C²SMART

Tier I University Transportation Center

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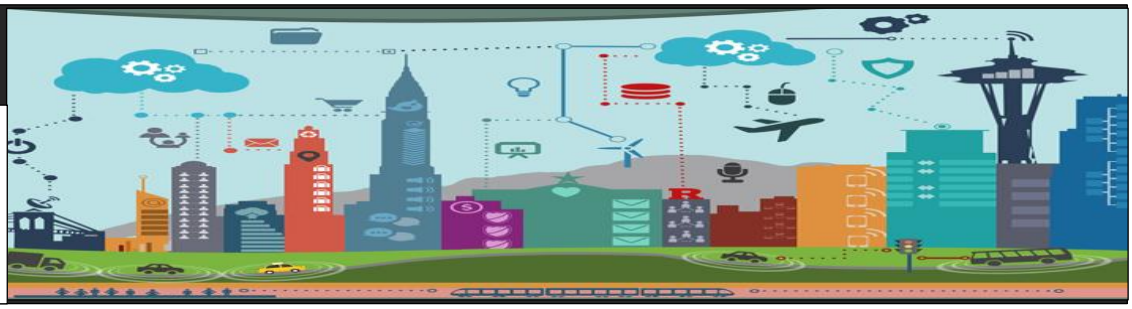

PROGRAM PROGRESS PERFORMANCE REPORT

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

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Center Director	Kaan Ozbay, Ph.D., Director, Professor of Civil and Urban Engineering, Tandon School of Engineering, New York University, kaan.ozbay@nyu.edu, (646) 997-3691
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Submitting Official Name: Kaan Ozbay

Signature: Kaan Ozbay

Consortium Members

New York University - Rutgers University - University of Washington, Seattle - University of Texas, El Paso* - The City College of New York*
*MSI-designated

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1 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 a range of cities among its consortium members as a decentralized but comprehensive living laboratory. In order to accomplish this mission the Center will study a number of challenging transportation problems and field test novel solutions in close collaboration with end-users, city agencies, policy makers, private companies, and entrepreneurs. The research approach of the Center is the use of a system-of-systems (SoS) perspective that integrates roads, transport services, energy grids, financial information, and other urban networks. The Center's novelty among its peers is the unique combination of the set of strengths and resources in urban informatics, connected technologies, behavioral informatics, and city partners that cannot be matched anywhere in the world.

B. Accomplishments under These Goals

i. Administrative

A number of administrative accomplishments were achieved in this reporting period.

Kick-off meeting: A kick-off meeting was held on May 31st at NYU, with co-PIs Prof. Jeff Ban (UW), Prof. Kelvin Cheu (UTEP), Prof. Camille Kamga (CCNY), and Prof. Hani Nassif (Rutgers) in attendance. The day-long event included administrative planning with the Director Prof. Kaan Ozbay and Deputy Director Prof. Joseph Chow, and research presentations in the afternoon to share and discuss our agendas for the Center.

Hiring of administrative staff: Two administrative positions, fully funded by the NYU School of Engineering, were advertised after the official start date of the Center on March 1, 2017. These positions were titled as "Senior Associate Director" and "Grants Administrator". As of June 20th 2017, both positions were filled with two excellent candidates who will start their duties on July and August, 2017, respectively.

Photos from the Kick-Off Meeting Held at NYU

Space allocation: Center will move to its dedicated temporary space in MTC 15 in Brooklyn in September 2017. This is a prime location next to the Tandon School Engineering main facilities with state-of-the-art office and research capabilities. This space will include offices for Center's Director, Deputy Director, Senior Associate Director, other administrative staff as well as full time research associates, post-doctoral fellow, and graduate and undergraduate students involved in the Center's activities.

A brand new long-term facility is being planned and designed for the Center in Rogers Hall. This will be an approximately 8000-sqf dedicated facility that will house office space and various research labs for the Centers activities. The completion date of the new dedicated facility is anticipated to be the summer of 2018.

