

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

Facilities & Staffing

Renovations of new permanent center space at NYU Tandon School of Engineering in Brooklyn, NY continue to progress with an anticipated move-in date of late 2019. C2SMART is also continuing to grow its full-time staff, including an ongoing search for additional postdoctoral research associates who will be based at NYU. Zhibin Chen has joined the NYU Shanghai faculty as an assistant professor focusing on transportation network modeling and optimization, transportation economics, ITS, and emerging vehicle technologies.

Data Management

C2SMART is working to ensure its projects are in compliance with all data management requirements, including uploading datasets, code and other outputs to the center's Zenodo Data Repository and submitting all products from completed projects to the National Transportation Library repository. The Center's Systems Engineer is coordinating efforts across the consortium and held a webinar attended by representatives from all of the consortium member universities to review data management requirements and walk through correct procedures for packaging and storing data.

Advisory Board

C2SMART held the first meeting of its advisory board in December 2018 with the advisory board members provided input and ideas. The board combines a diverse range of experience in the transportation industry, providing valuable perspectives on ways C2SMART can broaden its network and bolster the impact of its research. Semi-annual meetings are planned for the Advisory Board to advise on center research and outreach activity, with the next meeting scheduled to take place in July 2019 in Brooklyn.

2. Research

C2SMART-Funded Research Projects

Table 1: Projects completed during the reporting period

Emerging Leaders in Transportation / The Future of Mobility Workshop Series NYU	The two-day program equips early-career transportation professionals with leadership skills and strategies for facilitating innovation. The Future of Mobility workshops addressed current issues in transportation and informed the public on emerging trends in urban mobility.
Monitoring and Control of Overweight Trucks for Smart Mobility and Safety of Freight Operations Rutgers	The team has worked with NYCDOT to implement 3 weigh-in-motion (WIM) systems in NYC at sites to be determined by a traffic analysis. The team also installed a WIM system near a bridge that experiences extreme deterioration, used to monitor daily truck traffic and truck weight statistics.
A Multi-Stakeholder Approach to Developing Effective Policies to Reduce the Impact Costs of Overweight Vehicles on Roads and Bridges NYU, Rutgers	The team engaged stakeholders in academia, government and the freight industry through a forum on the impacts of overweight vehicles, resulting in a report covering research and potential policy directions. A follow-up event to disseminate findings is planned for the next reporting period.
Sustainability of Urban Consumption Practices NYU	A broad survey assessing consumer habits in New York and Paris resulted in a comprehensive final report. The project results were covered by several media outlets and contributed valuable insights to policy discussions about online shopping and curb regulations for deliveries.

Table 2: Updates on ongoing center-funded research projects

Urban Mobility and Connected Citizens	Integrative Vehicle Infrastructure Traffic System (iVITS) Control in Connected Cities CCNY, NYU	This continued project will complete the development of network-wide iVITS for NYC and develop a simulation-based approach for the evaluation of CV applications. The team has collected data for specific areas of NYC and is in the process of calibrating the model.
	Dual Rebalancing Strategies for Electric Vehicle Car-sharing Operations NYU	Researchers have tested their rebalancing algorithm in a simulated environment, comparing EV and non-EV scenarios. The research has garnered interest from several companies in the industry and is expected to conclude in the next reporting period.
	Development of a Mobile Navigation Smartphone Application for Seniors in Urban Areas UTEP	40 seniors are participating in the beta test of the app and will be surveyed on their experience during the next reporting period.
	Integrative Vehicle-Traffic Control in Connected/Automated Cities UW	The research team has begun developing models for feedback control and reinforced learning control of traffic signals, which will be tested in a simulation environment.
Urban Analytics for Smart Cities	Understanding Mobility Patterns and Decision-making Using an Integrated, Multi-Modal Sensing Platform in a Quantified Community NYU	Researchers are completing modeling and developing a visualization dashboard of WiFi probe request data from Lower Manhattan combined with physical, social and environmental data to understand mobility patterns and behaviors.
	Integrated Analytics and Visualization for Multi-Modality Transportation Data NYU	The researchers have developed a database of more than 40 million urban streetscape images and detected pedestrians. They have also developed a model for pedestrian density estimation and built a visual analytics tool for the exploration of the data set.
	Development of an Open-Source Multi-Agent Virtual Simulation Testbed for Evaluating Emerging Transportation Technologies and Policies NYU	Significant progress has been made on the virtual testbed of NYC to evaluate new technologies and policies. The research team has started evaluating several use case scenarios with the testbed's current functionalities.
	An Artificial Intelligence Platform for Network-wide Congestion Detection and Prediction using Multi-source Data UW	The model design for network-wide traffic congestion and prediction has been completed, and researchers are now developing the user interface for the AI platform.

Resilient, Secure, and Smart Transportation Infrastructure	Development of A-WIM System for Effective Enforcement of Overweight Trucks to Reduce their Socioeconomic Impact on Major Highways Rutgers	After reviewing currently available A-WIM technologies, the team has acquired sensors and data loggers, which will be implemented on a highway in collaboration with NJDOT.
	Automated Truck Lanes in Urban Areas for Through and Cross Border Traffic UTEP	The team has developed an analytical tool for analyzing bridge configurations and created a base simulation testbed that will be used to evaluate the potential impact of an automated truck lane.

In addition, C2SMART launched a new initiative to provide support for student-driven research projects with a goal to create inter-disciplinary research opportunities in emerging areas within the scope of the center. In future years, this program will attract students and faculty from different disciplines to create new and unique synergies. Director Kaan Ozbay and NYU Tandon Professor Zhong-Ping Jiang provided mentorship and advising for work led by graduate students at NYU on the following subjects:

- **Development of trajectory planning systems and learning-based control methods for CAVs** to achieve lateral motion control, such as lane keeping and lane change behaviors. *Mengzhe Huang, Ph.D. Candidate, Electrical and Computer Engineering Department*
- **Development of a data-driven optimal controller based on adaptive dynamic programming** to solve platooning control problems where CAVs share the road with human-driven vehicles. *Mengzhe Huang, Ph.D. Candidate, Electrical and Computer Engineering Department*
- **Development of a cooperative adaptive cruise control algorithm** designed for use with autonomous vehicles in the exclusive bus lane in the Lincoln Tunnel. *Weinan Gao, Ph.D. graduate, Electrical and Computer Engineering Department*

In November 2018, C2SMART issued a request for proposals for its next round of Center-funded research projects. In addition to its three main research areas, the RFP included an additional request for proposals that address issues with underrepresented populations in transportation research, such as seniors, women, or people with disabilities. Similar to the previous year, a multi-step peer-review process was employed to ensure high-quality projects with a focus on technology transfer and impact were funded. This include two rounds of administrative and peer review, with comments and revised proposal submissions. From the revised submissions, the following projects were awarded funding to commence in March 2019:

Table 3: Year 3 awarded projects

Urban Mobility and Connected Citizens	Impact of Ride-Sharing in New York City NYU	This project will develop a citywide transportation simulation modeling framework to assess mode shift and resulting impacts of ride-sharing in New York City.
	Increasing Work Zone Safety: Worker Behavior Analysis with Integration of Wearable Sensors and Virtual Reality NYU	Using wearable sensors and representations of work zones in virtual reality, this project aims to reduce incidents with warnings workers will respond to in work zones.
	Valuing Vehicle Rebalancing in Free-Float Carsharing Systems UW	This project will build on prior work to develop a tool for calculating the impact of relocating vehicles in a free-float carsharing system.
	Research and Field Testing of Vehicle-Traffic Control with Limited-Capacity Connected/Automated Vehicles UW	This project aims to extend and field test CAV-based traffic signal/ vehicle control methods developed by the team to better understand and quantify the benefits of CAV-based control in the real world.
	Simulation and Analytical Evaluation of Bus Redesign Alternatives in Transit Deserts with Ride-Hail Presence NYU	This project will extend the MATSim virtual testbed already under development to apply it to the evaluation of a bus network redesign for Brooklyn, NY, paying specific attention to the presence of ride hail fleets in justifying stop spacing and route allocations.

