C2SMART
CONNECTED CITIES WITH SMART TRANSPORTATION
A USDOT University Transportation Center

New York University
Rutgers University
University of Washington
University of Texas at El Paso
The City College of New York

PROGRAM PROGRESS PERFORMANCE REPORT

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

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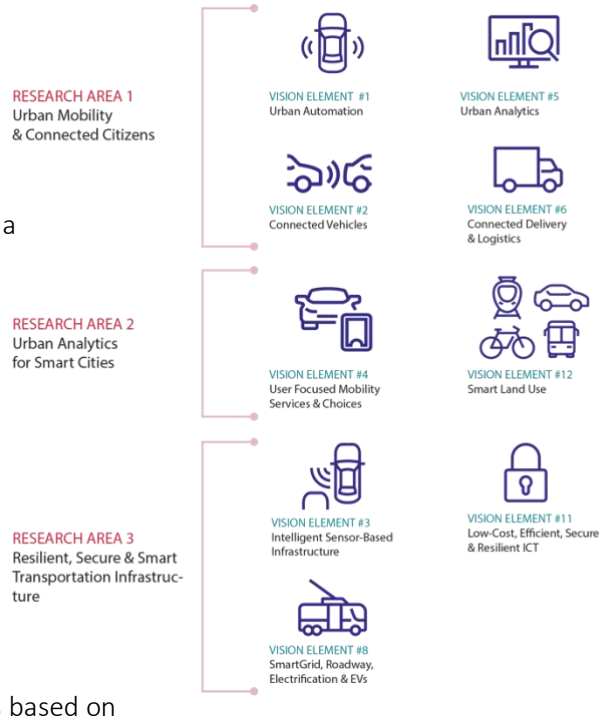
I. Accomplishments

A. Goals and Objectives



C2SMART is the first Tier 1 University Transportation Center (UTC) in New York City, led by the New York University (NYU) Tandon School of Engineering. The mission of C2SMART is to build a solution-oriented research center that uses resources from consortium members' cities as a decentralized but comprehensive living laboratory. The Center brings together a unique combination of strengths and resources in urban informatics, connected technologies, behavioral informatics, and city partners. Its research approach is based on a system-of-systems (SoS) perspective that integrates roads, transport services, energy grids, financial information, and other urban networks.

Research — C2SMART 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

1.1 Facilities

Renovations for a new dedicated space for C2SMART at NYU Tandon School of Engineering's downtown Brooklyn campus are underway. Among the new facilities to be added are expanded student/staff space and a state-of-the-art visualization/analysis lab to facilitate research, education, and tech transfer activities. The center is scheduled to move into the space once renovations are complete in 2019.

1.2 Staffing

C2SMART has hired a full-time Systems Engineer, who is responsible for leading research projects and developing web-based data management solutions at the center. This staff member will ensure that center activities are in line with its approved Data Management and Technology Transfer Plans. An Assistant Research Engineer, who is developing data services to integrate field-collected data into backend IT systems, was also added to the NYU staff to support center activities as well as other related projects and efforts led by NYU researchers.

NYU Tandon's transportation faculty has expanded with the addition of Assistant Professor Li Jin. A recent graduate of the Transportation Ph.D. program at the Massachusetts Institute of Technology, his research focuses on developing resilient control algorithms for cyber-physical systems, which has specific applications for connected and autonomous vehicles, automatic traffic control, and more.

Additionally, Assistant Professor Chen Feng has joined the NYU Tandon Department of Civil and Urban Engineering. He brings extensive experience with vision-based research, LiDAR, deep learning and more, which have significant potential applications in transportation, and is a potential collaborator with C2SMART researchers on future projects.

1.3 Data Management

Provisions for a data warehouse have been made to support the center's mission outlined in its data management and technology transfer plans. The servers will be accessible to all center researchers and data, and support git-based tracking and documentation.

1.4 Advisory Board

The Center has set up an advisory board of leading experts in the center's core competencies as well as related fields to help advise and direct the Center's activities. The objective of the board will be to provide oversight over the management of current and future activities through biannual board meetings and to ensure that the consortium members are abiding by the defined performance measures and acting to carry out the mission and vision of the C2SMART consortium. The C2SMART Board is currently comprised of:

Name	Title and Affiliation
Bruno Fernandez-Ruiz	Co-Founder and CTO - Nexar Inc
Evangelos Simoudis	Founder – Synapse Partners
Randy Iwasaki	Executive Director – Contra Costa Trans. Authority
Zachary Wasserman.	Head of Global Business Development - Via
Mary Ameen	Executive Director - North Jersey Transportation Planning Authority
Harry Capers	Vice President – Arora and Associates P.C.

2. Research

2.1 C2SMART-Funded Research Projects

The following projects were completed during this reporting period:

Urban Mobility and Connected Citizens	**City-scalable Destination Recommender System for On-demand Senior Mobility** NYU, UTEP	Completed.
	Development of a Mobile Navigation Smartphone Application for Seniors in Urban Areas UTEP, NYU	The Year 1 goals for this project were completed, and further research is underway to test and improve the developed application.
	Quantifying Uncertainty and Distributed Adaptive Control for Unanticipated Traffic Patterns NYU Abu Dhabi	Completed. Final report under review.
	Traffic Signal Optimization and Coordination in Connected Cities UW	Completed.

Urban Analytics for Smart Cities	**Emerging Leaders in Transportation** NYU	Completed.
Resilient, Secure, and Smart Transportation Infrastructure	**A Trusted Data Platform for Transportation Data Sharing** NYU	Completed.
	Designing & Managing Infrastructure for Shared Connected Electric Vehicles UW	Completed.