MOUs with industry partners: Two data sharing / confidentiality agreements were developed and finalized in collaboration with NYU's "Industry Liaison and Technology Transfer" office with two emerging transportation data companies namely, ZenDrive and Nexar.

In the next quarters we will continue to pursue similar MOUs and partnership agreements to advance Center's goal of finding innovative real-world solutions to real-world problems. For example, we are in various stages of collaborative arrangements with a number of partners: Arada Systems, BestMile, BMW ReachNow, Didi, Ford, GoGoVan, Gomentum Station/CCTA, Inrix, Microsoft, Next Future Transportation, TransLoc, Uber, and Via.

Leveraging consortium resources: NYU researchers have established a data sharing agreement with the University Transportation at NYU. The campus shuttle service operates both fixed routes in Manhattan and Brooklyn, and also late night on-demand transport. These services are all accessible via mobile apps on smartphones. NYU researchers are also in collaboration with NYU's Lutheran Medical Center Emergency Medical Services for a potential research project on EMS deployment in a smart city environment.

Data management: A draft data management plan was submitted to the USDOT for review and awaiting feedback and comments. After approval we will begin setting up the online data repository to be hosted on a server hosted at NYU.

CUTC Annual Summer Meeting: Prof. Chow attended the 2017 Council of the University Transportation Centers (CUTC) Annual Summer Meeting in Buffalo, NY, hosted by TransInfo Tier 1 UTC.

CUTC attendees getting a ride on CMU's autonomous vehicle on the campus road, courtesy of the state's recent legislation allowing AV testing

The attendees of the CUTC Annual Meeting listening to the Director of the Office of Research, Development, and Technology at the USDOT, Prof. Kevin Womack, provide opening remarks.

RiP database: The Center is in the process of inputting the selected research projects into the Research in Progress database (https://rip.trb.org/).

ii. Research

Research Projects in Progress

The following is the list of ongoing research projects:

- **Integrative Vehicle Infrastructure Traffic System (iVITS) Control in Connected Cities (CUNY / NYU):** This project will develop network-wide iVITS, leveraging team members' current research on local and regional iVITS models and algorithms. The research team will propose a simulation-based approach for the evaluation of traffic control algorithms that will utilize CV technologies. Given the ongoing CV pilot deployment in NYC, the proposed project will tie in to the objectives set out to be achieved as a part of the NYC CV pilot. The City College of New York (CCNY) team will

work with NYU and UW researchers to test the models and algorithms in microsimulation and hardware-in-the loop simulations on a NYC-specific network.

- **Monitoring and Control of Overweight Trucks for Smart Mobility and Safety of Freight Operations (RU/NYU):** This project will investigate technologies to screen overweight trucks including high-speed weigh-in-motion (HS-WIM) system integrated with license plate reader and/or security camera, and to evaluate the feasibility of such technologies compared to current screening practices at weighing stations. Infrastructure damage cost associated with the overweight trucks, as well as permits, will be evaluated to provide guidelines in developing the overweight and permit policies and fee structures. Two Apps, one for autonomous ticketing and the other for damage cost evaluation, will be developed.
- **City-scalable Destination Recommender System for On-demand Senior Mobility (NYU/UTEP)**: In this project led by Prof. Chow, we integrate state-of-the-art recommendation algorithms used by companies like Netflix and Yahoo to better inform on-demand mobility systems, particularly in serving the elderly.
- **Designing and Managing Infrastructure for Shared Connected Electric Vehicles (UW)**: This research led by Prof. MacKenzie and in collaboration with BMW ReachNow merges classical stochastic models with machine learning methods to improve the integrated management of EV carsharing fleets and supporting infrastructure. ReachNow has carsharing fleets in both Brooklyn and Seattle, and solutions can be tested for both cities in the future.
- **Development of A Mobile Navigation Smartphone Applications for Seniors in Urban Area (UTEP/NYU)**: This collaborative work between Prof. Cheu and Prof. Villanueva-Rosales from the Department of Computer Science seeks to prototype mobile apps to better serve senior mobility challenges. The research will link up with Prof. Chow's efforts at NYU and include survey efforts in El Paso and NYC.
- **Sustainability of Urban Consumption Practices (NYU)**: NYU Rudin will conduct research to understand the sustainability challenges associated with freight and passenger mobility in cities to recommend policies at the local level. The research is a joint collaboration with research group 6-t: Bureau de Recherche based in Paris, and policy recommendations will consider interoperability between NYC and Paris.
- **Traffic Signal Optimization and Coordination in Connected Cities (UW)**: This research led by D. Ban investigates traffic signal control strategies under a connected vehicle (CV) environment in smart cities. The project will reduce traffic congestion and energy use by leveraging the data and connectivity enabled by CV technologies.