Urban Analytics for Smart Cities	Urban Connector Application Pilot Test UTEP	This project will build a prototype smartphone app to cater to the navigational needs of seniors. New objectives include testing in New York City and an anonymous pilot test to collect usage data.
	Development and Tech Transfer of Multi-Agent Virtual Simulation Test Bed Ecosystem NYU	This research will further expand the capabilities of the virtual testbed of NYC, applying models to scenarios of interest to NYCDOT and the MTA, and focus on making the ecosystem accessible to all.
	Sparkman: A Smart Parking Management Tool for University Campuses UTEP	This project aims to develop a software tool that integrates a parking lot zoning and permit pricing model with demand models to help address parking management problems, with an initial test at UTEP.
	Connected Vehicles for Municipal Vehicular Fleets CCNY	This project aims to explore how connected vehicle applications can be implemented to reduce incidents involving vehicles in municipal fleets. It will work with NYC city-owned vehicles and their data.
Resilient, Secure, and Smart Transportation Infrastructure	Design of Resilient Smart Highway Systems with Data Driven Monitoring from Networked Cameras NYU	This project aims to develop a systematic way to design smart highway systems with networked video monitoring and control resiliency against environment disruptions and sensor failures.
	Development of Autonomous Enforcement Approach Using Advanced Weigh-in-Motion (A-WIM) System to Minimize Impact of Overweight Trucks Rutgers	This project will evaluate damage costs from overweight trucks and produce damage cost models for bridges and pavement from a national perspective. It will produce provisional guidelines for enforcement of truck weight regulations using A-WIM technology.
	Developing Secure Strategies for Vehicular Ad Hoc Networks in Connected and Autonomous Vehicles NYU	This project aims to develop a security framework for CAV networks that models potential malicious attacks on these networks and various defense mechanisms to protect against these attacks. A large planned outreach initiative will be undertaken with decision-makers.

Matching Projects Supporting C2SMART Goals

The following projects are funded by public agencies and are used as matching funds for C2SMART or have complementary research aims to C2SMART-funded projects. These projects have a state/local agency client and directly complement the research being conducted using center funding. Combined with C2SMART-funded research, these projects enable the center to build larger, more impactful efforts that have direct end-user benefits for state and local agencies as well as other users.

Table 4: Matching or complementary funded projects to C2SMART-funded projects

Urban Mobility and Connected Citizens	NYC Connected Vehicle Deployment & Mobile Accessible Pedestrian Signal System Application	NYCDOT/JHK Engineering
	Washington State Department of Transportation Spat Challenge	WSDOT
	CIDNY – Develop a 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/NYS DOT
Urban Analytics for Smart Cities	Calibration/Development of Safety Performance Function for New Jersey	NJDOT
	Development of Reconfigurable Environmental Intelligence Platform	NSF
Resilient, Secure, and Smart Transportation Infrastructure	Research on Concrete Applications for Sustainable Transportation: Life Cycle Cost Analysis	USDOT/UTC program
	Ongoing Research and Development of Situational Awareness Platform for the Port Authority of New York & New Jersey	Port Authority of NY & NJ
	Bridge Resource Program	NJDOT
	Technical Support Services for the Maintenance Department	NJ Turnpike Authority

3. Education

C2SMART undertakes numerous educational efforts in pursuit of its goal to train today’s transportation workforce across cities, companies and agencies. In October 2018, C2SMART held a **Two-day Training Workshop for NYCDOT employees** on traffic engineering fundamentals. During this course, NYU faculty taught DOT staff traffic control and operations theories, ITS system architecture, traffic management techniques, incident management, and advances in ITS architecture. This class also provided an opportunity to transfer findings from C2SMART-funded research, particularly in ITS and modeling and simulation, to DOT staff. A follow-up advanced course for senior staff is planned for 2019.



Figure 1: C2SMART faculty teaching NYCDOT employees as part of a two-day workshop



Figure 2: Participants in the 2018 Emerging Leaders in Program visit the East Side Access project

C2SMART also held the **Emerging Leaders in Transportation Program**. The program took place on December 7 and 14th, 2018, with 22 participants. The program included a workshop on building influence within your organization, a tour of the MTA’s East Side Access project, a startup panel discussion at the Grand Central Tech Hub, a panel on innovation in transportation, ideation sessions for participants to conceptualize and process ideas for improvement at their workplaces, and a networking reception.

C2SMART is also involved in supporting a variety of ongoing educational initiatives at its member universities aimed at preparing future members of the transportation workforce to deal with new and emerging mobility problems. Recent news and updates from these initiatives include:

UTEP-Czech Technical University Dual Master’s Degree – This international dual degree program began in 2018. Dr. Miroslav Svitek of Czech Technical University taught a graduate course with 28 students on the Fundamentals of Smart Cities at UTEP during the fall semester as part of this degree program and delivered a webinar on Telecommunications and Cooperative Driving hosted by C2SMART.

Vertically Integrated Projects (VIP) - This program provides a multi-year, multidisciplinary approach to learning that emphasizes project-based, innovative, research-active education. The C2SMART-affiliated VIP team is working on a database of infrastructure safety for autonomous vehicle planning. This is to be adapted through U. of Washington’s VIP Program to analyze the needs of different cities.

Institute of Transportation Engineers (ITE) and Intelligent Transportation Society (ITS) student chapters – C2SMART-funded graduate students continue to serve in leadership roles in these student-run organizations. Ph.D. candidate Jingqin Gao currently serves as the chapter president. The center provides space and support for their networking and educational activities during this reporting period, including:

- Smart Cities Tech & Career Talks featuring short presentations by experts working at companies at the intersection of transportation and technology including Siemens, Amazon and Sidewalk Labs
- A kickoff meeting for new members of the clubs
- The 2nd Annual Women in Transportation Panel Discussion and Networking Night

C. Dissemination and Outreach

C2SMART disseminates research findings through a variety of outlets. Center updates, including news, events, and research developments, are disseminated through the C2SMART website. Research outputs, including final reports and peer-reviewed publications resulting from center-funded research, are submitted to the National Transportation Library’s ROSA-P repository, Research Hub, and TRB’s TRID database.

Research results are also disseminated through papers, presentations, and meetings between center researchers and agency or industry partners and stakeholders. C2SMART also engages non-technical audiences to enhance public understanding of developments in transportation through media outreach.

