive Autonomously, NYU	A learning-based adaptive optimal control algorithm to achieve headway regulation for a string of connected vehicles in mixed traffic was verified by convergence proofs and stability analysis and validated by simulations. The team started studying the problem of combined longitudinal and lateral control of autonomous vehicles based on reinforcement learning and optimal control theory.
	Wearables to Command More Access and Inclusion in a Smarter Transportation System, NYU	The developed the graphical user interface (GUI) that supports use of the system and benchmarked its performance with six state-of-the-art localization algorithms on test data and developed an initial standardized operating protocol (SOP) to formalize the data acquisition process, They finalized the wearable data acquisition ‘kit’ involving a specialized, commercial 360-degree action camera, a modified ball cap with a mounting kit rigged into the brim.
	Cooperative Perception of Roadside Unit and Onboard Equipment with Edge Artificial Intelligence for Driving Assistance, UW	The team finalized the system structure design, trained and implemented the edge-based vehicle detection and classification algorithm and prototyped and assembled two customized mobile units for sensing traffic (MUST). They began to conduct field tests of their sensor and algorithm in the City of Bellevue, Washington.

Urban Analytics for Smart Cities	Development of Level of Service Analysis Procedures and Performance Measurement Systems for Parking, UTEP	After completing a review of the literature, the team has developed level of service analysis procedures for different parking lots and a multistory garage. They performed case studies on the UTEP campus, developed a performance management system for a smart parking garage and started analysis of street parking data from Los Angeles to explore a management system for street parking.
	Development and Tech Transfer of an Integrated Robust Traffic State and Parameter Estimation and Adaptive Ramp Metering Control System, NYU	Reinforcement learning techniques were applied to develop a ramp metering strategy that is adaptive to the long distance between the ramp and a far downstream bottleneck, to avoid the known time delay effect suffered by conventional linear ramp metering.
	Utilizing Social Media Data for Estimating Transit Performance Metrics in a Pre- and Post-COVID-19 World CCNY	A literature review was performed on factors that influence customer public transit choice, performance metrics measured by transit agencies, and use of social media for sentiment analysis in transportation. The team is assembling a dataset including MTA service alerts and delays and Twitter data for customer sentiment.
	Urban Connector UTEP	In-person human subject activities are on hold due to the COVID-19 pandemic.
Resilient, Secure, and Smart Transportation Infrastructure	Energy Harvesting for Self-Powered Sensors for Smart Transportation Infrastructures, CCNY	After modelling the optimum design of the energy harvester, the team has designed the harvester in AutoCad and will give the drawing to a Machine Shop company for precision fabrication. The team will field test the harvester on a real bridge with the goal of generating enough power for a health monitoring sensor.
	Street-Level Flooding Platform: Sensing and Data Sharing for Urban Accessibility and Resilience, NYU	The team developed two solar-powered flood sensors and received permission from NYCDOT to mount these on street signs. They have deployed these in the Gowanus area of Brooklyn, NY for real-world testing and flood data collection.
	Securing Intelligent Transportation Systems Against Spoofing Attacks, NYU	Novel models and methods to evaluate the security risks of dynamic routing were developed to design an efficient deployment of protecting resources. Parallel queuing systems subject to random malfunctions and/or malicious attacks were considered.
	Feasibility of Autonomous Enforcement Approach Using Advanced Weigh-in-Motion (A-WIM) System to Reduce Rehabilitation Cost of Infrastructure, Rutgers	The team reviewed weigh-in-motion (WIM) specifications in the U.S. and Europe, discussed legislation for automated camera enforcement for overweight trucks and how to stipulate calibration requirements. They estimated the number of overweight trucks according to different permissible errors to account for the WIM system & inherent weighing errors.
	Implementation and Effectiveness of Autonomous Enforcement of Overweight Trucks in an Urban Environment, Rutgers	The team worked with NYCDOT to re-calibrate the advanced WIM system with Quartz sensors at the BQE testbed. The team reviewed various specifications and different required accuracy levels of weighing overweight trucks for legislative enforcement. They also developed specs to evaluate the pavement conditions of another WIM testbed for direct enforcement using the Quartz Sensors.

C2SMART has placed an emphasis on research related to the COVID-19 pandemic and its impact to smart cities and transportation systems. The Center has developed a public-facing interactive, dynamic data dashboard that integrates several public and transportation data sources to monitor changing traffic, public transit ridership, traffic speeds, bikeshare geospatial activity, and more. The dashboard is public-facing and

can be accessed at: <http://c2smart.engineering.nyu.edu/covid-19-dashboard/>. C2SMART researchers have also developed a novel image-processing algorithm to observe and measure social distancing by individuals in public spaces using publicly available traffic cameras. This work is novel and has been presented to numerous academic, government, and industry audiences.

Four new on-call research projects, part of the multi-year agreement between C2SMART/NYU and the New York State Department of Transportation (NYSDOT), were developed. Two of these projects listed in Table 3, commenced during this reporting period. These projects are supported entirely by NYSDOT but match goals of 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