While not a specific research project onto itself yet, Center researchers led by Prof. Chow are developing a simulation-based test bed to connect newly developed transportation solutions to "traveler impacts" supported with real data from New York City, Seattle, and El Paso. The simulation component will be implemented in a well-known open-source

software platform called MATSim. The initial portion of this is being developed with NYC data as an evaluation tool for the recommender system project led by Prof. Chow. It will allow researchers to consistently evaluate demand and social impacts of different transportation technologies and policies in the future, and better understand how they scale from one city to another. In the long term this test bed will help governments around the country benchmark new transportation technologies and policies for faster and more reliable deployment to market.

Completed Research Projects

Nothing to report

Research Activities

Agency Sponsored Research Activities

There are several agency sponsored research activities that are currently active or being initiated as part the Center's long-term research goals. The following is the list of some of the sample research activities sponsored by agencies during this period.

-**NYC Connected Vehicle Pilot**: Both NYU and CUNY researchers under the leadership of Professors Kamga and Ozbay are involved as University partners in various tasks of this project that aims at testing safety related CV solutions in NYC.

-**New Jersey Turnpike Authority (NJTA) Safety App enhancements**: In this NJTA funded project, Rutgers and NYU researchers led by Professors Ozbay and Nassif are working on the development of a state-of-the-art traffic safety analysis software for NJTA.

-**New Jersey Turnpike and Garden State Parkway Maintenance Snow Program and Improvements:** This NJTA funded project, jointly conducted by Rutgers and NYU researchers, focuses on the development and deployment of a unique data analytics and visualization software for extreme weather conditions.

UTC Sponsored Research Activities

The following is the list of research activities conducted during this period. Six research projects have been initiated, two in each of the three primary thrust areas.

Traffic signal optimization and coordination in connected cities (UW) - Thrust Area 1:

Partially supported by the C^{2}SMART funding to UW, the team worked on developing integrated signal timing optimization and vehicle control methods to (i) optimize signal timing plans to minimize the delay of all vehicles passing through the intersection; and (ii) control the movement (trajectory) of individual vehicles to minimize their fuel consumption. This way both mobility and energy objectives can be considered, whereas at different priorities: mobility as the first priority and energy as the second priority. The

team summarized the results as a paper that was presented at the IEEE Intelligent Vehicles Symposium in June of 2017. The paper was selected for the Best Paper Award (2nd Prize).

Sustainability of Urban Consumption Practices (NYU) – Thrust Area 1:

In this collaborative research with research group 6-t: Bureau de Recherche based in Paris led by Drs. Sarah Kaufman and Mitchell Moss, the team is currently developing their research strategy.

City-scalable Destination Recommender System for On-demand Senior Mobility (NYU/UTEP) – Thrust Area 2:

In this project led by Prof. Chow, one graduate student is currently supported by NYU to work on this for the summer. In the fall and spring, three other graduate students will be supported on hourly basis to develop and test the recommender system for on-demand mobility, apply to elderly population in collaboration with Prof. Cheu's team, and build an initial simulation-based test bed using MATSim and local data from NYC and NYU Shuttle. So far Task 1 Literature Review is mostly complete, and progress is being made with Tasks 2 (collect travel data by age group), Task 3 (explore the Google Places API and Yelp API data) and Task 4 (design a routing-constrained recommender system).