1. Training and Tech Transfer Events

C2SMART planned and hosted a large-scale technology transfer event, the [6th Symposium on Connected and Autonomous Vehicles in New York City](#) in October 2018. The event brought together over 200 engineers, researchers, government agency representatives, and other speakers and attendees from more than 60 companies, agencies, and universities to weigh in on pressing issues involved in the real-world deployment of connected and autonomous vehicles (CAVs) in cities. The 2-day symposium provided a venue for stakeholders to present and discuss the latest research and policy and implementation challenges of CAVs. One of the sessions focused on the USDOT Connected Vehicle Projects, facilitating sharing of lessons learned to-date from this pilot.

Throughout the symposium, posters, videos and demos were on display, highlighting related research by C2SMART

researchers. A **Startup Showcase** featured pitches by ten mobility-focused startups to a panel of leading transportation industry innovators and an audience of approximately 60 attendees. All of the speakers and panel discussions were recorded and uploaded to C2SMART’s Youtube channel after the event, and are available at cavnycsymposium.com. A follow-up to the conference is scheduled for April 2019, where the center will present findings and transfer knowledge from the conference to transportation agency representatives.

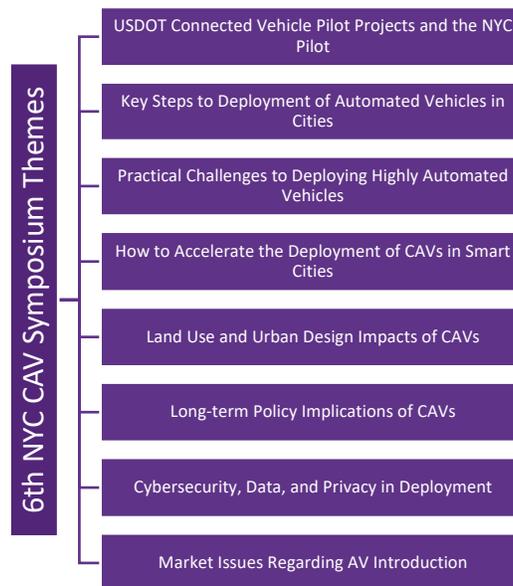


Figure 3: CAV Symposium Themes

C2SMART also served as the host for **TransportationCamp NYC 2018**, a non-traditional conference that brings together a range of students and professionals in the transportation field and others interested in urban transportation and technology. It provided a valuable learning and networking opportunity for C2SMART students who volunteered and participated.

C2SMART funded the **Future of Mobility Workshop Series**, led by PI Sarah Kaufman. Two of the events in the series, the **Transportation Startup Showcase** and **The Pink Tax on Transportation: Women’s Challenges in Mobility**, took place during this reporting period. The Pink Tax on Transportation event presented results of a travel survey conducted by NYU researchers about travel habits, safety while using different modes of transportation, costs of travel, and caregiver trips in NC. The workshop, which attracted about 40 attendees, also included a panel discussion on the importance of diversity in leadership and innovations in mobility.

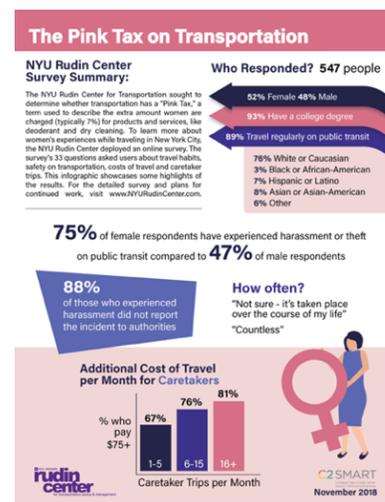


Figure 4: Findings from the Pink Tax on Transportation survey

Deputy Director Joseph Chow and PI Sarah Kaufman served as judges for the **Forbes Idea Incubator Challenge**, held at NYU Tandon in March 2019. This event, sponsored by Audi, offered female students at NYU an opportunity to pitch concepts for ways to address the impact that electric vehicles and related infrastructure will have on urban mobility. A total of 23 students participated in the challenge.

During this reporting period, the center undertook additional dissemination and outreach efforts:

Semi-Annual Progress Report

October 2018-March 2019

Conference Presentations

- C2SMART had a significant presence at the 98th Transportation Research Board Annual Meeting in January, with faculty and students affiliated with the Center presenting 45 conference publications. The Center also hosted a reception and had a booth in the conference’s Exhibit Hall, enabling faculty, staff and students to share information about the center’s research with a broad audience.
- PI Sarah Kaufman presented research on the Pink Tax on transportation, extra costs women face for transportation services, at the following conferences:
 - Transforming Transportation Conference, World Bank, Washington D.C., January 18, 2019
 - LA CoMotion, Los Angeles, CA, November 16, 2018
 - Social Justice and Equity in the Engineering of Smart and Connected Cities Workshop, University of Washington, December 10, 2018
- PI Constantine Kontokosta presented research results from his C2SMART project at the Association of Public Policy Analysis and Management Annual Research Conference

Research Showcases

- The UTEP research team made a joint presentation with representatives from the City of El Paso on their Urban Connector project at the 2019 Texas Recreation and Parks Society (TRAPS) Institute and Expo, held in February in El Paso.
- In collaboration with Carmera, PI Claudio Silva’s team presented research results to Metro-North as part of a Pedestrian Movement Technology showcase.
- C2SMART Director Kaan Ozbay presented on “Calibration/Development of Safety Performance Functions for New Jersey” at the 20th NJDOT Research Showcase

Workshops

- C2SMART held a 2-day training workshop in October 2018 for NYCDOT employees on traffic engineering fundamentals, which provided an opportunity to transfer findings from C2SMART-funded research, particularly in ITS and modeling and simulation, to DOT employees. A follow-up workshop is planned for summer 2019 on more advanced topics.
- C2SMART hosted an ASCE training course on high-rise building security and fire-life cycle management in February 2019.
- Deputy Director Joseph Chow and a graduate student presented a talk on “Evaluating emerging transportation technologies and policies with a Network of Living Labs” at a workshop hosted by the Center for Environmental Science, Horn Point Laboratory (UMCES), and the Center for Smart Growth Research and Education (NCSG) at the University of Maryland.
- Director Kaan Ozbay and Associate Director Hani Nassif gave a joint presentation at the NJIT Technology and Society Forum on strategies for strengthening city infrastructure.
- Director Kaan Ozbay and PI Constantine Kontokosta presented research at the National Academy of Science Workshop: Frontiers of Big Data, Modeling, and Simulation in Urban Sustainability. Prof. Ozbay spoke on a panel on data-driven transportation simulation and modeling, and Prof. Kontokosta spoke about innovation in geospatial data sources and spatiotemporal analysis.

2. Industry and Public Agency Outreach:

- The research team at UTEP has been working with the City of El Paso Parks and Recreation Dept. on the Urban Connector project as they work toward a beta test of the navigation app for seniors.
- PI Sarah Kaufman presented the results of the Pink Tax research at the Rosenthal Roundtable on Women’s Economic Empowerment, an event for New York City Councilmember Helen Rosenthal.
- PI Jeff Ban organized a panel discussion on big data related promises and issues at UW in September 2018. Participants include FHWA project managers, WSDOT engineers and managers, transportation

professionals from cities (Bellevue), transit agencies, planners from PSRC, representatives from data providers, and university researchers (UW, CMU).

- C2SMART’s team at NYU hosted several visiting delegations from transportation industry companies and their representatives during the current reporting period for the purposes of knowledge sharing, transfer, and developing new opportunities for collaboration. These included domestic companies as well as industry from Norway, Germany, and China.