Urban Mobility and Connected Citizens	NYC Connected Vehicle Deployment – Mobile Accessible Pedestrian Signal System Application	USDOT/ NYCDOT/JHK Engineering
	NYC Connected Vehicle Deployment – Connected Driving	Engineering
	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
	Real Time Public Transit Route Deviation Operational Policies	FTA
	Smart Social Connector: An Interdisciplinary, Collaborative Approach to Foster Social Connectedness in Underserved Senior Populations.	NSF
	Statewide Open Source Advanced Traffic Management System (ATMS) Software Research and Pilot	NYSDOT
	Statewide Mobility Services Program Strategic Procurement Planning	NYSDOT
	Transportation Gaps and Disability-Related Unemployment: Smarter Cities and Wearables combating Commuting Challenges for the Visually Impaired	NSF
	U.S. Mexico Interdisciplinary Research for Smart Cities	NSF
Urban Analytics for Smart Cities	Algorithms to Convert Basic Safety Messages into Traffic Measures	NCHRP/Noblis
	Needs Assessment for the Development of Data-Driven Predictive Non-Recurrent Delay Models for TRANSCOM	TRANSCOM/ Infosenseglobal
	Development of Reconfigurable Environmental Intelligence Platform	NSF
	Data-driven Real-time Prediction and Multi-level Coordinated Control for Smart Transportation	NSF
	Learning-Based Fault-Tolerant Traffic Management Algorithms for Intelligent Transportation Systems	NSF
Resilient, Secure, and Smart Transportation Infrastructure	AASHTO and NBI (National Bridge Inventory) Element Deterioration Rates for Bridge Management System	NYSDOT
	AI-powered and Robot-assisted Manufacturing for Modular Construction	NSF
	Bridge Resource Program	NJDOT
	Capital Program Resource Model	NYSDOT
	Capital Region Mobility Hubs	NYSERDA
	Enable Elastic Capacity for Transportation Infrastructure through a Transmodal Modular Autonomous Vehicle System	NSF
	Technical Support Services for the Maintenance Department	NJ Turnpike Auth.
	Update of Highway Capacity Manual: Merge, Diverge, and Weaving Methodologies	NCHRP
Real-Time Flood Monitoring Dashboard	NYSEDF	

3. Education

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

- **Vertically Integrated Projects (VIP)**, a multi-year approach to learning that emphasizes project-based, innovative, research-active education for undergraduate students continued during this reporting period. C2SMART supports 4 NYU VIPs: **Smart Cities Technology, NYU Hyperloop, NYU Self Drive and NYU Urban LiDAR and Remote Sensing.**
- **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. This reporting period, the joint ITE/ITS chapter was awarded NYU’s both the **ITE Student Chapter Award** and the inaugural **Student Chapter Momentum Award** (for a chapter displaying the most improvement on key benchmarks from one year to the next) in recognition of the outstanding services the organization provided to its members this year. They were selected out of over [150 student chapters worldwide](#). In addition, the NYU ITE Student Chapter Traffic Bowl Team won the 2020 ITE Northeastern Collegiate Traffic Bowl competition, held virtually on September 22. This is the first time NYU ITE has ever won the Northeastern edition of the Traffic Bowl, and will compete in the Traffic Bowl Grand Championship, on October 22.
- On August 14, 2020, 62 New York City high school students presented their summer research virtually as part of the **Applied Research Innovations in Science and Engineering (ARISE) Colloquium**. Students presented their work on the impact of COVID-19 in the Citi Bike system from data gathered from Citi Bike’s database to understand how the COVID-19 pandemic has disrupted transportation in New York City. They used data management and programming tools such as Python and Mapbox to analyze trends in ridership, identify popular destinations, and depict fluctuations in Citi Bike revenue.
- C2SMART welcomed new, and returning, transportation students to the Fall 2020 academic year with a virtual kick-off. Students learned about new opportunities for student research and entrepreneurship including: an upcoming hackathon using industry or agency transportation data, a competition for student entrepreneurship, funding for student-driven implementation of research projects, and a free C2SMART-provided online course series centered around data science and programming, visualization and spatial analysis, traffic simulations, and machine/deep learning. ITE/ITS/ASCE student chapters from each of the consortium Universities also spoke to engage new students.
- The **C2SMART Learning Hub**, launched in September 2020, will begin to offer free courses such as Applied Data Science with Python Programming, and weekly workshops to learn how to use MATSim NYC, open to all students attending C2SMART Consortium Universities. Students can master research- or job-ready skills in course domains, including data science, computer science, and traffic simulation. Hands-on projects are provided to accelerate applied learning. The Fall programming schedule, taught by C2SMART doctoral candidates and postdoctoral students will cover the following classes:
 - The MATSim-NYC Workshop Learning Series (7 weekly sessions)
 - Applied Data Science with Python Specialization (2 sessions)
 - Introduction to Machine Learning
 - How to Collect Useful Data to Support Transportation Research Using Google API Travel Time Data
- C2SMART launched the [Student Voices in Smart Cities blog series](#), accepting short blog post topics from all Consortium students on transportation and smart cities topics of interests. The blog allows students to express their thoughts on topics of interest and related to Center research.



C. Dissemination and Outreach

1. Training and Tech Transfer Events

During this reporting period, C2SMART faculty and researchers undertook the following outreach activities:

a) Conference Presentations and Research Showcases

- At the second annual Bridging Transportation Research Conference (BTR) on August 11-12, *Ding Wang, Brian Yueshuai He, Jingqin Gao, Joseph Chow, and Kaan Ozbay* presented the ***Impact of COVID-19 Behavioral Inertia on Reopening Strategies for New York City Transit***; *Kaan Ozbay, Fan Zuo, Jannie Gao, Abdullah Kurkcu, Hong Yang, & Qingyu Ma* presented ***Remote capturing of social distancing through advanced video analytics under COVID-19 condition***
- C2SMART Director *Kaan Ozbay* and Postdoctoral Associate *Jingqin Gao* also gave two presentations, one on transportation data collected during the pandemic, and one on the social distancing image recognition work, to the NYU President's Office Faculty Research Working Group
- At the 23rd IEEE International Conference on Intelligent Transportation Systems, *Bekir Bartin, Abdullah Kurkcu, Jingqin Gao and Kaan Ozbay* presented ***Investigation of the Extent of Field Data Required for Reliable Calibration and Validation of Large Scale Traffic Simulation Models: A Case Study***; *Yue Zhou, Michael Cholette, and Pushkin Kachroo* presented ***A Mode Switching Extended Kalman Filter for Real-Time Traffic State and Parameter Estimation***. C2SMART doctoral candidates *Ding Wang* and *Zilin Bian*, along with *Director Dr. Kaan Ozbay* have authored a paper accepted for presentation at the 23rd IEEE International Conference on Intelligent Transportation Systems, titled ***A Mixture Model-based Clustering Method for Fundamental Diagram Calibration Applied in Large Network Simulation***.
- At the 6th IEEE International Smart Cities Conference, *Aleksi Paaso, Jeff Schlegelmilch, Yinhai Wang, Kaan Ozbay, and Vijay Vittal* served as panelists for ***Effect of COVID-19 on Transportation: Discussion on the Impacts, the Usefulness of Data Dashboards and Lessons Learned***
- ***An Interactive Data Visualization and Analytics Tool to Evaluate Mobility and Sociability Trends During COVID-19***, authored by *Fan Zuo, Jingxing Wang, Jingqin Gao, Kaan Ozbay, Xuegang Jeff Ban, Yubin Shen, Hong Yang, and Shri Iyer* was accepted for presentation on August 24th at Urbcomp 2020 (The 9th SIGKDD International Workshop on Urban Computing.)