Development of A Mobile Navigation Smartphone Applications for Seniors in Urban Area (UTEP/NYU) - Thrust Area 2**:**

The researchers have completed the search and review of existing smart phone applications for seniors (Task 1). We have met with the city managers in charge of paratransit and senior centers (Task 3) and begin to explore the functionality and design of our smart phone applications (Task 4). Literature review (Task 2) has just started.

Designing and Managing Infrastructure for Shared Connected Electric Vehicles (UW) - Thrust Area 3:

The team collaborates with ReachNow in Seattle to investigate the best strategies for designing and managing infrastructure systems to facilitate shared connected electric vehicles. The team just started the collaboration and research, currently focusing on literature view.

Monitoring and Control of Overweight Trucks for Smart Mobility and Safety of Freight Operations -Thrust Area 3:

Under the leadership of Professors Nassif and Ozbay, the team collaborates with the NJTA, NJDOT and NYCDOT to develop new methodologies and applications to alleviate the impact of overweight trucks to the infrastructure.

iii. Education

During this period, the C²SMART accomplished the following:

The U.S.-Mexico Bidirectional Study Abroad Program on Smart Cities is offered every summer since 2016, for 16 to undergraduate seniors, graduate and Ph.D. students in any discipline in the College of Engineering at UTEP and 16 students from Centro Universitario de Ciencias Economico Administraivas (CUCEA) at University of Guadalajara (UdeG) every summer. The program co-directors are Prof. Kelvin Cheu in Department of Civil Engineering at UTEP, and Prof. Victor Larios in Information Systems Department in UdeG. The study abroad program consists of 3 parts, cumulating towards the Hackathon competition in the last day. The Hackathon is a competition supported by IBM in which students compete in binational and multidisciplinary teams to develop prototype smart cities services delivered to customers mostly through smartphone applications. This study program begins with 3 weeks of online lessons on the fundamental knowledge of smart cities, Hackathon team formation and project development. The UdeG students visit UTEP for one week to work with UTEP students on team projects, attend lectures and field trips (supported by the City of El Paso). The UTEP students then continue with similar activities in UdeG campus or CCD for 10 days. While in Guadalajara, they have the opportunity of testing the project prototype on UdeG smart cities living lab as well as the CCD implementation site in downtown Guadalajara. The 2017 program started on May 15 with Part 1 from May 15 to June 2. 16 UdeG students and 3 faculty visited UTEP for Part 2 from June 3 to June 11. 16 UTEP students and 3 faculty will be visiting Guadalajara from June 20 to July 2 as Part 3 of this program. The students are grouped into 8 teams of 4 students. They have been assigned projects in smart mobility (3 teams), smart building (3 teams) and smart health care (2 teams).

UTEP Smart Cities Educational Initiatives

The NYU team actively participates in undergraduate training and research programs in the summer. One such program is the Undergraduate Summer Research Program offered by NYU Tandon since 2007. In the BUILT lab, four undergraduate students from under-

represented minorities have been recruited from Civil Engineering, NYU Abu Dhabi, and Courant Institute. UrbanMITS lab at NYU continues its efforts to bring undergraduate students to its summer internship program. This summer, three undergraduate students are participating in this highly intense internship program where students learn about data analytics and visualization and traffic simulation and modeling through their participation in real-world research projects. Prof. Ozbay and his graduate students are actively advising and working with these undergraduate students during their stay at NYU.

The NYU team is involved in the Vertically Integrated Projects (VIP) Program, which unites undergraduate education and faculty research in a team-based context that creates long-term, large-scale projects. Some projects are based on the Center's research, where undergraduates gain experiential learning to develop disciplinary and professional skills. The VIP Program started at Purdue in 2001 and has expanded to a consortium of 24 universities. Projects include: Quantified Cities, Autonomous Vehicles, Connected Infrastructure, and Shared Mobility Transportation Users.