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](#).

Distinguished Speaker Series

- Dr. Jonathan Peters, Professor, College of Staten Island of the City University of NY, “Variation in Household Spending on Transportation Services – Urban, Rural and City Specific Differences.”
- Dr. Karl Johansson, Professor and Director of the Stockholm Strategic Research Area ICT The Next Generation, “Control of Automated Transport Systems.”
- Dr. Shengchuan Zhao, Dean of the School of Transportation and Logistics at Dalian University of Technology, “Transportation Infrastructure Development Under Rapid Motorization in China.”

Additional Seminars

- Dr. Peng Wei, Assistant Professor, Iowa State University, “Unlock the Personal Sky – Safe and Assured Autonomy for On-Demand Urban Air Mobility.”
- Dr. Ricardo Daziano, Associate Professor, Cornell University, “Exploring the Use of Immersive Virtual Reality Environments for Travel Behavior Analysis.”
- Dr. Dengfeng Sun, Associate Professor, Purdue University, “Stochastic optimization of large scale air traffic flows.”
- Dr. Alejandro Henao, National Renewable Energy Lab Mobility Researcher, “How is ride-hailing affecting mobility and energy use?”
- Dr. Saurabh Amin, Associate Professor, MIT, “Analytics-Driven Operations for Critical Infrastructure Resilience.”
- Dr. Oded Cats, Associate Professor, and Panchamy Krishnakumari, Ph.D. student, Delft University of Technology, “Capacity allocation for on-demand services, demand-anticipatory operations and analyzing demand patterns.”
- Dr. Rahul Mangharam, Associate Professor, University of Pennsylvania, “Designing Safe Autonomous Systems – On the Ground and in the Air.”
- Dr. Abolfazl Safikhani, Assistant Professor, Columbia University, “Spatio-temporal modeling of yellow taxi demands in New York City using generalized STAR models.”
- Dr. Shanjiang Zhu, Associate Professor, George Mason University, “Assessing Travel Behavior Responses to Transit Network Disruptions Using Innovative Data Collection Methods.”
- Dr. Tarun Rambha, Assistant Professor, Indian Institute of Science Bengaluru, “Modeling departure time decisions during hurricanes using a dynamic discrete choice framework.”
- Deputy Director Joseph Chow also presented a seminar on the evaluation of mobility-as-a-service alternatives as part of the LSGI Distinguished Lecture Series at Hong Kong Polytechnic.
- PI Jeff Ban presented a talk at the University of Tokyo on transportation big data issues.

Webinars

- Prof. Tomas Zelinka, Faculty of Transportation Sciences, Czech Technical University, “Telecommunications and Cooperative Driving.”
- Matthew Vechione and Okan Gurbuz, Ph.D. Candidates in Civil Engineering, UTEP, “Development of a Mobile Smartphone Application for Seniors in Urban Areas.”
- Prof. Joseph Chow, NYU, “A City-Scalable Destination Recommender System for On-Demand Senior Mobility.”
- Facilitated by the Rutgers research team, C2SMART held an online training and education event on Weigh-in-Motion sensors presented by Kistler Corporation and Prof. Hani Nassif.

4. Media Coverage and Public Outreach

- C2SMART has continued to grow its mailing list, which is used to advertise center events and disseminate news and research findings via regular newsletters. The center’s email communications achieve consistently high open and click rates, averaging 40.2% and 8.4% respectively. These results are well above the 17.1% open rate and 2% click-through rate averages for other mailing lists in education and training reported by MailChimp, the email marketing service used by the center.
- C2SMART also works to reach a wider public audience through its [Youtube channel](#). All of the center’s seminars are streamed live, and video recordings from other events and webinars are posted as well. During this reporting period, the center’s Youtube channel accumulated 1,366 views.
- Research conducted by one of C2SMART’s graduate students was featured in a [TED talk](#) by Tommaso Gecchelin, co-founder of NEXT, on how car-jumping can transform transportation in cities. Prof. Joseph Chow of NYU leads C2SMART’s research partnership with NEXT.
- Director Kaan Ozbay was featured in a [news segment on CBS](#) about the NYCDOT-led Connected Vehicle Project, explaining some of the significance of the project and its potential impacts.
- The UTEP team designed posters to show the results of last year’s survey on seniors’ transportation needs and preferences, and copies were provided to the City of El Paso Parks & Recreation Department to put on display at 11 senior centers. Additionally, members of the research team set up booths at the El Paso Senior Games to promote the project.
- The report resulting from PI Sarah Kaufman’s project, Sustainability of Urban Consumption Practices, was covered in [AM New York](#).
- PI Sarah Kaufman’s report on the Pink Tax in Transportation was covered in at least 13 media outlets, including [Fox 5 New York](#), [Business Insider](#), and [Wired](#).
- UTEP Ph.D. Candidate Okan Gurbuz and PI Kelvin Cheu were featured in the [UTEP newspaper](#) about their new project focused on solutions for parking management on university campuses.
- Assistant Professor Li Jin and graduate students were featured in a recent episode of a new podcast entitled “The Future Of,” looking at emerging technological innovation and research via interviews with NYU Tandon faculty and students. The C2SMART students and faculty were interviewed for the show’s third episode, [The Future Of: Transportation](#).
- Director Kaan Ozbay and Associate Director Hani Nassif were named to an expert panel to advise on reconstruction of the Brooklyn-Queens Expressway, which was widely covered in New York media outlets, including [Gothamist](#), [Brooklyn Daily Eagle](#), [New York Daily News](#), and more.

D. Plans for Next Reporting Period

Continuing its research program, several C2SMART-funded projects are scheduled for completion in the coming months. C2SMART is also uniting and expanding on its previous research and events under a new Women in Transportation Initiative. C2SMART will host events featuring female leaders in transportation, and the Center will present research at the Women’s Issues in Transportation Conference in September. In media and public outreach, Director Kaan Ozbay and Deputy Director Joseph Chow will be presenting on the future of mobility and smart cities to members of the media at the New York Auto Show. C2SMART is also planning a new *Technology Transfer Day*, a second forum on impacts and policy directions for overweight trucks, and a follow-up event from the NYC CAV Symposium in partnership with NYC Town+Gown. In education, C2SMART is co-sponsoring a hackathon to be held at UTEP during the next reporting period.

II. Participants and Collaborating Organizations

A. Partner Organizations

C2SMART has established partnerships with a range of agencies and private companies, outlined in Table 5:

Table 5: 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	
Bestmile	San Francisco, CA		X	
BMW ReachNow	Seattle, WA		X	
Carmera	Brooklyn, NY		X	
Castrol	Various		X	
Central Japan Railways	Tokyo, Japan	X		
City of El Paso	El Paso, TX		X	
Cuebiq	New York, NY			X
Drive Engineering	Blue Bell, PA			X
Foundation for the Future	Brooklyn, NY			X
Ikos Lab	Europe (various)			X
Intelligent Transportation Society of NY	New York, NY		X	
King County Metro	Seattle, WA			X
Kistler Instrument Corp.	Buffalo, NY		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	New York City, NY			X
NYCDOT	New York City, NY	X		
NYSDOT	Albany, NY	X		
Parkofon	Alexandria, VA		X	
Port Authority of NYNJ	New York City, NY	X		
Puget Sound Regional Council	Seattle, WA		X	
Red Hook Initiative	Brooklyn, NY		X	
Sound Transit	Seattle, WA			X
Texas Department of Transportation	Austin, TX		X	
Toyota	Various			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	
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

- C2SMART's symposium on connected and autonomous vehicles involved extensive collaboration with other departments and centers at NYU, featuring professors from the Electrical and Computer Engineering and Computer Science departments at NYU Tandon and NYU School of Law among the speakers and panelists, providing a multidisciplinary perspective on CAVs.