The following projects are currently underway. Recent research progress updates for each are provided:

Urban Mobility and Connected Citizens	**Integrative Vehicle Infrastructure Traffic System (iVITS) Control in Connected Cities** CCNY, NYU	This Year 2 continuation of a Year 1 project aims to complete the development of network-wide iVITS for New York City and develop a simulation-based approach for the evaluation of CV applications. Development of the simulation network has begun, and the team is in the process of data collection to calibrate the network.
	Dual Rebalancing Strategies for Electric Vehicle Car-sharing Operations NYU Abu Dhabi, NYU	Researchers have completed work on a rebalancing algorithm and begun simulation testing experiments.
	Integrative Vehicle-Traffic Control in Connected/Automated Cities UW	This project aims to investigate key issues for integrative vehicle traffic control (iVTC). The researchers have developed a 7-intersection simulation model and completed the trajectory estimation method.
Urban Analytics for Smart Cities	**Understanding Mobility Patterns and Decision-making Using an Integrated, Multi-Modal Sensing Platform in a Quantified Community** NYU	Researchers have completed data collection and cleaning as well as initial modeling and data analysis, including constructing trajectory models from an urban testbed in New York City.
	Sustainability of Urban Consumption Practices NYU	Researchers conducted a survey designed to better understand and compare consumption practices and mobility behaviors of residents of Paris and NYC. Results were presented at a project advisory group meeting, and the final report is nearing completion pending translation from French to English.
	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 have started the process of extracting pedestrian data using deep learning techniques, which will be used to develop a pedestrian dynamics model for urban areas.
	Development of an Open-Source Multi-Agent Virtual Simulation Testbed for Evaluating Emerging Transportation Technologies and Policies NYU	This project has begun development and calibration of a virtual testbed of New York City that can be used to evaluate new technologies and policies on transportation systems. When complete, it will provide resources and a virtual framework that can help fill the gap between basic research and field deployment for public sector decision-makers.
	Emerging Leaders in Transportation / The Future of Mobility Workshop Series NYU	The accepted participants for the 2018 Emerging Leaders in Transportation program, which develops early-career transportation professionals to develop and promote innovations within their organizations, have been announced. The Future of Mobility is a series of three workshops about timely issues in transportation. The first, which looked at autonomous, shared, and electric mobility revolutions in New York City, took place in spring 2018, and the remaining two are scheduled for the next reporting period.

	An Artificial Intelligence Platform for Network-wide Congestion Detection and Prediction using Multi-source Data UW	The research team has acquired two real-world datasets and redesigned the architecture of DRIVE Net (Digital Roadway Interactive Visualization and Evaluation Network) for network-wide congestion detection and prediction using multi-source data.
Resilient, Secure, and Smart Transportation Infrastructure	**Monitoring and Control of Overweight Trucks for Smart Mobility and Safety of Freight Operations** Rutgers	The team has worked with NYCDOT to implement three weigh-in-motion (WIM) systems in NYC at sites to be determined by a traffic analysis. The team also installed a WIM system on a local road near a bridge that experiences extreme deterioration, which will be 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	This project will combine the results of modeling transportation infrastructure deterioration related to overweight trucks with economic approaches to estimate the contribution of these vehicles to maintenance costs. The research team has already engaged a wide range of stakeholders in academia, government and the freight industry through a forum on the impacts of overweight vehicles, with a draft findings document developed and plans for future web forums underway.
	Development of Advanced Weigh-In-Motion (A-WIM) System for Effective Enforcement of Overweight Trucks to Reduce their Socioeconomic Impact on Major Highways Rutgers	This project will implement an advanced weigh-in-motion (A-WIM) system with high accuracy and will investigate the feasibility of using such technology in the U.S. to assist enforcement officials on highways without interrupting the traffic flow. The team has developed a web-based GIS application to quantify the damage cost associated with overweight trucks or permitted trucks and has completed a review of current enforcement systems and practices in foreign nations.
	Automated Truck Lanes in Urban Areas for Through and Cross Border Traffic UTEP	This project proposes to develop and demonstrate, through microscopic traffic simulations, the concept of operations of autonomous truck lanes along interstate freeways in order to recommend vehicle management, infrastructure design and policy guidelines for state and local agencies. The research team has acquired geometric design data from Texas DOT and begun developing simulation models for two interchanges.

C2SMART will issue a request for proposals for new projects in the next reporting period. All proposals will go through the Center's three-step review process: 1) Internal review by a panel to ensure the appropriateness of the proposed project for the Center's mission. 2) External peer review conducted by international area experts to obtain independent assessment of the intellectual merit, broader impact and feasibility of the project. 3) An in-house review by an executive committee consisting of the Center's experts and other invited experts and chaired by Director Kaan Ozbay. This approach was used successfully last year and will continue to be employed to ensure the selection of feasible, impactful projects.

2.2 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 up larger, more impactful efforts that have direct end-user benefits for state and local agencies as well as other users.

Urban Mobility and Connected Citizens	NYC Connected Vehicle Deployment & Mobile Accessible Pedestrian Signal System Application	NYCDOT/NYSDOT
	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/NYSDOT
Urban Analytics for Smart Cities	Portable and Integrated Multi-Sensor System for Data-Driven Performance Evaluation of Urban Transportation Networks	USDOT/UTC program
	Calibration/Development of Safety Performance Function for New Jersey	NJDOT
Resilient, Secure, and Smart Transportation Infrastructure	Research on Concrete Applications for Sustainable Transportation: Life Cycle Cost Analysis	USDOT/UTC program
	Bridge Resource Program	NJDOT
	Technical Support Services for the Maintenance Department	NJ Turnpike Authority

2.3 Research Awards and Recognition

C2SMART members and affiliates received recognition from numerous organizations for their research, including:

- The ACI Lifetime Achievement Award, present to Dr. Hani Nassif, C2SMART's Associate Director for Outreach and Technology Transfer, by the New Jersey chapter of the American Concrete Institute at their annual NJ Concrete Awards dinner.
- The Dr. Louis J. Pignataro Memorial Transportation Education Award, presented to C2SMART Ph.D. candidate Diego Correa-Barahona by the Institute of Transportation Engineers (ITE) Metropolitan Section of New York and New Jersey.
- The Professor F.J. Gerstner Medal of Merit, presented to Dr. Kelvin Cheu, C2SMART's Associate Director for Research, by Czech Technical University for his distinguished academic contributions.
- The Molitoris Leadership Scholarship for Undergraduates, awarded to Elsa Kong by the WTS Foundation. Elsa worked with Deputy Director Joseph Chow as a summer undergraduate researcher.

3. Education

C2SMART undertakes numerous educational efforts in pursuit of its goal to train today's transportation workforce across cities, companies and agencies. In this reporting period, C2SMART began providing financial support for a graduate student to lead center educational and workforce development activities in support of the Center's Associate Director for Educational Initiatives and Workplace Development, reinforcing the Center's commitment to its educational goals. With their support, the Center has begun coordinating numerous events focused on both the current and future transportation workforce, which will take place in the next reporting period.

The Center's educational activities during this reporting period included hosting a forum at the NYU Tandon Brooklyn campus on new policies and directions for overweight, heavier and larger vehicles. The event convened transportation stakeholders from the public and private sectors to identify concerns and solicit input on regulatory policies from trucking and freight industry stakeholders. Dr. Hani Nassif presented

research on the impact of overweight vehicles on bridge decks, providing attendees with a data-driven perspective for assessing and modifying current policies.