Other educational activities were as follows:

- At UW, Prof. Jeff Ban teaches courses in transportation engineering and transportation network system analysis. He integrates research results into course materials via labs, discussions, and course projects. Prof. Don MacKenzie teaches courses in applied statistics, transportation sustainability, and the UW's transportation engineering capstone. He has updated the content and delivery in CEE 584: Analytical Methods in Human Factors & Transportation, putting lectures and quizzes online to enable more interactive classes. He has developed a new, cross-disciplinary, graduate-level course integrating technical and policy analysis (CEE 583: Transportation Energy & Sustainability) integrating results, insights, and materials from his research on electric vehicles, vehicle automation, and shared mobility.
- Prof. Chow teaches courses in urban transportation systems, public transit, traffic engineering, travel behavioral informatics, and sustainable logistics and freight. For the spring semester of 2017, he developed and taught an undergraduate Traffic Engineering course to a class of 25 students. The course includes new perspectives of transportation technologies on the traffic engineering discipline, such as impacts of connected and autonomous vehicles on vehicular traffic, and city monitoring. It covers material that includes queueing, fundamental diagram, freeway incident management, and signalized traffic control design. Prof. Chow is now developing a new graduate level course in the fall semester on Travel Behavioral Informatics, which looks at development of information systems for ITS as well as advanced travel demand analysis, discrete choice modeling, and decision theory.
- Prof. Ozbay teaches a "Data-driven Simulation and Modeling (GX 9007)" class in the Spring semester as part of the MS program offered at the NYU Center for Urban Science

and Progress (CUSP). This class is a unique blend of data science and traffic modeling and simulation that is designed for both data scientists with an interest in transportation simulation and modeling as well as regular transportation engineers / planners. There more than 20 graduate students distributed evenly between data science and transportation fields which demonstrates the success of this course in attracting for both traditional and nom-traditional students to the transportation field.

- The Center actively participates in the ARISE program offered by NYU Tandon School of Engineering since 2013. The 7-week summer research program supports 10th and 11th grade students in NYC (primarily from under-represented minorities) interested in STEM. Two students will be joining Prof. Chow's BUILT lab at the Center this summer: Alexander Leon and Harpreet Kaur, both from Brooklyn Technical High School.

iv. Outreach Activities

TRB Reception

Center personnel attended a reception sponsored by the NYU Tandon School of Engineering at the 96th TRB Annual Meeting on January 8th where they announced the establishment of the Center[1]. There were more than 100 attendees and it was regarded as a successful event. The Chair of the Department of Civil Engineering at NYU, Prof. Magued Iskander, was present to give remarks alongside the Center Director. NYU Tandon issued a press release:

http://engineering.nyu.edu/press-releases/2017/01/04/new-university-research-center-test-boundaries-smart-transportation-ny

Smart Traffic Analytics Symposium

C2SMART researchers in collaboration with CUSP organized Smart Traffic Analytics Symposium in January 13th 2017 in Brooklyn NY. Hosted by Tandon School of Engineering @ New York University (NYU) and New York City Department of Transportation (NYCDOT), the Smart Traffic Analytics Symposium & Hackathon brought the expertise of the data science and transportation community to bear on data openly available from the NYCDOT. The event consisted of an initial invitation, the publication of the data, an informational webinar, a hackathon, and the symposium itself. The event was very positively received and the hackathon will be extended to allow additional participation.

[1] Reception was sponsored and funded by NYU Tandon School of Engineering, and did not utilize any Center or other federal or matching funds

Scenes from the TRB Reception held by the Center and NYU Tandon School of Engineering

Connected and Autonomous Vehicles (CAV) Workshop

The 5th CAV workshop was co-organized with the contributions of UTRC at CUNY, NYU Tandon School Of Engineering and CUSP, TransINFO at SUNY Buffalo, SUNY Polytechnic Institute, CoE-SUFS at RPI as well as State and City agencies including NYCDOT, NYSDOT, ITSNY and private companies. It was hosted in Brooklyn NY by C²SMART researchers at NYU Tandon School of Engineering.

http://www.connectedvehicleworkshop.com

2017 ITE Northeastern District Collegiate Traffic Bowl and Research Symposium

NYU hosted the ITE event on March 23, 2017. It was organized by the student chapter with support from the Center. NYU had a team participate this year. In addition, Drs. Chow and Ozbay participated in a panel on "Innovations in Transportation Education" to share perspectives on career roles for these emerging transportation engineers.