- C2SMART has continued its collaboration with INTERCEP, a research center based at NYU Tandon that is focused on organizational resilience. The center is working closely with the Rutgers team on a project focused on developing effective policies to reduce the impact costs of overweight vehicles on roads and bridges. INTERCEP and the Rutgers team are collaborating on a second forum on overweight trucks in the coming months to follow up and expand on the progress and conclusions of the first event in June 2018.
- Director Kaan Ozbay & Prof. Zhong-Ping Jiang in the Electrical and Computer Engineering department at NYU Tandon co-advised and mentored ECE graduate students on transportation-related research.

2. Inter-University collaboration

- Consortium member universities as well as multiple universities beyond C2SMART’s consortium were involved in the planning and execution of the 6th CAV Symposium, including Princeton, the State University of New York and Rensselaer Polytechnic Institute.
- PI Claudio Silva’s team at NYU collaborated with a Ph.D. student in Urban Systems at Rutgers on the development of a pedestrian density estimation and visual analytics tool.
- C2SMART hosts several researchers from other institutions as Visiting Scholars on a regular basis
- PI Jeff Ban of UW has been collaborating with Prof. Li Li from Tsinghua University as part of his research on traffic signal control with connected vehicles, resulting in the completion of a joint journal paper on urban traffic control methods in CAV environments.
- UTEP continues its partnership with Czech Technical University on a dual degree program. Prof. Tomas Zelinka taught a course at UTEP during the fall semester.

3. Other collaborations

- In October 2018, Dr. Jeffrey Weidner of UTEP led a team of public stakeholders representing the El Paso Region at the 3rd Annual Texas Mobility Summit in Arlington, TX. The team included members from the City of El Paso, El Paso County, TXDOT, the regional MPO, and UTEP.
- C2SMART Director Kaan Ozbay and Associate Director Hani Nassif were named to a new expert panel formed by New York City Mayor Bill de Blasio to evaluate options for reconstruction of the Brooklyn-Queens Expressway. Profs. Ozbay and Nassif will work with the other 14 members of the panel, which includes leaders in urban planning, engineering, construction, traffic modeling, and historic preservation, to consider solutions for replacing the highway.

III. Outputs

C2SMART is exceeding its targeted performance metrics in each of the areas identified in its Technology Transfer Plan. C2SMART is achieving a significant volume of outputs in the areas identified in Table 6.

A. Publications, Conference Papers and Presentations

1. List of Journal Publications

- Abu-Obeidah, Adi; Nassif, Hani; Brewer, Gregory; Na, Chaekuk; Corso Jr, Frank A., 2019. Utilization of Fiber Reinforced High Performance Concrete (FR-HPC) in Reconstructed Bridge Decks. Transportation Research Board 98th Annual Meeting, Transportation Research Board.
- Allahviranloo, M., Chow, J.Y.J., 2019. A fractionally owned autonomous vehicle fleet sizing problem with time slot demand substitution effects, Transportation Research Part C 98, 37-53.
- Bian, Z., & Ozbay, K., 2019. Estimating Uncertainty of Work Zone Capacity using Neural Network Models. Transportation Research Record. <https://doi.org/10.1177/0361198118825136>
- Bartin, B., Ozbay, K., Xu, C., 2019. Extracting Horizontal Curvature Data from GIS Maps: A Clustering Method. Proc. 98th Annual Meeting of the Transportation Research Board, Washington, D.C. (Committee ABJ60: Geographic Information Science and Applications), National Academies, Washington, D.C.

- Bartin, B., Ozbay, K., Yang, H. Evaluation framework for mobile ticketing applications in public transit: a case study. IET Intelligent Transport Systems, Volume 12, Issue 9, November 2018, pp. 1166–1173. DOI: [10.1049/iet-its.2018.5248](https://doi.org/10.1049/iet-its.2018.5248)
- Cao, Y., Kurkcu, A., Ozbay, K., 2019. Blockchain: A Safe, Efficient Solution for Driver Privacy and Connected Vehicle Transportation Data Sharing. Proc. 98th Transportation Research Board, (Committee ABJ50: Information Systems and Technology), National Academies, Washington, D.C.
- Caros, N., Chow, J., 2019. Effects of violent crime and vehicular crashes on active mode choice decisions in New York City, Proc. 98th Annual Meeting of the Transportation Research Board, Washington, D.C.
- Gao, J., Ozbay, K., Kurkcu, A., 2019. Multi-Source Data Fusion for Urban Traffic State Estimation: A Case Study of New York City. Proc. 98th Annual Meeting of the Transportation Research Board, Washington, D.C. (Committee ABJ30: Urban Transportation Data and Information Systems), National Academies, Washington, D.C.
- Gao, J., Ozbay, K., Nassif, H., Kalan, O., 2019. Stochastic Multi-Objective Optimization-Based Life Cycle Cost Analysis for New Construction Materials and Technologies. Proc. 98th Annual Meeting of the Transportation Research Board, Washington, D.C. (Committee AHD35: Bridge Management), National Academies, Washington, D.C.
- Guo, Q, Li, L, Ban, X., 2019. Urban traffic signal control with connected and automated vehicles: A survey. *Transportation Research Part C* 101, 313-334.
- Jung, J., Chow, J.Y.J., 2019. Effects of charging infrastructure and non-electric taxi competition on electric taxi adoption incentives in New York City. *Transportation Research Record*, in press, doi: 10.1177/0361198119837955.
- Jung, J. and Chow, J., 2019. Large-Scale Simulation-Based Evaluation of Fleet Repositioning Strategies for Dynamic Rideshare in New York City, SAE Technical Paper 2019-01-0924, <https://doi.org/10.4271/2019-01-0924>.
- Kalan, O., Kurkcu, K., Ozbay, K., 2019. Is Additive Utility Function Always A Sufficient Method in the Project Prioritization Process? A Bridge Management Perspective. Proc. 98th Annual Meeting of the Transportation Research Board, Washington, D.C. (Committee AHD35: Bridge Management), National Academies, Washington, D.C.
- Khan, S.A.K., Bierds, W., Bringardner, J., Chow, J. Y. J., 2019. Adapting the business model canvas entrepreneurship tool to assist transportation technology transfer. 98th Annual Meeting of the Transportation Research Board, Washington, D.C.
- Xie, K., Ozbay, K., Yang, H., 2019. A multivariate spatial approach to model crash counts by injury severity, *Accident Analysis & Prevention*, Volume 122, pages 189-198, ISSN 0001-4575. <https://doi.org/10.1016/j.aap.2018.10.009>.
- Lou, P., Gao, D., Nassif, H., Reddy, M., 2019. Reliability Assessment of Steel Bridges for Specialized Hauling Vehicles. Proc. 98th Annual Meeting of the Transportation Research Board, Washington, D.C.
- Ma, T.Y., Pantelidis, T., Chow, J. Y. J., 2019. Optimal queueing-based rebalancing for one-way electric carsharing systems with stochastic demand. Proc. 98th Annual Meeting of the Transportation Research Board, Washington, D.C.
- Traunmueller, M.W., Johnson, N., Malik, A., Kontokosta, C.E., Digital footprints: Using WiFi probe and locational data to analyze human mobility trajectories in cities, *Computers, Environment and Urban Systems*, Volume 72, 2018, Pages 4-12, ISSN 0198-9715, <https://doi.org/10.1016/j.compenvurbsys.2018.07.006>.
- Pantelidis, T., Li, L., Ma, T.Y., Chow, J. Y. J., Jabari, S. E., 2019. Doubly-constrained rebalancing for one-way electric carsharing systems with capacitated charging stations, abstract accepted to TSL Workshop, Vienna, Austria.
- S. Demirogluk, K. Ozbay and H. Nassif, 2018. Mapping of truck traffic in New Jersey using weigh-in-motion data, IET Intelligent Transport Systems, vol. 12, no. 9, pp. 1053-1061, doi: 10.1049/iet-its.2018.0055
- Sha, D., Ozbay, K., Bian, Z., Wang, D., Ding, Y., 2019. A Stochastic Collocation Method for Uncertainty Quantification and Calibration of Microscopic Traffic Simulation Models. 98th Transportation Research Board (Committee AHB45: Traffic Flow Theory and Characteristics), National Academies, Washington, D.C.
- Tokuda, E., Lockerman, Y., Ferreira, G., Sorrelgreen, E., Boyle, D., Cesar Jr., R., Silva, C. A new approach for pedestrian density estimation using moving sensors and computer vision. Submitted to *ACM Transactions on Spatial Algorithms and Systems*. <https://arxiv.org/abs/1811.05006>
- W. Gao, J. Gao, K. Ozbay and Z. Jiang, 2019. Reinforcement-Learning-Based Cooperative Adaptive Cruise Control of Buses in the Lincoln Tunnel Corridor With Time-Varying Topology, *IEEE Transactions on Intelligent Transportation Systems*. doi: 10.1109/TITS.2019.2895285
- Xu, C., Gao, J., Zuo, F., Ozbay, K., Cui, H., 2019. Understanding Spatial-Temporal Impact on Mode Preference between Taxi and E-Hailing Service. Proc. 98th Annual Meeting of the Transportation Research Board, Washington, D.C. (Committee AP020: Emerging and Innovative Public Transport and Technologies), National Academies, Washington, D.C.
- Yang, D., Xie, K., Ozbay, K., Yang, H., Budnick, N., 2019. Zone-based Modeling Time-dependent Safety Performance Using Smartphone-based Connected Vehicle Data. 98th Transportation Research Board (Committee ANB25: Highway Safety Performance), National Academies, Washington, D.C.
- Zhu, Y., Ozbay, K., Yang, H., Zuo, F., Sha, D., 2019. Modeling and simulation of cascading failures in transportation systems during hurricane evacuations. 98th Transportation Research Board (Committee ABR20: Logistics of Disaster Response and Business Continuity), National Academies, Washington, D.C.