Additionally, Deputy Director Joseph Chow arranged for two workshops on the basics of MATSim for C2SMART students, presented by visiting scholar Milos Balac, a MATSim expert from ETH Zurich. The workshops covered:

- MATSim introduction: basic functions of MATSim, essential modules and query codes with examples.
- MATSim extensions: creating a basic extension for MATSim using a sample bike-sharing extension.

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

Applied Research Innovations in Science and Engineering (ARISE) – This full-time, seven-week program for academically strong, current 10th and 11th grade New York City students with a demonstrated interest in science, technology, engineering and math. C2SMART faculty and graduate students welcomed four interns from this highly competitive program during summer 2018, with two students each joining Prof. Ozbay's UrbanMITS lab and Prof. Chow's BUILT@NYU lab. Research Associate Abdullah Kurkcu and PhD student Yueshuai He provided instruction and mentoring as the students undertook research projects on sensor-based systems for improving parking efficiency and detecting double parking, analyzing taxi route selection behaviors from GPS trajectory data, and methods for preserving privacy in open data sharing. The ARISE students made final presentations to their peers and NYU graduate students, and their results have since been shared at subsequent NYU research showcase events.

Vertically Integrated Projects (VIP) - This program provides a multi-year, multidisciplinary approach to learning that emphasizes project-based, innovative, research-active education. Jack Bringardner, C2SMART's Associate Director for Educational Initiatives and Workplace Development, leads the program at NYU. C2SMART students and faculty have continued to work with the Smart Cities VIP team on a project with NEXT Future Transportation, including demonstrating prototypes of vehicle scale models at a C2SMART-hosted symposium.

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. The center provides space and support for their networking and educational activities, including a Tech & Transportation Talks featuring short presentations by experts working at the intersection of transportation and technology and a kickoff meeting for new members this fall.

UTEP-Czech Technical University Dual Master's Degree – This international dual degree program began in fall 2018. Dr. Miroslav Svitek, a professor at Czech Technical University, is teaching courses at UTEP this semester as part of this degree program and will deliver a seminar as part of the Distinguished Speaker Series.

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 results are also disseminated through journal papers, presentations, and meetings between the center's principal investigators and agency or industry partners and stakeholders. C2SMART also seeks to engage non-technical audiences and enhance public understanding of developments in transportation through media outreach. During this reporting period, the center undertook the following dissemination and outreach efforts:

Conference Presentations:

- Matthew Vechione and Okan Gorbuz, Ph.D. students at the University of Texas at El Paso, presented their work on a C2SMART project at Keystone ITE 2018. The project team, led by Dr. Kelvin Cheu, identified the unique mobility needs and preferences of seniors in urban areas and developed a navigation app that meets those needs.
- Dr. Hani Nassif led a session on Bridge Safety Evaluation and Risk Assessment: Code Requirements vs. Practical Considerations at the IABMAS 2018 conference.
- C2SMART Senior Associate Director Shri Iyer presented NYU Tandon and partner institution research and center activity at the University Transportation Center (UTC) Mobility Summit in Washington. DC.
- Dr. Hani Nassif served as a session moderator at the Second European and Mediterranean Structural Engineering and Construction Conference for a session on The Use of Fillers and Special Techniques for Improving Concrete Behavior.
- Dr. Peng Lou, research associate in Dr. Hani Nassif's lab, served as co-chair for a general session and mini symposium during IABMAS 2018.
- Researchers and staff from C2SMART showcased the center's research and Deputy Director Joseph Chow presented a talk at the ITS-NY 2018 conference.
- Center Director Kaan Ozbay participated in panels at the Kavli Futures Symposium: Sensing the City at NYU's Center for Urban Science and Progress and NYU's Second Annual Urban Research Day, held by the Wagner Graduate School of Public Service.

Research Showcases:

- Students displayed recent work at the 2018 NYU Tandon School of Engineering Research Expo, including sensor technologies and transportation simulation and modeling. The group also met and discussed their work with Chandrika Tandon, Chair of the NYU Tandon Board of Overseers.

Workshops:

- The first in the Future of Mobility Workshop Series was held on May 23, 2018. The Three Mobility Revolutions Panel attracted approximately 50 attendees and focused on three forthcoming revolutionary changes in mobility: automated, shared and sustainable transport. The panel included local transportation industry and policy leaders who spoke about New York City's unique qualities in these three revolutions and was moderated by C2SMART PI Sarah Kaufman.
- Dr. Jeff Ban co-organized a workshop at the University of Washington on transportation demand management and commute trip reduction strategies. The workshop was a collaborative effort between PacTrans researchers, UW faculty and Washington State DOT.
- C2SMART hosted a mobility workshop as part of Smart Cities New York, a three-day event featuring panels, workshops and speakers on all aspects of smart cities. Senior Associate Director Shri Iyer and Deputy Director Professor Joseph Chow served as presenters for a workshop on "The Path of Mobility Solutions: From Ridesharing to Connected Vehicles, Hyperloop and Beyond." Additionally, Sarah Kaufman, assistant director for technology planning at the NYU Rudin Center for Transportation and C2SMART PI, moderated a panel on "Integrated Mobility: Safe, Smart Streets."

Industry and Public Agency Outreach:

- As part of a C2SMART-funded collaborative project between the International Center for Enterprise Preparedness at NYU and the Rutgers Infrastructure Monitoring and Evaluation (RIME) Group, C2SMART hosted a forum on the impact of overweight, heavier and larger vehicles on infrastructure. The event brought together stakeholders from public agencies and the trucking and freight industries, fostering open discussion on the latest research and potential future directions for government policy.

- Deputy Director Joseph Chow served as an evaluator for the NYCx Climate Action Challenge, which posed the question of how NYC could replace all gas-powered vehicles in the city, calling for proposals for breakthrough electric vehicle charging technologies that can scale EV charging infrastructure and accelerate EV use. NYCx, an initiative of the NYC Mayor's Office of the Chief Technology Officer, works with communities to identify urgent priorities and invites entrepreneurs and technology professionals to propose solutions through its Challenge program.
- The center hosted visiting delegations from Beijing and the Tianjin Municipal Engineering Design & Research Institute, providing presentations on some of C2SMART's latest research.