Panel Discussion at the ITE Traffic Bowl Event (source: NYU)

Emerging Leaders in Transportation Program

NYU Rudin is preparing another round of the workforce training program designed to develop early career transportation professionals to promote innovation within their organizations. Initiated in past years as a training program from the regional UTRC, this year's program will emphasize connected cities innovations and will additionally call out to professionals in the consortium's network of cities. Participants in the program from 2016 are shown in the following link:

https://wagner.nyu.edu/rudincenter/2016/10/announcing-emerging-leaders-transportation-2016

Other Outreach Efforts

The UW team is collaborating with TrafficCast and ReachNow for the current projects, and is also reaching out to public agencies (WSDOT) and private sectors (Microsoft, Inrix, Uber, Didi from China) for possible collaborations and data support.

Prof. Jeff Ban shared his research findings on congestion effect of e-hailing transportation services (e.g., taxis and ridesourcing services) on a transportation network at the Transportation Research and Education Center of the University of Portland and at the Institute of Pure and Applied Mathematics (IPAM) of the University of California, Los Angeles. He also shared his research results on network modeling and traffic simulation with managers and engineers of the Toll Division of the Washington Department of Transportation (WSDOT).

Prof. Don MacKenzie engages with policymakers at the local, state, and federal levels to share insights from his research. For example, he has presented findings from his research on the energy impacts of automated vehicles to staff from the U.S. Department of Energy and the U.S. Environmental Protection Agency. He has shared insights from his research on electric vehicle charging behavior through the UC Davis Policy Institute for Energy, Environment, and the Economy and the Washington State EV Working Group, and shared his research on the behavioral effects of real-time information displays with the Seattle Department of Transportation.

Prof. Yinhai Wang is reaching out to Microsoft on collecting, archiving, and sharing transportation data via a trusted data platform. A joint project is under development between UW team and Microsoft.

Students from Prof. Chow and Prof. Ozbay participated in the Annual Research Expo hosted by the NYU Tandon School of Engineering on April 21, 2017.

v. Dissemination of Results

C²SMART is in the process of establishing a comprehensive dissemination plan that will take advantage of the existing information dissemination infrastructure of the lead and partnering institutions as well as very strong relationships with partnering agencies.

Prof. Jeff Ban's team presented a paper at the IEEE Intelligent Vehicles Symposium in June of 2017, titled: V2I Based Cooperation between Traffic Signal and Approaching Automated Vehicles. The paper was selected Best Paper Award (2nd Prize) of the Symposium, representing one of the two papers from over 300 papers submitted to the Symposium. More details can be found here: http://depts.washington.edu/pactrans/pactrans-associate-director-and-student-research-present-at-ieee-intelligent-vehicles-symposium/.

Prof. Don MacKenzie engages the public with his research through a mix of traditional and new media. Early in 2016 he launched the Sustainable Transportation Lab blog, where he and his students engage with transportation sustainability topics in an accessible way. The blog has been cited on CleanTechnica and Slate (http://faculty.washington.edu/dwhm/category/blog/). MacKenzie has shared research insights with the public via in-person and online presentations through the MIT Faculty Forum Online (https://youtu.be/kif1STNXbKs), Google Hangouts On Air (https://youtu.be/dTrKuRMCoXE), the EnergyCollective (www.theenergycollective.com), and the Seattle Electric Vehicle Association. When his paper on the energy impacts of automated vehicles was published earlier in 2016, the research was featured by 60 news outlets reaching a combined audience of more than 2 million. A recent in-depth Associated Press article citing this work was picked up in more than 500 outlets.