b) Workshops

- C2SMART PIs *Hani Nassif* and *Anil Agrawal*, co-organized and hosted a virtual workshop on July 21–22, 2020, titled ***Workshop on Redundancy in Bridges for Risk Mitigation in a Multi-Hazard Environment*** and sponsored by the Federal Highway Administration (FHWA.), with over 100 attendees.
- C2SMART PI *Zhong-Ping Jiang* presented at an IEEE CDC '2020 Workshop in Celebration of Professor *Laurent Praly's* 65th Birthday'

2. Industry and Public Agency Outreach

- As part of the New York State Department of Transportation (NYSDOT) project on a [Statewide Mobility Services Program Strategic Procurement Planning](#) led by Prof. *Joseph Chow* of NYU, C2SMART has helped promote NYSDOT's Request for Information (RFI) for a Statewide Mobility Services Program (SMSP). This RFI on the changing marketplace for mobility services (including those provided under the existing Active Transportation Demand Management (ATDM) program contract) will lead to one or more RFPs to contract for services that ensure that the current needs of the public and private mobility marketplace are considered and included.
- The FloodNet team, led by PI *Elizabeth Henaff*, held several meetings with community partners at the Gowanus Canal Conservancy and Gowanus by Design. They also conducted outreach to businesses located in Gowanus to establish pilot sensor locations, continue to maintain relationships with city agencies (Mayor's Office of Resiliency and Mayor's Office of the Chief Technology Officer (MOCTO)), and outreach to additional city agencies (Department of Environmental Protection and the Department of

Transportation). The team jointly applied to the NYS Empire State Development Fund’s SmartCities call and was awarded funding for a total of \$90,500 to support the development of a custom frontend and backend system for data storage and dissemination. The team also received permission from the NYCDOT Assistant Commissioner of Traffic Control & Engineering to deploy flood sensors on NYC traffic signs, opening many opportunities for sensor deployments on flood prone roadways.

- Co-PIs Jeffrey Weidner and Okan Gurbuz of UTEP have been invited by the City of El Paso to join the Parking Advisory Committee and the Subcommittee on Parking Data Management. The group meets weekly and is comprised of different city departments including researchers, people from the downtown business district, and the Chamber Commerce.
- The Rutgers team continues extensive outreach to NYCDOT. The team provided their recommendations and findings on the live load analysis they conducted on the BQE test with calls to NYCDOT on 5/11/20, 5/18/20, 5/22/20, and 6/4/20. The team has been collaborating with NYCDOT and NYSDOT to introduce legislation for automated camera enforcement of overweight trucks on the bridge and met with them about the calibration and pavement condition evaluation procedures.

3. Webinars

As part of the C2SMART’s Webinar Series, Center faculty, students and visiting researchers present their work to a live audience virtually due to the COVID-19 pandemic. All webinars are archived for viewing on the Center’s [YouTube channel](#). The following webinars took place during this reporting period:

- 4/10 – Link Criticality Index (LCI) for Analysis of Large Transportation Networks, *Anil Yazici*
- 4/10 – How Disasters Shape New York: The Impact of Coronavirus on Life and Death in the Nation’s Largest City Part 2, *Mitchell Moss*
- 4/29 – Open Source Multi-Agent Virtual Simulation Test Bed in NYC, *Joseph Chow & Yueshuai Brian He*
- 5/14 – UHPC: An Opportunity to Reinvent Steel and Reimagine Concrete, *JP Binard*
- 5/15 – Collective Behavior Over Social Networks, *Yan Leng*
- 5/26 – Increasing Work Zone Safety: Worker Behavioral Analysis with Integration of Wearable Sensors and Virtual Reality, *Zhengbo Zou & Semiha Ergan*
- 6/5 – Impact of COVID-19 on Mobility and New York’s Response, *Kaan Ozbay & Camille Kamga*
- 6/8 – Using Queuing Models to Design Connected and Autonomous Transportation Systems, *Li Jin*
- 6/23 – Developing Resilient Mechanisms to Cyber Security Threats in Connected and Autonomous Vehicles: From Anomaly Detection to Multi-Modal Planning, *Quanyan Zhu & Rae Zimmerman*
- 7/15 – Optimizing a Redesigned Bus Network using Open-Source Simulation, *Joseph Chow, Ziyi Ma*
- 8/6 – Transportation Transformation: How Autonomous Mobility Will Fuel New Value Chains, *Evangelos Simoudis*
- 8/19 – SPARKMAN, The Smart Parking App: Optimizing Parking on College Campuses, *Kelvin Cheu & Okan Gurbuz*
- 9/10 – Calibration and Development of Safety Performance Functions for New Jersey, *Bekir Bartin*
- 9/24 – Simulating the Impact of Ridesharing in NYC, *Stanislav Sobolevsky*
- 9/30 – Developing C2SMART’s Interactive Data Dashboard: COVID-19 & Transportation, *Jingqin Gao & Yubin Shen*

4. Media Coverage and Public Outreach

- C2SMART’s email communications averaged 23% and 11% respectively. These results in line with the 23% open rate and exceeding the 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 has launched a new Twitter account (@C2SMARTNYU) to promote its research, webinars, and other events and news, with a goal of two daily tweets or retweets. The account currently has 32 followers, with a goal to continue growing over the next reporting period. C2SMART will also revitalizing the existing LinkedIn Group to increase awareness of Center News and Events.