Seminars

- The center's Distinguished Speaker Series continued with the following seminars:
  - Professor Zdenek Bazant, McCormick Institute Professor, Walter P. Murphy Professor of Civil and Environmental Engineering, Mechanical Engineering and Material Science and Engineering at Northwestern University. "Design of New Materials and Structures to Maximize Strength at Probability Tail: A Neglected Challenge for Quasibrittle and Biomimetic Material." April 2018
  - Justin Schorr, collision reconstruction engineer at DJS Associates. "Ambivalent Automation." April 2018
  - Saad Shaikh, general manager at Chariot. "An overview of Chariot and the future of urban mobility." April 2018
  - Giancarlo Fortino, Professor of computer engineering at the University of Calabria. "Agents meet the IoT: Towards Cognitive and Interoperable Ecosystems of Networked Smart Objects." April 2018
  - Dr. Daniel Rodriguez-Roman, Assistant Professor of Civil Engineering at University of Puerto Rico, Mayagüez. "Surrogate-Based Optimization Approach for the Design of Area Charging Schemes under Environmental Considerations." June 2018
- In addition to the Distinguished Speaker Series, C2SMART hosted the following seminars:
  - Lina Al-Kanj, Associate Research Scholar at the Operations Research and Financial Engineering Department at Princeton University. "Approximate Dynamic Programming for Planning Driverless Fleets of Electric Vehicles."
  - Li Jin, then Ph.D. candidate at Massachusetts Institute of Technology. "Resilient Operations of Smart Highways with Smart Vehicles."
  - Michael Hyland, Ph.D. candidate at Northwestern University. "Shared-Use Autonomous Vehicle Mobility Services: Operational Control and Transit Impacts."
  - Shamsunnahar Yasmin, Postdoctoral Associate and Graduate Faculty Scholar, University of Central Florida. "Fractional Split Approach: A Parsimonious Econometric Framework for Analyzing Transportation Related Issues."
  - Ding Zhao, Assistant Research Scientist, University of Michigan. "Are Autonomous Vehicles Safe? In the Era when Robo-Cars Meet Big Transportation Data."
- Dr. Kelvin Cheu presented a seminar on lane-changing research at the Royal Institute of Technology in Stockholm.
- PI Saif Jabari delivered a presentation on stochastic modeling of traffic dynamics at UC Berkeley as part of ITS Berkeley's Seminar Series.
- Center Director Kaan Ozbay was an invited speaker at the NSF-funded Smart and Connected Communities and Aging Population Workshop at SUNY Stony Brook, presenting a talk entitled, "What is Smart and Connected Communities?"

Media Coverage and Public Outreach

- C2SMART has compiled a mailing list of researchers, government agency and industry contacts and other interested parties and has begun sending out quarterly newsletters highlighting recent center activities and accomplishments. The list is also used for advertising upcoming events, such as the symposium planned for October 2018.
- C2SMART produced an Annual Report providing an overview of the center's goals and accomplishments since it was founded, which was distributed to the center's full mailing list and made available on the center website.
- Master's student Assel Dmitriyeva presented her work on a destination recommender system for shared mobility services at Transit Techies NYC, an open Meetup group for transit technology enthusiasts. Assel, who is pursuing an M.P.S. in the Interactive Telecommunications Program at NYU's Tisch School of the Arts, has been working with Deputy Director Joseph Chow on developing the destination recommender tool as part of a C2SMART-funded project.
- C2SMART was featured in NYU Tandon's 2018 Year in Review book, specifically highlighting one of the Center's Ph.D. students and her research on double-parking.

D. Plans for Next Reporting Period

C2SMART plans to continue grow in pursuit of our mission during the next reporting period, including hosting a high-profile symposium on connected and autonomous vehicles to be held at NYU Tandon in October 2018. It will also expand its educational initiatives with collaboration across member institutions. C2SMART will also be the host for Transportation Camp, a non-traditional conference that brings together a range of professionals in the transportation field and others interested in urban transportation and technology. The center also plans to open a request for proposals for its Year 3 cohort of projects, seeking proposals that align with the center's mission and have strong technology transfer elements.

II. Products

A. Publications

C2SMART collaborators authored or co-authored over 30 papers during the reporting period that were presented at conferences or published in journals. They are highlighted below:

1. Journal Publications

- Abdulhameed, H., Nassif, H., & Khayat, K. (2018). Use of Fiber-Reinforced Self-Consolidating Concrete to Enhance Serviceability Performance of Damaged Beams. Transportation Research Record, Journal of the Transportation Research Board
- Bartin, B., Ozbay, K., Gao, J., Kurkcu, A. (2018) "Calibration and validation of large-scale traffic simulation networks: a case study." Procedia Computer Science, Elsevier, Volume 130, Pages 844-849. https://doi.org/10.1016/j.procs.2018.04.076
- Bartin, B., Ozbay, K., Yang, H. (2018) "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.
- Demiroluk, S., Ozbay, K., Nassif, H., (2018) "Mapping of Truck Traffic in New Jersey Using Weigh-In-Motion (WIM) Data," Journal of IET Intelligent Transport Systems
- Demiroluk, S., Ozbay, K., Nassif, K. (2018) "Mapping truck traffic in New Jersey using Weigh-in-Motion Data." IET Intelligent Transport Systems, Volume 12, Issue 9, November 2018, pp. 1053 – 1061.