Table 6: Output Performance Measures

Performance Measures	Annual Goal	Achieved (current period)
Peer-reviewed papers	20	25
Conference presentations	10	12
Joint proposals/projects with industry/agency partners	10	22
Website analytics	5,000 unique pageviews	12,092 unique pageviews

2. Books or other non-periodical, one-time publications

Nothing to report during this reporting period.

3. Other Publications, Conference Papers and Presentations

C2SMART Professors Kaan Ozbay, Joseph Chow, Camille Kamga, and Li Jin led multiple sessions at the 6th Symposium on Connected and Autonomous Vehicles in NYC. The Center's faculty and students also gave 45 lectern and poster presentations at the 98th Annual Meeting of the Transportation Research Board in January 2019. Other conference and workshop presentations by C2SMART during this period include:

- Bartin, B., Ozbay, K., Yang, H. (2018) "Evaluation framework for mobile ticketing applications in public transit: a case study." ITS World Congress, Copenhagen, Denmark, October, 2018.
- Chow, J., He, Y. "Evaluating emerging transportation technologies and policies with a Network of Living Labs." Workshop, Center for Environmental Science, Horn Point Laboratory (UMCES) and the Center for Smart Growth Research and Education (NCSG) at the University of Maryland. February 22, 2019.
- Kaufman, S. "The Pink Tax on Transportation." Transforming Transportation Conference, World Bank, Washington D.C., January 18, 2019
- Kaufman, S. "The Pink Tax on Transportation." LA CoMotion, Los Angeles, CA, November 16, 2018
- Kaufman, S. "The Pink Tax on Transportation." Social Justice and Equity in the Engineering of Smart and Connected Cities Workshop, University of Washington, December 10, 2018
- Kontokosta, C., Johnson, Malik, A., Traunmueller, M. "Public ICT Policy and the Provision of Fiber: Does Ultra-Fast Broadband Increase Firm Productivity." Association for Public Policy Analysis and Management 40th Annual Fall Research Conference. November 8, 2018, Washington D.C.
- Kontokosta, C. Panel: "Innovation in geospatial data sources and spatiotemporal analysis." National Academy of Science Workshop: Frontiers of Big Data, Modeling, and Simulation in Urban Sustainability. January 30-31, 2019.
- Nassif, H. "Calibration of Service I Limit State for Reinforced Concrete Bridge Deck Designed Using Empirical Method" with the collaboration with Embry-Riddle Aeronautical University. ACI Fall 2018, Las Vegas, NV.
- Nassif, H. "Structural Health Monitoring of Latex-Modified Concrete (LMC) Overlays on Bridge Decks" with the collaboration from Florida Institute of Technology. ACI Fall 2018, Las Vegas, NV.
- Ozbay, K., Nassif, H., "City Resilience: Structural Health Monitoring and Big Data Modeling of Transportation." NJIT Technology and Society Forum. October 24, 2018.
- Ozbay, K. Panel: "Modeling, simulation and data" National Academy of Science Workshop: Frontiers of Big Data, Modeling, and Simulation in Urban Sustainability. January 30-31, 2019.
- Ozbay, K., Bartin, B. "Calibration/Development of Safety Performance Functions for NJ." Presentation at the 20th NJDOT Research Showcase, Conference Center at Mercer County Community College, West Windsor, NJ. October 17, 2018.
- Ozbay, K. Chair, Session 590: 2019 TRB Conference - Session: 590 Estimation, Detection, and Prediction of Traffic Conditions with Machine Learning Tools. January 2019. TRB Annual Meeting, Washington D.C
- Vechione, M., Marrufo, C., Vargas Acosta, R. A., Jimenez, M., Gurbuz, O., Dmitriyeva, D., Cheu, R. L., Villanueva-Rosales, N., Nunez-Mchiri, G., Chow, J. (2018). "Smart mobility for seniors: challenges and solutions in El Paso, TX and New York, NY." Poster presented at CTECH (Center for Transportation, Environment & Community Health) Annual Meeting, October, 7, 2018, Davis, California.