D. Plans for Next Reporting Period

- C2SMART will continue to build out three new initiatives: the C2SMART Learning Hub, offering free workshops to all Consortium Students on job-training and research skills; a Student Entrepreneurial Competition in which student teams will compete to win small seed grants for transportation innovations of their design; and additional funding for student-driven research projects.
- C2SMART has planned a joint day-long symposium between Tongji University in Shanghai, China, on “Smart Cities in the Pandemic Era” that will share recent COVID-19 related-research between universities including C2SMART’s COVID-19 Transportation Dashboard and related findings.
- C2SMART will continue its aim of at least 2 Webinars per month, at least one monthly event mailing, and two daily tweets.
- C2SMART will also help to organize two major events over the next reporting period: the 27th Annual ITS-NY Annual Meeting and Technology Exhibition, and Transportation Camp NYC 2020, both to be held virtually.

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	
Arcadis	New York, NY		X	
Bestmile	San Francisco, CA		X	
BMW ReachNow	Seattle, WA		X	
Calstart	Various, USA			X
CarbonCure	Dartmouth, Canada		X	
Carmera	Brooklyn, NY		X	
Castrol	Various		X	
Clayton Concrete	Lakewood, NJ		X	
Central Japan Railways	Tokyo, Japan	X		
City of El Paso	El Paso, TX		X	
Conway Marine Construction, Inc.	Long Island, NY		X	
Cuebiq	New York, NY			X
Daidone Electric, Inc.	Newark, NJ		X	
Drive Engineering	Blue Bell, PA			X
ETH Zurich	Zurich, CH			
Euclid Chemical	Cleveland, OH		X	
Federal Transit Administration	Washington, DC	X		
Foundation for the Future	Brooklyn, NY			X
Gowanus Canal Conservancy	Brooklyn, NY			X
Gowanus By Design	Brooklyn NY			X
Ikos Lab	Europe (various)			X
Intelligent Transportation Society of NY	New York, NY		X	
International Parking & Mobility Institute	Alexandria, VA	X		

King County Metro	Seattle, WA			X
Kistler Instrument Corp.	Buffalo, NY		X	
Korea Expressway Corporation	Korea		X	
The Lighthouse Guild	US (various)		X	X
Nexar	New York City, NY			X
NEXT	Silicon Valley, CA			X
NJ Turnpike Authority	Woodbridge, NJ	X		
NJDOT	Newark, NJ	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		
Parkofon	Alexandria, VA		X	
Populus	San Francisco, CA			X
Port Authority of NY&NJ	New York City, NY	X		
Precast Systems Engineering	Exmore, VA			X
Puget Sound Regional Council	Seattle, WA		X	
Red Hook Initiative	Brooklyn, NY		X	
Science and Resiliency Institute	Jamaica Bay, NY			X
SHARE NOW	Seattle, WA			X
Silvi Concrete	Fairless Hill, PA		X	
Sound Transit	Seattle, WA			X
Texas Department of Transportation	Austin, TX		X	
Toyota	Various			X
The Things Network	Amsterdam, Neth.		X	
TrafficCast International	Middleton, WI		X	
Transpod	Toronto, Canada			X
Trust for Governor's Island	New York City, NY		X	
US-China Clean Energy Research Center	Various			X
Via	New York City, NY		X	
Voltaic	Brooklyn, NY		X	
Washington State DOT	Olympia, WA		X	X
Zendrive	San Francisco, CA			X

B. Other Collaborators or Contacts

1. Collaborations with Other Departments and Research Centers

- NYU Professors JR Rizzo and Chen Feng are have collaborated with Prof. Claudio Silva with whose help the team obtained the large-scale dataset from a self-driving car company, *Carmera*.
- Dr. Okan Gurbuz, a former student of PI Kelvin Cheu who assisted with his previous research project, ***Sparkman: the Smart Parking App for College Campuses***, now works at the Texas A&M Transportation Institute in El Paso and is a subcontractor of this project. Dr. Gurbuz has provided street parking data and land-use data from downtown Los Angeles that the team is evaluating.