- Dilip, D., Lin, D., and Jabari, S.E.* (2018). Learning traffic flow dynamics using random fields. Under review. [arXiv:1806.08764]
- Gao, J., Xie, K., Ozbay K., (2018) "Exploring the Spatial Dependence and Selection Bias of Double Parking Citations Data", Transportation Research Record: Journal of Transportation Research Board (Committee ABJ30: Innovations in Urban Data and Mobility Modeling), National Academies, Washington, D.C., Sage Publications. Article first published online: August 18, 2018. http://dx.doi.org/10.1177/0361198118792323
- Holguín-Veras, J., Hodge, S., Wojtowicz, J., Singh, C., Wang, C., Jaller, M., Aros-Vera, F., Ozbay, K., Weeks, A., Replogle, M., Ukegbu, C., Ban, J., Brom, M., Campbell, S., Sánchez-Díaz, I.D., González-Calderón, C., Kornhauser, A., Simon, M., McSherry, S., Rahman, A., Encarnación, T., Yang, X., Ramírez-Ríos, D., Kalahashti, L., Amaya, J., Allen, M.S., Allen, B., Cruz, B., (2018) "The New York City Off-Hour Delivery Program: A Business and Community-Friendly Sustainability Program", Interfaces, 48(1) pp.70-86. https://doi.org/10.1287/inte.2017.0929
- Lou, P., Nassif, H., and Truban, P. (2018) "Development of Live Load Model for AASHTO Strength II Limit State," Transportation Research Record: Journal of the Transportation Research Board (TRB), Structures, TRB of the National Academies, Washington, D.C.
- Mudigonda, S., Ozbay, K., Bartin, B. "Evaluating the resilience and recovery of public transit system using big data: Case study from New Jersey." Journal of Transportation Safety & Security, Published on-line: March 2018. https://doi.org/10.1080/19439962.2018.1436105 (NSF 1541164 and Mineta)
- Ozbay, K., Ban, X., Yang, C.Y.D. (2018) "Developments in connected and automated vehicles." Journal of Intelligent Transportation Systems, Volume 22, Issue 3, June 2018, Pages 187-189. https://doi.org/10.1080/15472450.2018.1466407
- 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, 2018.
- Xie, K., Yang, D., Ozbay, K., Yang, H. (2018) "Use of real-world connected vehicle data in identifying high-risk locations based on a new surrogate safety measure." Accident Analysis & Prevention. (In Press) https://doi.org/10.1016/j.aap.2018.07.002
- Xie, K., Ozbay, K., & Yang, H. (2018) "Secondary Collisions and Injury Severity: A Joint Analysis Using Structural Equation Models," Traffic Injury Prevention, Volume 19, Issue 2, 189-195 http://dx.doi.org/10.1080/15389588.2017.1369530
- Yang, H., Wang, Y., Xie, K., Ozbay, K., Imprialou, M. (2018) "Methodological evolution and frontiers of identifying, modeling and preventing secondary crashes on highways." Accident Analysis and Prevention, Volume 117, August 2018, Pages 40-54.
- Yang, H., Xie, K., Ozbay, K., Ma, W., Wang, Z. "Use of Deep Learning to Predict Daily Usage of Bike Sharing Systems." Transportation Research Record: Journal of Transportation Research Board (Committee ANB20: Cycling Safety and Comfort), National Academies, Washington, D.C., Sage Publications. Article first published online: October 6, 2018. https://doi.org/10.1177/0361198118801354
- Zhu, Y. Xie, K., Ozbay, K. (2018) "Hurricane Evacuation Modeling Using Behavior Models and Scenario-Driven Agent-Based Simulations." Procedia Computer Science, Elsevier, Volume 130, Pages 836-843.
- Zuo, F. Kurkcu, A., Ozbay, K. (2018) "Crowdsourcing Incident Information for Emergency Response using Open Data Sources in Smart Cities. "Transportation Research Record: Journal of Transportation Research Board (Committee ABE20: Transportation Economics), National Academies, Washington, D.C., Sage Publications. Article first published online: October 1, 2018. http://dx.doi.org/10.1177/0361198118798736

2. Conference Papers

- Abou-Dasm, O., Ma, Z., Chow, J. Y. J., Diabat, A., Quantifying the effect of cyclist behavior on bicycle crashes and fatalities. Transportation Research Record, accepted.
- Balac, M., He, Y., Chow, J. Y. J., Axhausen, K., Exploratory analysis of free floating carshare trip patterns under varying reservation costs. Transportation Research Record, in preparation.
- Bartin, B., Ozbay, K., Gao, J., Kurkcu, A. (2018) "Calibration and validation of large-scale traffic simulation networks: a case study." ABMTRANS 2018: The 7th International Workshop on Agent-based Mobility, Traffic and Transportation Models, Methodologies and Applications, May 8-11, 2018, Porto, Portugal.

- Caros, N., Chow, J. Y. J., Effects of violent crime and vehicular crashes on active mode choice decisions in New York City. Transportation Research Record, accepted.
- Caros, N., Chow, J. Y. J., Two-sided market evaluation of last-mile transit operations with en-route transfers, abstract accepted to hEART Symposium 2018.
- Cheu, R. L., Villanueva-Rosales, N., Nunez-Mchiri, G. G., Vechione, M., Vargas Acosta, R. A., Marrufo, C., Jimenez, Gurbuz, O. (2018). "Taking smart mobility to seniors: challenges and solutions in the El Paso Region." The 4th IEEE International Smart Cities Conference (ISC2), Sept. 16-19, 2018, Kansas City.
- Fiorillo, G., Nassif, H. "The application of machine learning techniques for the analysis of NBI and bridge element data", TRB 2019, accepted for presentation and pending for publication.
- He, Y., Zhou, J., Dmitriyeva, A., Su, H., Ma, Z., Shlyakhova, C., Chow, J. Y. J., Balac, M., Mode choice model with emerging mobility services in New York. Transportation Research Record, in preparation.
- He, Y., Ma, Z., Zhou, J., Balac, M., Su, H., Dmitriyeva, A., Shlyakhova, C., Chow, J. Y. J., Perturbing tour-based nested logit mode choice model parameters to fit to aggregate emerging mobility trip data. 17th TRB National Transportation Planning Applications Conference, abstract submitted.
- 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, revision under review.
- Kurkcu, A. and Ozbay, K. (2018) "An empirical investigation of achievable of flows gains on a dedicated bus lane by minimizing extreme headways." TRB Traffic Flow Committee Mid-Year Meeting, Woods Hole, Massachusetts, August 7-9, 2018.
- Marrufo, C., Jimenez, Gurbuz, O. (2018). "Taking smart mobility to seniors: challenges and solutions in the El Paso Region." The 4th IEEE International Smart Cities Conference (ISC2), Sept. 16-19, 2018, Kansas City. Submitted for review.
- Pantelidis, T., Ma, T. Y., He, Y., Chow, J. Y. J., Queueing-based rebalancing optimization for free-floating electric vehicle carshare. 2019 TRB Annual Meeting, in preparation.
- Yoon, G., Chow, J. Y. J., Bootstrapped casual pass choice model for bike-share revenue management. Transportation Research Record, in preparation.
- Zheng, F., Jabari, S.E.*, Liu, H., and Lin, D. (2018). Traffic state estimation using stochastic Lagrangian dynamics. Transportation Research Part B (in press). [preprint: arXiv:1806.02692]
- Zhu, Y. Xie, K., Ozbay, K. (2018) "Hurricane Evacuation Modeling Using Behavior Models and Scenario-Driven Agent-Based Simulations." ABMTRANS 2018: The 7th International Workshop on Agent-based Mobility, Traffic and Transportation Models, Methodologies and Applications, May 8-11, 2018, Porto, Portugal.