B. Websites

The **C2SMART website** (c2smart.engineering.nyu.edu) continues to be used for disseminating information about the Center's activities and research. The site is frequently updated with news about events and achievements involving C2SMART faculty and students, and final project reports and additional research progress updates are added regularly. C2SMART's website had 12,092 unique pageviews during this reporting period, exceeding its annual goal of 5,000 pageviews. C2SMART also launched a website (cavnycsymposium.com) to advertise, provide information and register attendees for the Symposium on Connected and Autonomous Vehicles.

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 by PI Sarah Kaufman, including the Emerging Leaders in Transportation program. The [Rutgers Infrastructure Monitoring and Evaluation Group \(RIME\)](#) website provides regular updates on the group's activities.

INTERCEP is developing a Resource Hub to consolidate research related to the impacts of overweight trucks on infrastructure. When completed, this resource will be disseminated to stakeholders.

C. Technologies or Techniques

C2SMART’s research projects have produced several technologies and techniques during this reporting period. As part of the Integrated Analytics and Visualization for Multi-Modality Transportation Data project, PI Claudio Silva’s team developed a model for pedestrian density estimation built using recent advances in computer vision to identify the presence of people in large collections of images. The research team also developed an interactive visual analytics tool that can be used to explore and analyze large collections of images, which has a wide variety of potential use cases in urban environments.

PI Constantine Kontokosta’s team has developed models for mobility patterns and behavior in dense urban environments based on WiFi probe request data, and is now combining these models with other physical, social and environmental data. A dashboard for visualizing the impact of environmental and other changes on pedestrian movement patterns is in development.

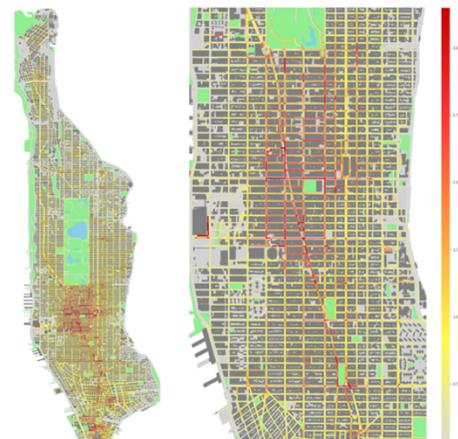


Figure 5: Heatmap showing relative pedestrian density using the developed estimation model

A significant amount of progress has been made on the development of the virtual testbed for New York City. The research team is in the process of calibrating models in MATSim and SUMO, and they have also started evaluating preliminary use case scenarios using the testbed, such as analyzing the impact of congestion pricing and Citi bike service expansion.

D. Joint Proposals/Partnerships with Industry/Agency Partners

Table 4 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:

- NYU researchers applied as part of teams for the new National UTC funding opportunities from USDOT, aligned with other leading national universities (decision pending)
- New York City Department of Environmental Protection RFP on Energy Infrastructure – Pathways to Achieve 80x50 Study
- PI Joseph Chow successfully applied for a Federal Transit Administration grant for a study on the Synthesis of real time public transit route deviation operational policies, expected for 2019
- PI Kaan Ozbay applied for and was awarded an NCHRP grant in partnership with Noblis on Algorithms to Convert Basic Safety Messages into Traffic Measures
- C2SMART researchers jointly applied for the Port Authority of New York & New Jersey’s Request for Proposals for Academic Institutions to advise on discrete engineering projects on a “call-in” basis in 2019 (decision pending)
- PI Kaan Ozbay was awarded a research project from Transcom, a coordination agency composed of all New York & New Jersey-area transportation agencies, on a Needs Assessment for the Development of Data-driven Predictive Non-recurrent Delay Models, in partnership with Infosense Global Solutions, expected to commence in April 2019
- NYU applied jointly with the Rochester Institute of Technology for designation as a New York State Center for Advanced Technology focused on autonomous vehicle technology

- PI Don Mackenzie is working on the following projects in partnership with agencies/companies:
 - EV infrastructure simulation and design project with WSDOT
 - Understanding consumer preferences for different types of automation-enabled mobility services with Toyota
 - Modeling individuals' attitudes and intent to adopt new mobility services and automated vehicles with USDOE: US-China Clean Energy Research Center
 - Equity in Latin American transit systems with the Toyota Mobility Foundation
 - Industry-funded capstone project developing a traveler-facing tool for managing extreme traffic events with King County Metro, Sound Transit and WSDOT
- PI Constantine Kontokosta renewed collaborations with the Alliance for Downtown New York and the Trust for Governor’s Island as part of the Quantified Community project
- PI Jeff Ban worked on the following projects and proposals with industry or agency partners:
 - NSF CPS on smart transportation data and control with the City of Madison
 - CSET UTC on advanced technologies for remote communities with Westport
 - PacTrans proposal on transportation demand management with WSDOT
 - FHWA Big Data Project - Phase II with FHWA, WSDOT, and PSRC
 - NSF SaTC proposal on transportation data privacy with City of Madison and industry
- Rutgers and NYU awards with NJDOT and NJ Turnpike on the “Calibration/Development of Safety Performance Functions in NJ”, “NJ Bridge Resource Program”, and “On-Call Technical Services” were all renewed/extended during this reporting period

E. Other Products

Two reports offering insights into different aspects of urban mobility have been produced: the first, “Online Consumption and Mobility Practices: Crossing Views from Paris and Manhattan,” details the results of a comprehensive comparative survey on online consumption and mobility habits of residents of the two cities. “The Pink Tax on Transportation: Women’s Challenges in Mobility,” shows different ways transportation is more costly for women due to issues of safety, access, etc.

A summary report of a forum on overweight vehicles organized in May 2018 has been produced, titled “New Policies & Directions for Overweight, Heavier & Larger Vehicles: A Multi-Stakeholder Approach to Developing Effective Policies to Reduce the Impact Costs on Roads and Bridges.” The report provides research and policy insights that will inform various agencies and stakeholders about policies in the area of overweight vehicles and their impact on transportation infrastructure. It is currently under review by other forum presenters and is expected to be made available in the next reporting period.

IV. Outcomes

A. Increased Understanding and Awareness of Transportation Issues

C2SMART’s outreach, dissemination and education efforts have reached a wide audience. The results of the **Sustainability of Urban Consumption Practices** project received coverage in consumer media, including front page coverage by AM New York, increasing awareness of these issues to a wider audience beyond academia. The results have been shared with policy leaders at the NYCDOT, providing valuable insights for policy discussions about online shopping and curb regulations for deliveries.

Table 7: Outcomes Performance Measures

Performance Measures	Annual Goal	Achieved (current period)
Media interviews, mentions, coverage	10	14
Workshops, webinars and seminars	10	18

The **Future of Mobility workshop series** has also contributed to improved understanding of transportation issues. The Startup Showcase provided the opportunity for emerging startups to connect with each other and industry leaders. Several of the companies connected with NYC Transit's new TransitLab, which develops technologies for pilots in the subway and bus system. Feedback from public sector attendees and panelists offered opportunities for companies to hone their technologies for more public-serving features, and public-sector attendees gained insight into current industry developments. Additionally, the **Pink Tax on Transportation** report and panel discussion have generated a large-scale discussion about this issue. City policymakers are looking into new safety solutions, while leaders from other U.S. cities are considering their local Pink Tax issues. NYU has heard from San Francisco MTA Officials about a possible collaborative study in the future on the Pink Tax. The World Bank is aiming to evaluate the Pink Tax on transportation in cities across developing nations using the survey as a foundational document.