2. Inter-University Collaboration

- Prof. Li Jin has worked with Prof. Zhongping Jiang to produce a forthcoming publications on ***Latency-Robust Control of High-Speed Signal-Free Intersections***
- The Rutgers team collaborated with Stevens Institute of Technology to submit a proposal on Low Carbon Concrete to reduce the carbon dioxide footprint in the construction and concrete industry for sustainable and resilient infrastructure and transportation systems to Port Authority of NY&NJ.
- Rutgers and UW collaborated with NYU and other C2SMART consortium members to develop the interactive data dashboard to consolidate public data sources to track the COVID-19 Pandemic's impact on transportation systems.
- The FloodNet team has collaborated with CUNY on sensor development research. They were successful in securing funding from the New York State Empire State Development Fund to support technology development contextualized within “municipal testbeds”, in collaboration with academic “anchor institutions”. The grant provides funding for complimentary activity to the ***Street-level Flooding Platform: Sensing and Data Sharing for Urban Accessibility and Resilience***, funded by C2SMART, by funding software development to implement a backend data infrastructure to log and store sensor data from a large scale number of sensors, and frontend data visualization to display. The project funded by C2SMART was key in meeting the eligibility requirements for the grant.
- The Rutgers team worked with NYU and CUNY to submit a proposal about asset management using AgileAsset and AASHTOWare BrM to help NYSDOT allocate the limited capital to improve our infrastructure and resiliency, and continues to collaborate with NYU on the development and extension of the Brooklyn Queens Expressway testbed.
- C2SMART has organized a joint day-long symposium between Tongji University in Shanghai, China, on ***Smart Cities in the Pandemic Era***. Researchers from both universities will approach the topic from two sets of perspectives and data sources.
- The Rutgers and NYU teams continued their collaboration on NJ Turnpike Authority and NJDOT projects, as well as new proposals to the Port Authority of NY&NJ on Low-Carbon Concrete.
- Deputy Director Joseph Chow and Xiaopeng Li of the University of South Florida aim “to test the feasibility of using emerging modular autonomous vehicles (MAV) to make transportation infrastructure capacity ‘elastic’ to bridge the gap between time-varying and spatially continuous travel demand and timely-invariant and spatially-aggregated transportation road infrastructure” with a 2-year \$300,000 NSF grant.
- As PI, Prof. Li Jin put forth an NSF proposal titled ***Joint Architectural Design of Cyber and Physical Layers of Connected and Autonomous Transportation Systems: Theoretical Foundation and Hardware-in-the-Loop Simulation*** and as Co-PI ***Improving the robustness of the transportation network to social-media induced cyber-disruptions under fluctuating demand conditions***.

3. Other Collaborations

- NYCDOT has continued to provide in-kind support and C2SMART’s Urban Roadway testbed on the Brooklyn-Queens Expressway (BQE) to evaluate the performance of weigh-in-motion and other technologies and to test the integrated systems. Kistler Instrument Corp has continued to provide technical support and collaborative research contributions to develop an integrated system for direct enforcement of overweight vehicles on the BQE.
- The FloodNet team has worked with the Science and Resiliency Institute at Jamaica Bay, New York for collaborative research on sensor development, the NYC Mayor’s Office of Resiliency and the Mayor’s Office of the Chief Technology Officer for research support. Voltaic has provided in-kind solar hardware, the Internet of Things Network has provided in-kind contribution of hardware for sensor connectivity. Community outreach efforts in the Gowanus neighborhood have been focused

on nurturing the established relationships with the Gowanus by Design and Gowanus Canal Conservancy groups through remote meetings.

- UTEP Co-PIs Jeffrey Weidner and Okan Gurbuz have met with The City of El Paso International Bridges Department every month and the Department is in the process of providing more parking data at downtown of El Paso (from the city’s contractor).
- C2SMART Deputy Director, Joseph Chow, collected commute data from Via ridesharing in their operating cities and will use this dataset, along with other data sources including the U.S. Census to develop a model relating performance metrics of different classes of operations to city attributes.
- The Lighthouse Guild, a National Nonprofit Organization, will assist in experimental data collection with low vision end users and also assist in the behavioral science aspects of PIs Joseph Rizzo and Chen Feng’s ethogram work. The NYC Mayor’s Office for People with Disabilities, NYCDOT, and the MTA, have worked with the team in an advisory capacity towards plans for community engagement.
- Clayton Concrete and Silvi Concrete provided supporting letters offering their facilities for the development of low-carbon concrete as part of the joint-proposal between NYU, Rutgers, and Stevens Institute of Technology. CarbonCure offered their advanced technologies to minimize carbon dioxide during concrete production, Euclid Chemical in Cleveland, OH, offered to provide their advanced chemical admixture, and Precast Systems Engineering will be providing their expertise for the development of precast elements using low-carbon concrete.
- The NYU team continues extensive collaboration with NYC-area agencies on several projects related to Connected Vehicles and the deployment, including a new task focused on Connected Driving under the USDOT Connected Vehicle Pilot Project. They also collaborated with the NYC-area MPO, NYMTC, on development of a survey related to the COVID-19 pandemic’s impact on transportation.

III. Outputs

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

Table 5: Output Performance Measures

Performance Measures	Annual Goal	Achieved (current period)
Peer-reviewed papers	20	38
Conference presentations	10	36
Joint proposals/projects with industry/agency partners	10	20
Website analytics	5,000 unique pageviews	20,124 unique pageviews

A. Publications, Conference Papers and Presentations

1. List of Journal Publications

- Amjadian, M., Agrawal, A. K., Silva, C., & Dyke S. (2020). Magneto-solid damper: modeling, fabricating, and testing. *Journal of Mechanical Systems and Signal Processing*. Under review.
- Braguim, T., Lou, P., Nassif, H., Optimization of Truck Platooning Based on the Load-Induced Fatigue of Steel Bridges. *Transportation Research Record*. Accepted.
- He, Y., Zhou, J., Ma, Z., Wang, D., Sha, D., Lee, M., Chow, J. Y. J., Ozbay, K. (2020b). A validated multi-agent simulation test bed to evaluate congestion pricing policies on population segments by time-of-day in New York City. Under preparation.
- Graziano, F., Nassif, H., Development of a Risk Assessment Module for Bridge Management Systems in New Jersey. *Transportation Research Record*. Accepted.
- Guo, Q., Liu, Z., Angah, O., Ban, X., Hybrid Deep Reinforcement Learning Based Eco-Driving for Low-Level Connected and Automated Vehicles Along Signalized Corridors. *Transportation Research Part C*. Submitted.
- Huang, M., Jiang, Z. P., Ozbay K., Learning-based adaptive optimal control for connected vehicles in mixed traffic: Robustness to driver reaction time, *IEEE Trans. Cybernetics*, 2020. Accepted.
- Khulbea, D., Kanga, C., Ukkusuri, S., Ozbay, K., Sobolevsky, S., Transportation Interventions Reshaping NYC Commute: the Probabilistic Simulation Framework Assessing the Impacts of Ridesharing and Manhattan Congestion Surcharge. Under preparation.