3. Presentations

The following presentations were made by center personnel at events or conferences:

- Chow, J. "The Path of Mobility Solutions: Near Term Obstacles and Advances", Smart Cities New York 2018. New York, NY, April 2018.
- Chow, J. "Overcoming obstacles toward a mobility-as-a-service future", ITS-NY Annual Meeting 2018, Saratoga Springs, NY.
- Chow, J. "The Future of Cities: Mobility in Smart and Connected Cities." Future of Cities Program, New York, NY, June 2018.
- Chow, J., Dmitriyeva, A. "City-scalable Destination Recommender System for On-demand Senior Mobility." NSF RCN Workshop on Smart & Connected Communities and Aging Population. Stony Brook University. April 19-20, 2018.
- Demiroluk, S., Ozbay, K., Nassif, H. "Mapping of Truck Traffic in New Jersey Using Weigh-In-Motion (WIM) Data." 25th ITS World Congress, Copenhagen Denmark, September 17-21, 2018.
- H. Nassif and P. Lou, "Bridge Safety Evaluation and Risk Assessment: Code Requirements vs. Practical Considerations." July 9-13, 2018, IABMAS 2018.
- H. Nassif, C.K. Na, H. Al-Nawadi, and A. Abu-Obeidah, "Structural Health Monitoring (SHM) Of Corrosion Potential in Concrete Bridge Decks". Euro-Med-Sec-2, Beirut, Lebanon, July 23-28, 2018.
- Lou, Peng, General Session GS03 Co-Chair. "General Inspection and Maintenance." July 9-13, 2018, IABMAS 2018.

- Nassif H., Session A3 Moderator. “The use of Fillers and Special Techniques for Improving Concrete Behavior.” EURO-MED-SEC, July 23-28, 2018
- Nassif, H. "Advanced Technologies in Concrete" 12th International Symposium on Ferrocement and Thin Cement Composites. Belo Horizonte, MG, Brazil, July 16-19, 2018.
- Nassif, H. and Abu-Obeidah, A. “Comparison of Model Predictions for SCC with and without Fibers.” ACI Spring 2018.
- Nassif, H. Keynote speaker. “Performance of FRF and FR-SCC in Repair of Damaged Beam”. 12th International Symposium on Ferrocement and Thin Cement Composites. Belo Horizonte, MG, Brazil, July 16-19, 2018
- Ozbay, K. “What is S&CC?” NSF RCN Workshop on Smart & Connected Communities and Aging Population. Stony Brook University. April 19-20, 2018.
- Ozbay, K. Invited panelist. “Large Sensor Networks Panel.” Kavli Futures Symposium: Sensing the City. Center for Urban Science and Progress, New York University Tandon School of Engineering. April 26, 2018.
- Ozbay, K. Invited panelist. “Date-driven Evacuation Modeling.” NYU Second Annual Urban Research Day, New York University Wagner Graduate School of Public Service. March 20, 2018.
- Peng Lou, H. Nassif, P. Truban, "Bridge Safety Assessment for Strength II Limit State in AASHTO LRFD Specifications", IABMAS 2018.
- Vechione, M., Vargas Acosta, R. A., Marrufo, C., Jimenez, Gurbuz, O., Cheu, R. L., Villanueva-Rosales, N., Nunez-Mchiri, G. G., (2018). “Taking smart mobility to seniors: challenges and solutions in the El Paso Region.” Poster presentation at the 2018 ITE Western and Texas Districts Annual Meeting, June 26, 2018, Keystone, Colorado.
- Xia, J., Chow, J. “Modeling non-separable, social-influenced multimodal route choice with congestible link capacities.” 15th International Conference on Travel Behavior Research. July 15-20, 2018.

4. One-Time Publications

- Chow, J. (2018). *Informed Urban Transport Systems: Classic and Emerging Mobility Methods Toward Smart Cities*. Elsevier.
- Kachroo, P. and Ozbay, K. (2018). *Feedback Control Theory for Dynamic Traffic Assignment*. Springer-Verlag Series: Advances in Industrial Control, Springer-Verlag. Second Edition.

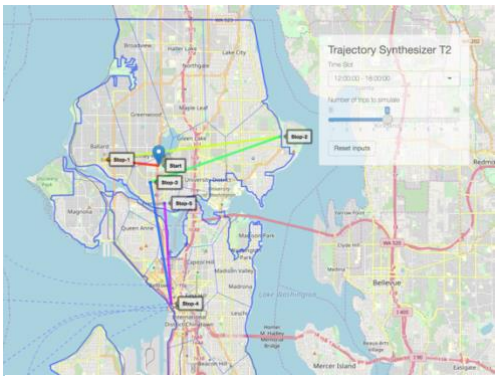
B. Websites

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.

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 and research projects.

C. Technologies

Trajectory Synthesizer Web Application - As part of a C2SMART-funded project led by PI Don Mackenzie, a destination model using Naïve Bayes classifier was built to predict the trajectory of the free-floating electric carshare vehicle given the start location and time. The model was deployed as a web application, which displays the vehicle's predicted trajectory on a map of Seattle.

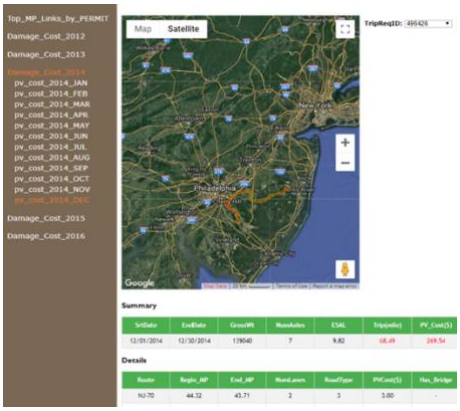


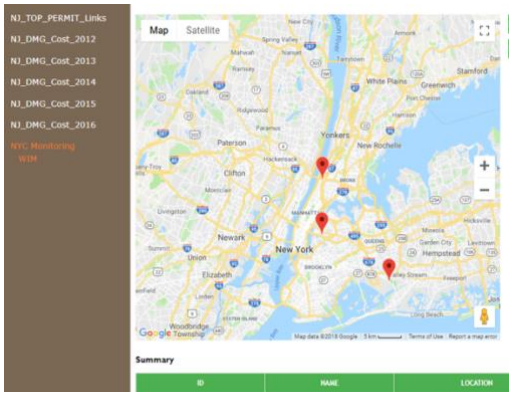
A sample screenshot of the trajectory synthesizer developed by PI Don Mackenzie's team.

Destination Recommender System - The research team for Deputy Director's Joseph Chow's Year 1 project developed a destination recommender system for on-demand shared ride mobility providers. The source code of the developed framework for the destination recommender system is released as an open source software and can be found in the BUILT GitHub account.