Through ongoing collaboration with city staff during the course of their project, **Development of a Mobile Navigation Smartphone Application for Seniors**, C2SMART's team at UTEP has created awareness of the need to educate and train seniors on how to make better use of smartphones to improve their ability to move around their cities easily and overall quality of life. As this project develops, it provides new and valuable insights for researchers and policymakers into the needs and preferences of seniors, a group that faces specific challenges when it comes to urban transportation.

B. Increases in the Body of Knowledge

Multiple C2SMART projects are contributing to the body of knowledge on 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 are working 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. The UW team is developing models for traffic signal control that integrate data from connected vehicles to optimize system performance. Additionally, the **C2SMART symposium** on this topic facilitated information exchange between stakeholders on the challenges and opportunities that come with CAVs, as well as current research that is addressing those challenges.

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

At UTEP, C2SMART's researchers have recruited 40 seniors to participate in a pilot test of its **Urban Connector** application. As a result of the team's outreach and collaboration efforts to local government agencies throughout the course of the project, the City of El Paso has expressed interest in expanding the features in the Urban Connector app to serve the needs of other groups beyond seniors, such as people with mobility limitations. The project's PI and co-PI are meeting with the city's ADA Coordinator in April 2019 to discuss. After the research team's presentation at TRAPS, staff from agencies in other Texas cities expressed interest in implementing the Urban Connector app in their cities. Research staff plan to follow up on these inquires once results are available from the pilot test in El Paso.

At Rutgers, the research team's work on the impact costs of overweight vehicles on transportation infrastructure is offering results that can help contribute to the development of improved policies and enforcement mechanisms. The implementation of A-WIM and Quartz sensors in the course of their research will demonstrate the feasibility of a **Direct enforcement system for overweight trucks**. The study of bridge deck and pavement deterioration models and cost models associated with overweight trucks both furthers the scientific body of knowledge in this research area and can aid local agencies in developing new truck permit policies to better manage overweight trucks and the infrastructure damage

costs associated with them. The team has developed a web-based application to estimate infrastructure damage cost induced by overweight permitted vehicles, which will be employed by NJDOT. Additionally, the Rutgers team has developed **High-early strength high-performance concrete and corresponding technical specifications** to minimize concrete cracks at early stages. New Jersey Turnpike Authority has implemented the mix design and specifications on numerous bridges in NJ.

Two of C2SMART’s projects have used distinct approaches to develop models for **Pedestrian density estimation and mobility patterns**, contributing to increased understanding of urban pedestrian flows and what impacts these patterns. PI Claudio Silva’s work in this area resulted in the creation of a visual analytics tool for pedestrian density estimation. The research team collaborated with Carmera, a company that provides HD maps and navigation-critical data for autonomous vehicles, throughout the project, and the company is now employing the visual analytics tool in their operations. Prof. Ozbay and Silva’s previous collaboration on smart sensors extended it to a major NSF project on **Development of Reconfigurable Environmental Intelligence Platform**.

Deputy Director Joseph Chow’s research on **Electric vehicle rebalancing operations** has drawn the interest of Avis Budget Group and Car2Go, both of which have reached out about potential future collaborative research opportunities. Additionally, Prof. Chow’s work on a **Virtual Testbed for New York City** resulted in the start of a new project with the Federal Transit Administration.

C2SMART faculty are also contributing their expertise on developing transportation issues in several ways. PI Yin Hai Wang has been invited to join the Executive Committee of the **Autonomous Vehicle Working Group** of Washington State, and Director Kaan Ozbay and Associate Director Hani Nassif were named to an expert panel to evaluate solutions for reconstruction of the Brooklyn-Queens Expressway.

V. Impact

A. Effectiveness of the Transportation System

Through C2SMART’s funded and matching research projects, it has collaborative relationships with 7 of the major state and local transportation agencies in the New York-New Jersey area. Through UW and UTEP, it is also well connected with WSDOT and Texas DOT, as well as local agencies in Seattle and El Paso. These connections provide an opportunity to introduce planners, engineers, and decision-makers to center research and topics, and transfer findings into tangible improvements to the transportation systems of these regions.

Table 8: Impacts Performance Measures

Performance Measures	Annual Goal	Achieved (current period)
Instances of software, tools, research results, or guidelines adopted by transportation agencies leading to operational improvements	5	4
Partnerships/collaborative relationships with companies or transportation agencies established or renewed	10	36

For example, as a result of the Rutgers team’s collaborative work with the New Jersey Turnpike Authority to implement **technical specifications for fiber-reinforced high-performance concrete**, a noticeable reduction in cracking intensity has been observed. The NYU team is determining the most **safe and efficient way to introduce connected vehicles** to New York City. UW researchers are also focused on introducing **CAV technology**, while UTEP researchers are working to improve **trucking**. Transportation agencies are continuously working with center faculty to anticipate and plan changes to the transportation system with the introduction of autonomous vehicles in the future.

B. New Practices or Companies

PI Claudio Silva's team continuously collaborated with Carmera throughout the development of the pedestrian density estimation model and visual analytics tool that resulted from their research. As a result, Carmera is now using the pedestrian density estimation technique for city-wide pedestrian analytics, pedestrian traffic patterns and comparison with historical trends.

C. Body of Scientific Knowledge

Several projects across the consortium include the development of virtual testbeds of various scales for use in simulation and modeling of new transportation technologies and policies. These testbeds demonstrate the center's progress in developing a network of living labs. Through this work, C2SMART is providing a platform for future research that will enhance the ability of policymakers to observe impacts of technology/infrastructure development prior to real-world implementation.

As part of work complementary to C2SMART's research, PI Jeff Ban produced the following report on big data for the Federal Highway Administration:

- Ban, X., Chen, C., Wang, F., Wang, J., Zhang, Y., 2018. Promises of Data from Emerging Technologies for Transportation Applications: Puget Sound Region Case Study. Final Report Submitted to Federal Highway Administrations (FHWA), US Department of Transportation, and Washington Department of Transportation (WSDOT).

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:

- Supporting the Emerging Leaders in Transportation program. This workshop directly supports the development of the current transportation workforce by teaching early-career professionals leadership skills, how to build influence in their organizations, and strategies for effecting change. C2SMART's Systems Engineer Abdullah Kurkcü participated in the program this year.
- Providing substantive opportunities for research and training, through which C2SMART supports the education of future transportation professionals. Weinan Gao, who was mentored in his work as a graduate student by Director Kaan Ozbay, is now an Assistant Professor at NYU Tandon. Gao recently received the David Goodman Research Award, presented to students in the Department of Electrical and Computer Engineering with excellent research performance. Yuan Zhu, who completed his Ph.D. in Transportation Planning and Engineering at NYU Tandon last year, has secured an Assistant Professor position at Inner Mongolia University. Additionally, several current C2SMART graduate students have secured summer internships with leading transportation companies including Uber, Stantec and Scoop Technologies.
- Organizing and hosting a workshop for NYCDOT employees, which provided continuing education for current members of the transportation workforce. In addition to traffic control and operations, the course provided attendees with information about advances in ITS architecture and traffic simulation and modeling. In this way, C2SMART supported professional development at transportation agencies that will better equip members of the workforce to work with new technologies impacting the transportation field.

VI. Changes/Problems

Nothing to report during this reporting period.