- Sha, D., Ozbay, K., Ding Y., Applying Bayesian Optimization for Calibration of Transportation Simulation Models. Transportation Research Record, 2020. Accepted.
- Xie, K., Ozbay, K., Yang, D., Yang, H., Zhu, Y., Modeling lane-specific breakdown probabilities at freeway diverge sections. Physica A: Statistical Mechanics and its Applications, 2021. Accepted.
- Dynamic Origin–Destination Matrix Prediction with Line Graph Neural Networks and Kalman Filter. Xiong, Kaan Ozbay, Li Jin, Chen Feng. Transportation Research Record, 2020. Accepted.
- Zhou, J., Chow, J.Y.J., Simulation-based optimization of autonomous taxi fleet service area design. Under preparation.
- Zhou, Y., Ozbay, K., Kachroo, P., Zuo, F., Ramp Metering for A Distant Downstream Bottleneck Using Reinforcement Learning with Value-Function Approximation. Journal of Advanced Transportation 2020. Accepted.

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

Nothing to report during this reporting period.

3. Other Publications, Conference Papers and Presentations

- Amjadian, M., Agrawal, A. K., Feasibility of Using a High-Power Electromagnetic Energy Harvester to Power Structural Health Monitoring Sensors and Systems in Transportation Infrastructures. SPIE Conference: 2021 (Abstract Submitted).
- Bartin, B., Demiroglu, S., Ozbay, K., Jami, M. Automatic Identification of Roadway Horizontal Alignment Information Using GIS Data: CurvS Tool. Transportation Research Board’s 100th Annual Meeting, Washington, DC, USA, January 21-29, 2021. Accepted.
- Bernardes, S. D., Zou, Z., Zuo, F., Ergan, S., Khan, J. A., Ozbay, K. Development of a Virtual-Reality Based Immersive and Integrated Traffic Simulation Platform for Studying Traffic Work Zone Safety Problems. Transportation Research Board’s 100th Annual Meeting, Washington, DC, USA, January 21-29, 2021. Submitted for presentation and publication.
- Cui, L., Ozbay, L., Jiang, Z. P., Combined longitudinal and lateral control of autonomous vehicles based on reinforcement learning, 2021 American Control Conference, New Orleans, Louisiana, May 26-28, 2021 Submitted.
- Demiroglu, S., Ozbay, K., Nassif, H. Analysis of Big Transportation Data for Better Infrastructure Management: A Case Study Using Very Large Weigh-in-Motion Data. Transportation Research Board’s 100th Annual Meeting, Washington, DC, USA, January 21-29, 2021. Accepted.
- Demiroglu, S., Nassif, H., Ozbay, K., Chaekuk, N. Analysis of Overweight Truck Permit Policy in New Jersey. Transportation Research Board’s 100th Annual Meeting, Washington, DC, USA, January 21-29, 2021. Accepted.
- Guo, Q., Liu, Z., Angah, O., Ban, X., Hybrid Deep Reinforcement Learning Based Eco-Driving for Low-Level Connected and Automated Vehicles Along Signalized Corridors. 100th Annual Meeting of Transportation Research Board, Washington, DC, USA, January 21-29, 2021. Submitted.
- Huang, M., Cui, L., Ozbay, K., Jiang, Z. P. Stable reinforcement learning for real-time control of connected vehicles in mixed traffic, IEEE Trans. Intelligent Transportation Systems, August 2020. Submitted.
- Rizzo, J.R., Feng C., Riewpaiboon, W., Mongkolwat, P., IEEE Digital Health as a Service Symposium 2020. Accepted.
- Tang, Y., Wen, Y., Jin, L., Security risk analysis of the shorter-queue routing policy for two symmetric servers. 2020 American Control Conference. Accepted.
- Wang, D., Ozbay, K., He, B.Y., Shen, B. Y., Chow, J. Y., 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.
- Zhou, Y., Ozbay, K., Cholette, M.E., Kachroo, P., A Mode Switching Extended Kalman Filter for Real-Time Traffic State and Parameter Estimation; The 23rd IEEE Conference on Intelligent Transportation Systems; 2020; Accepted.
- Zhu, Y., Demiroglu, S., Ozbay, K., Xie, K., Sha, D. SAVE-T: Safety Analysis Visualization and Evaluation Tool. Transportation Research Board’s 100th Annual Meeting, Washington, DC, USA, January 21-29, 2021. Accepted.

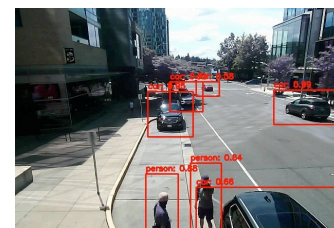
- Zimmerman, R., “Network-based Drivers of Technical and Social Innovations in Integrated Food, Water and Energy (FEW) Systems.” Proceedings of the International Conference on Sustainable Development (ICSD) September 21-22, 2020, New York, NY. Accepted.

B. Websites

The **C2SMART website** (c2smart.engineering.nyu.edu) continues to be used for disseminating information about the Center’s activities and research and had 20,124 unique page views during this reporting period, up from 13,918 unique pageviews last reporting period, and far 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. PI Don Mackenzie created the [Misplaced Wheels](#) web app for users to report dockless bicycle and scooter parking violations, and the accompanying [Misparked Repo](#) where users can analyze data related to the location and severity of the violation.