Position-Weighted Backpressure Algorithm - C2SMART PI Saif Jabari completed a project focused on improving traffic network control technique using real-time data to adapt to uncertainties in traffic conditions to reduce delays due to natural and man-made disruptions. The research team developed a new kind of algorithm for network control, referred to as position-weighted backpressure (PWBP), which can account for queue buildup and dissipation dynamics resulting from traffic disruptions. The PWBP algorithm improves on the original backpressure theory, and researchers demonstrated that it is capable of stabilizing a network quickly after a disruption and can adapt to different traffic conditions.

Carshare Rebalancing Algorithm - Deputy Director Joseph Chow's researchers developed a full rebalancing algorithm that can be used by electric vehicle carsharing operations. The team tested the algorithm in simulation, producing experimental results in small, medium and large test networks.





Sample screenshots from the New Jersey (left) and New York (right) versions of the GIS application developed by the Rutgers team for estimating damage cost due to overweight trucks.

Overweight Truck Damage Cost Assessment Application - As part of their Year 2 project on advanced weigh-in-motion systems for enforcement of overweight trucks, the Rutgers team has developed a web-based geographic information system (GIS) application to quantify the damage cost to infrastructure incurred by overweight trucks or permitted trucks.

Additionally, a Technology Transfer Plan for the center was submitted to USDOT. This plan details efforts for a web-based innovation platform, which if approved, will be used to house and disseminate new tools and technologies developed by C2SMART.

D. Other Products

Image Database for Modeling Urban Pedestrian Dynamics - C2SMART PI Claudio Silva's team has built a database of more than 40 million street-level images, which is being used to build a model of pedestrian dynamics in cities. The researchers are using deep learning techniques to recognize pedestrians in the images. This data will be added to the database when the pedestrian detection process is complete.

III. Participants and Collaborating Organizations

A. Partner Organizations

C2SMART has established partnerships with a range of public agencies and private companies. The nature of those partnerships is outlined below:

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	
Bestmile	San Francisco, CA		X	
BMW ReachNow	Seattle, WA		X	
Carmera	Brooklyn, NY			X
City of El Paso	El Paso, TX		X	
DiDi Chuxing	Beijing, China			X
Drive Engineering	Blue Bell, PA			X
Ford Smart Mobility	Dearborn, Mich.		X	
Foundation for the Future	Brooklyn, NY			X
Ikos Lab	Europe (various)			X
Nexar	New York City, NY			X
NEXT	Silicon Valley, CA		X	
NJ Turnpike Authority	Woodbridge Township, NJ	X		
NJDOT	Newark, NJ	X		
NYC Mayor's Office of the CTO	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	
ReThink Studio	New York City, NY		X	
Texas Department of Transportation	Austin, TX		X	
TrafficCast International	Middleton, WI		X	
Transpod	Toronto, Canada			X
Via	New York City, NY		X	
Washington State DOT	Olympia, WA		X	
Zendrive	San Francisco, CA			X

Additionally, Dr. Jeff Ban is in conversation with WSDOT managers and staff about further opportunities for collaboration and is working with the City of Madison, Wisc., on obtaining access to city data.

B. Other Collaborators or Contacts

Collaborations with other departments and research centers

- C2SMART has invited professors and researchers from other departments to participate in its upcoming symposium on connected and autonomous vehicles, including the Electrical and Computer Engineering and Computer Science departments at NYU Tandon and NYU School of Law, providing a multidisciplinary perspective on CAVs.
- Dr. Kelvin Cheu has been working with Dr. Gina Nuñez-Mchiri, Director of Women and Gender Studies and Associate Professor of Anthropology at UTEP, for his project focused on creating a smartphone app to improve senior mobility in urban areas.
- C2SMART has continued and expanded 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. This collaboration combines INTERCEP's skills in stakeholder engagement and policy development with the Rutgers researchers' expertise on transportation infrastructure maintenance and management.

Inter-University collaboration

- Center Director Kaan Ozbay is the co-PI of the NJDOT Bridge Resource Program and is working very closely with its director and center PI, Prof. Hani Nassif of Rutgers University. Prof. Nassif is also the co-PI with Prof. Ozbay on the NJDOT Safety Performance Function project funded by NJDOT. These joint efforts between NYU and Rutgers University will facilitate the implementation of some of C2SMART's research projects in a real-world environment.
- Center Director Kaan Ozbay has a joint C2SMART project with Dr. Camille Kamga at City College of New York, as well as cooperative efforts on the New York City Connected Vehicle Pilot.
- C2SMART is working with researchers from other universities, including Princeton University and Rensselaer Polytechnic Institute, in planning an upcoming symposium on connected and autonomous vehicles.
- UTEP has expanded its partnership with Czech Technical University, launching a dual master's degree program on smart cities. The collaboration builds on more than a decade of collaboration between the two universities. Prof. Kelvin Cheu has played a leading role in growing this partnership, helping create the dual degree program and serving as the program's faculty advisor.

Other collaborations

- The multi-stakeholder forum on heavy and overweight vehicles also included participants from external organizations, including MTA Bridges and Tunnels, Federal Highway Administration, NY Metropolitan Trucking Association, trucking and freight companies, and more.

IV. Impact

A. Development of the Principal Discipline

Research across C2SMART's consortium is providing insight on managing implementation of CAVs in urban environments and potential applications for the vast quantities of data produced by CAVs. In

particular, PI Saif Jabari's project demonstrated how real-time data from CAVs can be used to help urban networks recover from disruptions. Additionally, Dr. Jeff Ban's and Dr. Camille Kamga's work on integrated vehicle traffic control is providing a foundation for vehicle and signal control and coordination in connected cities. Using connected vehicle data from the Michigan CV pilot test and industry partners, Director Kaan Ozbay's team showed that connected vehicle data can be used for safety-related projects. Dr. Ozbay also collaborated with Professor Zhong-Ping of NYU Tandon's Electrical and Computer Engineering Department to develop autonomous vehicle control algorithms that can learn in mixed traffic, which were applied to case studies involving dedicated bus lanes with focus on the Lincoln Tunnel Express Bus Lane. This work contributes to the overall knowledge base surrounding CAVs and helps prepare for real-world implementation of these technologies on a large scale.

The Rutgers team has furthered the study of transportation through the methodology they developed to improve the accuracy of the collected weigh-in-motion data. This methodology will enable traffic engineers to better utilize traffic and weight data in their research. Their work on bridge deck deterioration has also helped engineers and other stakeholders better understand the damage cost to infrastructure incurred by overweight trucks.

B. Other Disciplines

Nothing to report at this time.

C. Transportation Workforce Development

C2SMART has supported transportation workforce development by teaching classes, supporting students involved in transportation research projects, providing funding for masters and Ph.D. students, and providing research opportunities for undergraduate students. Our efforts in this area also include:

- Hosting seminars, conferences and workshops. Highlights include:
  - The forum on overweight truck policy, which familiarized students from Rutgers and NYU with a multifaceted stakeholder outreach experience and disseminated research on damage caused to transportation infrastructure caused by heavy and overweight vehicles to the transportation workforce beyond academia.
  - The continuation of the Distinguished Speaker Series, which provides an opportunity for students to learn from a range of experts outside of their coursework and research. During this reporting period, seminar topics ranged from the ethics and liability issues involved in the deployment of autonomous vehicles to the path toward expanding ecosystems of interoperable networked smart objects.
- Contributing to the development of the future transportation workforce through:
  - Hosting four high school students for a summer research experience through the ARISE program, in which the students received mentoring from graduate students and took on real-world research, learned new technical skills, and developed their presentation skills.
  - In addition, the center will also host workshops and education redevelopment activities for transportation agency staff during the next reporting period.

D. Physical, Institutional, and Information Resources

C2SMART researchers are in the process of creating a large-scale, open-source, agent-based model of NYC using MATSim, an activity-based, extendable, multi-agent simulation framework implemented in Java, and calibrating it based on public sector data from the New York metropolitan area. This data-driven approach to validate and calibrate the proposed agent-based model is one of the first attempts to

develop a highly dynamic simulation tool that incorporates big data into microscopic simulation. The research team has incorporated data for more than 30 million individual trips based on data from the NYMTC Household Travel Survey (2011) into the testbed and developed a mode choice model that includes transit, walking, taxi, bikes and carpool. The testbed is also designed to incorporate new forms of mobility, including Citibikes and for-hire vehicles.

The Rutgers team is currently collaborating with NYCDOT and local county government for field implementation of three weigh-in-motion (WIM) systems and sensors in New York City. The site location for the installation will be based on a traffic analysis conducted in cooperation with NYU to localize hot spots with high traffic volume in NYC. In addition, the team instrumented a WIM system at a local road where the nearby bridge experiences extreme deterioration. The WIM system covers both directions (two lanes) to monitor the average daily truck traffic (ADTT) as well as the weight statistics of these trucks. The installation of these WIM systems provides a reliable source of data on overweight truck traffic that can be used to assess infrastructure damage cost due to these vehicles and develop new policies and permit fee structures accordingly.

The Rutgers team has also been collaborating with the New Jersey Turnpike Authority to aggregate information from their various databases, including accident, line stripping, maintenance, etc. This information will be used in the development of an app with various modules that will allow NJTA employees to process the data according to their needs.

The INTERCEP team developed a short briefing and policy document describing the issue of overweight trucks and their impact on regional infrastructure, as well as outlining some initial policy options and the different constraints various regions may face in addressing this problem. Additionally, the team began constructing a resource hub for the overweight truck policy project. It will be available to others so that stakeholders can access relevant research and other resources, see evolving proceedings documents, and understand how the models were constructed and how estimates were made.

E. Technology Transfer

C2SMART's research efforts focused on the impacts of overweight vehicles have also prioritized technology transfer activities. The forum on policies for heavy and overweight trucks facilitated information exchange between researchers and industry/govt representatives, specifically regarding costs of overweight vehicles in terms of deterioration caused to pavement and bridges. The event had 31 participants from government and industry and 16 representatives from academia. The Rutgers team also met with engineers at the local county office to discuss the effects of overweight trucks on their bridges and installation procedures for WIM systems.

The Rutgers team has undertaken significant technology transfer efforts leading to the adoption and continued use of applications by New Jersey transportation agencies, including the following:

- WeatherEVANT: Real-time Weather-related Event Visualization and ANalytics Tool, used by the maintenance department of New Jersey Turnpike Authority
- SAVE-T: Safety Analysis Software, adopted by Operations Department of New Jersey Turnpike Authority for analyzing crash data.
- T.R.I.P: Total Roadway Inspection Program, an asset management and maintenance planning tool adopted by the maintenance department of New Jersey Turnpike Authority.

The Rutgers team, in close collaboration with NYU's UrbanMITS lab team, demonstrated the SAVE-T app they developed to report and generate crash and accident statistics of two New Jersey major highways at

the New Jersey Turnpike Authority Trooper D Headquarters. The troopers provided feedback and the team incorporated their comments in the updated app. The Rutgers team has also held multiple meetings with NJTA employees to demonstrate and solicit feedback on an app being developed to process the agency's wide variety of data.

C2SMART researchers also undertook the following technology transfer efforts:

- The UTEP team designed and distributed a poster summarizing project findings to senior centers across El Paso, raising awareness of the project and resulting app among the target user group.
- Early outcomes from the Urban Sustainability project, led by PI Sarah Kaufman, were presented to the Paris Deputy Mayor for Transportation, Marianne Daude. Daude was highly invested in the results and intends to work on policies linked to the study when it is complete.
- Researchers from NYU, led by Deputy Director Joseph Chow, presented plans for a project that aims to develop a large-scale, open-source, agent-based model of NYC using MATSim, an activity-based, extendable, multi-agent simulation framework to representatives from NYCDOT.

F. Beyond Science and Technology

C2SMART's research has had the following impacts beyond science and technology:

- The UTEP team's project has created new awareness among seniors in the El Paso area about the potential of their smartphones to help them with their navigation needs, potentially improving their ability to move around their city.
- Due to the success of the Emerging Leaders program, the NYC Department of Transportation has instituted its own, internal version of the Rudin Center's development program.
- The forum on policies for heavy and overweight trucks preliminarily established an Infrastructure Owner & User Stakeholder Group that may be utilized at a later time for vetting of and input on other C2SMART activities and products.
- The web-based GIS app developed by the Rutgers team for better understanding infrastructure damage cost associated with overweight and permitted vehicles offers a data-driven tool that can be used in the development of strategies and policies to recover these costs, potentially improving infrastructure resiliency and reducing maintenance costs to taxpayers.

V. Changes/Problems

On July 6, 2018, several C2SMART computers were subject to a ransomware attack and all files used in research were encrypted. As a result of this, some work related to the [Put the proper project title here] project for the final recommender system code and computational experiments with Yelp and taxi data from New York City was lost. Instead, an earlier build of the recommender system code that did include full routing constraints was completed, though the project team was limited to delivering the final recommender system tool and test results on synthetic data, as opposed to tests on the NYC data set that were originally planned. This hack led the end date for the project to be delayed by two months.