C. Technologies or Techniques

- 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 NYCDOT and including activities that make the testbed 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.
- PI Jiang has developed a novel vehicle control technology that integrates advances in reinforcement learning, adaptive dynamic programming and modern control theory, for real-time control of connected vehicles in mixed traffic with robustness to human reaction time.
- PI Li Jin’s research is working to synthesize queuing theory and game theory for novel application to transportation research.
- PI Ergan’s research team is working on Hardware-In-the-Loop to create a virtual boundary of work zones in the VR environment based on the physical dimensions of a lab. This will help with tracking the localization of the participant in the VR environment. Professor Ergan’s team has also developed an approach to bringing realistic traffic simulations conducted in the simulation tools (i.e., SUMO) into the VR environments in real-time.
- PI Wang and his team have developed a new method and software tool for infrastructure independent localization and navigation system in urban environments. They have also developed a vehicle detection algorithm reaching 85% accuracy in the complex curbside scenario. To address a drop in accuracy in low light conditions (e.g. night), the team introduced a new IP camera with night vision in the Mobile Unit for Sensing Traffic (MUST) sensor.
- PI Elizabeth Henaff and her team created a flood sensor that is batter and solar-powered, for which the complete unit bill of material and its construction procedure is available online.
- C2SMART researchers, including PhD student Fan Zhu, developed a computer imaging processing algorithm using public NYCDOT traffic camera feeds that can monitor trends in social distancing by distinguishing vehicles, people and other objects.



UW Vehicle Detection Algorithm

D. Industry/Agency Partners

Table 4 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:

- Response to RFP for Academic Institutions to Advise on Best Practices in Low Carbon Concrete Capture, submitted to Port Authority of New York & New Jersey
- Next Future Transportation’s letter of support to NSF for Joseph Chow and Xiaopeng Li of the University of South Florida for a two-year, \$300,000 Early-Concept Grant for Exploratory Research, aimed at optimizing autonomous transportation pod-based systems like Next’s.
- A Connected Driving task under the USDOT Connected Vehicle Pilot Project
- C2SMART is actively working with the New York State Department of Transportation on four research proposals 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 (American Association of State Highway and Transportation Officials) and NBI (National Bridge Inventory) Element Deterioration Rates for Bridge Management System

E. Other Products

C2SMART 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 Ergan’s research team created a database hosted at C2SMART’s PostgreSQL server for storing in real-time sensor data collected by the sensors implemented for virtually delimiting workzone boundaries based on the physical environment of the lab. The database also serves as backend for the VR + Traffic simulation platform.
- The FloodNet team developed a functional prototype for a street-level urban floodwater sensor that records and transmits water presence and height, currently deployed in-field in Gowanus. The sensor is battery powered with solar energy harvesting for extended operation and will typically upload data every 30 mins with faster update rates when flood water is detected.
- Pi Jiang developed a learning-based vehicle control algorithm with robustness to human reaction time with simulation and implementation results posted at the [PI’s lab website](#).
- PI Anil Agrawal and Postdoctoral fellow Mohsen Amjadian have designed a 3D energy harvester in AutoCAD that will be used to harvest traffic-induced vibrations as an energy source. They are currently in the process of finalizing this design and purchasing its component from McMaster-Carr.
- Deputy Director Joseph Chow has developed a mode choice model with multiple transportation modes (motorized and non-motorized) including VIA rideshare data. User behavior in the form of preferences about cost and travel time were incorporated to estimate user choices.
- Professor Chow’s team has also developed a simulation model for within-day and day-to-day simulation of VIA service for different VIA operation classes using MATLAB, which uses the estimated mode choice model to simulate different VIA operation settings.
- PI Rizzo and PI Chen developed a new method and tool for infrastructure independent localization and navigation system in urban environments. The team has also finalized a wearable data acquisition ‘kit’; involving a 360-degree action camera, a modified ball cap with a mounting kit.
- PI Wang has produced two prototypes of customized MUST sensors. Four sensors will be equipped on the MUST: Wi-Fi detector, Bluetooth detector, Environment detector, and Vision Camera.



MUST Sensor Prototype

IV. Outcomes

A. Increased Understanding and Awareness of Transportation Issues

- C2SMART co-hosted the **Pink Tax on Transportation Workshop Series**, bringing together diverse leaders from transportation, government, industry, research, investors and advocates to draft an R&D / tech demonstration road map with an emphasis on innovations that can be tested in NY and scaled. With support from Lyft and NYSEDA, the workshop builds upon prior C2SMART research into the gender disparity in transportation. Over 65 participants attended 3 workshops on caregiver accessibility, passenger safety and action planning, and responded to a post-workshop survey with further implementation ideas.
- C2SMART researchers also created, tested and disseminated a survey specifically focused at essential workers, and others not typically reached in transportation. The survey was designed to learn how transportation patterns have changed and continue to change as the COVID-19 pandemic evolves and particularly how the pandemic has disproportionately affected the mobility options of essential workers, lower-income individuals, people with disabilities, gender/ethnic minorities, etc.
- The research team led by PI Semiha Ergan had identified work zone characteristics that can influence construction workers' safety onsite, characteristics including work zone duration, location, dimension, and construction work type. Despite the apparent connection between work zone characteristics and the incident frequency/rate, there has been little research focusing on analyzing onsite worker behaviors given specifics of the work zones.
- PI Li Jin's research has so far led to preliminary understanding of how sensing faults can affect the efficiency of transportation systems. His model also provides insights about the interaction between system operators and malicious attackers.
- Using data from the BQE testbed, the Rutgers team estimated the number of overweight trucks to guide NYSDOT legislation for overweight trucks. It was found that the majority of overweight trucks fall within 80-88 kips of GVW.

B. Increases in the Body of Knowledge

- C2SMART's work 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, continues. In addition, the NYU has begun work on a Connected Driving task under the CV Pilot. NYU continues to collaborate with the NCHRP research panel on connected vehicle communication technologies.
- PIs Rizzo and Chen are working to enhance the transportation engineering community's understanding of image-based infrastructure independent localization system using visual place recognition methods, to improve accessibility in complex urban environments.
- PI Jiang's research on learning-based solutions to the problem of combined lateral and longitudinal control of autonomous vehicles in mixed traffic and in the presence of human reaction time, will have an impact on the implementation of advanced vehicle control technology in connected and automated vehicles on roadways with mixed traffic flows.
- PI Li Jin has produced a set of tools to quantify the security risk in transportation systems with state-dependent routing.
- C2SMART Director Dr. Kaan Ozbay and postdoc Yue Zhou developed an innovative supervisory observer to inform traffic state estimators (TSE) of correct instants for mode switching. They

Table 6: Outcomes Performance Measures

Performance Measures	Annual Goal	Achieved (current period)
Media interviews, mentions, coverage	10	3
Workshops, webinars, and seminars	10	36

achieved, for the first time in relevant literature, the ability to augment a capacity drop proportion to the state vector so that its value can be calibrated online.

- The Rutgers team reviewed different truck weight calibration standards and methodology in the U.S. and Europe and discussed with NYCDOT to develop a weight calibration procedure that could cover different standards to improve the accuracy for future enforcement. The same team also developed specifications to evaluate pavement conditions to improve the WIM accuracy.
- Deputy Director Professor Joseph Chow in his MATSim project, based on simulation results, proposes that New York City’s congestion pricing policy would significantly decrease the car trips in the charging area (Manhattan 60th Street south) and people from both charging-related and non-charging-related segments would benefit from this policy. His simulation also predicts that the Brooklyn Queens Connectors (BQX) would attract more passengers than the proposal’s prediction and that the service might take up to 18,000 drivers off the road to take transit per day.

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

- C2SMART’s Urban Roadway Testbed continues to expand. NYCDOT permitted implementing the software-based automatic license plate recognition (ALPR) system at the testbed to develop the integrated systems between Weigh-In-Motion Sensors and ALPR camera to develop a procedure for direct enforcement of weight limits to trucks.
- Through conversations with the NYCDOT Assistant Commissioner of Traffic Control & Engineering, permissions were granted for the FloodNet team to deploy sensors on NYC traffic signs.
- In this reporting period, the Federal Transit Administration [began to allow subsidies towards other shared ride options such as shared taxis](#). Deputy Director Joseph Chow completed a study for FTA in the last reporting period in which he researched and provided detail on the value of microtransit and on-demand mobility for transit use.

V. Impact

A. Effectiveness of the Transportation System

In response to the COVID-19 pandemic, C2SMART researchers have developed a public, interactive, data dashboard integrating several open agency and industry data sources around the country, used to monitor the effect of the pandemic on transportation systems. Research has focused passenger travel trends and long-term changes to mode

choice during the recovery and the effect of social distancing policies on transit use and mobility patterns. Of particular note is a computer imaging processing algorithm using public traffic cameras to monitor social distancing practices in several areas.. C2SMART put together several [white papers](#) and has delivered several presentations at conferences and to the public.

B. New Practices or Companies

In September, C2SMART commenced a new Student Entrepreneurship Grant Competition, open to all students in the C2SMART Consortium. Support will be available to student teams who wish to begin a new entrepreneurial activity in collaboration with the Center. Awarded teams will then spend the rest of

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	4
Partnerships/collaborative relationships with companies or transportation agencies established or renewed	10	14

the school year developing a prototype, investigating the market, and preparing the business plan for the topic with the aid of a faculty mentor. At the end of the spring semester, students will report out on their progress and their future plans for advancing and sustaining the business to an audience that includes identified industry stakeholders, and/or potential investors and clients.

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:

- Haoran Anthony Su, who worked as a research assistant for NYU Professor Li Jin, was awarded the Dwight David Eisenhower Transportation Fellowship from the FHWA.
- Srushti Rath, an NYU PhD student in the Transportation & Planning program, was awarded scholarships by the Women Transportation Society (WTS) Greater New York Chapter.
- Professor Anil Agrawal won the 2020 Arthur M. Wellington Prize for the ***Heavy Truck Collision with Bridge Piers: Computational Simulation Study*** in the Journal of Bridge Engineering.

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.

VI. Changes/Problems

The COVID-19 pandemic has continued to affect on-campus activities and planned outreach activities and events. In their place, virtual events continue to be held. C2SMART had planned an in-person Smart Cities Symposium, which will be postponed until new guidelines allow for in-person gathering. In its place, multiple smaller virtual events have been held. Project tasks have also been affected:

- The UTEP Urban Connector project, for which only in person technology transfer aimed at senior adults is remaining from the original project scope, continues to be on hold
- COVID-19 moved the implementation schedule of the Implementation and Effectiveness of Autonomous Enforcement of Overweight Trucks to the last quarter of the project.
- The field testing of the control algorithms in autonomous vehicles in the Learning to Drive Autonomously project may be delayed due to maintenance of social distancing guidelines.
- The scope of Development of Level of Service Analysis Procedures and Performance Measurement Systems for Parking project was changed to use past field data for open surface lots.
- Lab testing of the energy harvesting device in Energy Harvesting for Self-Powered Sensors for Smart Transportation Infrastructures is delayed and field implementation is indefinitely delayed.
- COVID-19 has stalled data collection for JR Rizzo and Chen Feng's project, Wearables to Command More Access and Inclusion in a Smarter Transportation System. This led to a collaboration with former PI Silva and the company Carmera and their large scale image dataset of New York City.
- Social distancing guidelines have also delayed user testing for Professor Ergan's VR Increasing Work Zone Safety: Worker Behavior Analysis with Integration of Wearable Sensors and Virtual Reality

The EcoCar3 project at UW was changed to conduct a high-fidelity Vehicle-In-the-Loop simulation in lieu of field tests to validate the developed methods and algorithms due to unavailability of partners. Finally, the Connected Vehicles for Municipal Vehicular Fleets project at CCNY was replaced with a new project, Utilizing Social Media Data for Estimating Transit Performance Metrics in a Pre- and Post-COVID-19 World, after repeated failed attempts to secure datasets crucial to the original project.