The Director of C²SMART, Prof. Ozbay's recent work on traffic safety in collaboration with ZenDrive received substantial attention from various media outlets mainly due to their creative approach of combining traditional crash data with novel in-vehicle data collected by ZenDrive. The statistically significant correlations identified between crash data and Zendrive's vehicle based data was presented at the 2017 Vision Zero Cities conference in NY City (https://www.visionzerocities.org) and was reported by various articles as an important development in safety studies "to stop reckless driving before it causes collisions, injuries and deaths. http://diginomica.com/2017/06/23/zendrive-says-big-data-eliminate-traffic-fatalities-really/

Other press coverage related to the same study in frequently venues such as "NY Daily News" and "Governing" are as follows:

http://www.nydailynews.com/news/national/new-data-shows-easily-nypd-crackdown-drivers-article-1.3174098

http://www.governing.com/topics/transportation-infrastructure/gov-pedestrian-deaths-vision-zero-data.html

Prof. Ozbay was also interviewed by Salon.com about Elon Musk's proposal for building subterranean highways under LA and his comments was included in an article published at the Salon web site (http://www.salon.com/2017/05/06/elon-musks-tunnel-vision-why-his-boring-company-underground-traffic-solution-is-a-bad-idea/ .

Prof. Chow's work on evaluating an autonomous vehicle fleet as an alternative to a light rail line in NYC was covered by the Village Voice: http://www.villagevoice.com/news/instead-of-building-de-blasio-s-streetcar-what-if-we-had-self-driving-uber-vans-9602278

vi. Plans for Next Reporting Period

We have now completed and executed Year 1 subcontracts for all of our consortium partners. We are in the process of completing the Scope of Work for internal Year 1 NYU projects. In the next reporting period, all of the internal NYU projects will be active and we will report their progress. These are:

Project TA1.1 - *10,000 Travelers over 20 years: Use of decade-long panel data* for *microscopic modeling and simulation of a city-scale multi-modal decision-making process of connected travelers.* **Co-Leads:** Glimcher (NYU); **Partners:** Ozbay (NYU); NYCT; NYCDOT.

Project TA1.2 – Data-driven models for understanding driver and infrastructure safety in presence of connected and autonomous vehicles. ***Co-Leads:*** *Ozbay (NYU);* ***Partners:*** *Nassif (Rutgers); NYCT; NYCDOT; NJDOT.*

Project TA2.1 - *Integrated analytics and visualization for multi-modality transportation data.* **Co-Leads**: Silva (NYU); **Partners**: NYCT; NYCDOT; NYC TLC.

Project TA2.2 - *Understanding mobility patterns and decision-making using an integrated, multi-modal sensing platform in a quantified community*. In transportation (the subway and streetscape), retail (TWC) and cultural space (Jazz at Lincoln Center and Central Park). Pattern recognition algorithms will be developed to understand the use patterns within and across these spaces. **Lead:** Kontokosta (NYU); **Partners:** Chow (NYU); NY City, NY City DOT

Project TA3.1 - *Data-driven assessment of multi-modal transportation infrastructure resiliency and security.* **Co-Leads:** Jabari (NYUAD); Madanat (NYUAD); Ozbay (NYU); **Partners**: Raisch (NYU); NYCDOT; NYMTC

We will develop an online system to track both technical and financial progress of all the projects funded by the Center.

NYU researchers are working with Rutgers researchers in finalizing several NJ funded research projects as part of their plan to bring agency funded projects to the Center. In a similar vein, NYU and CUNY are working together to develop NYCDOT and NYSDOT funded projects that will be conducted by Center's researchers. We will report the status and progress of these efforts in our next reporting period.

On the education side of the Center's activities, NYU is working on revamping its Transportation planning and engineering program at the Master's level by revising its current curriculum to be more in line with the requirements of partnering State agencies. We will conduct a one day education workshop with other consortium Universities and State agencies to identify the education needs for transportation agencies in a quickly changing world. We will report the outcome of this effort in the next period.

We will also start planning a half day event at the TRB conference in January 2018 where C^{2}SMART students will get together to discuss their research projects and share their findings so far. This will help us to build a real community of researchers from a geographically dispersed consortium of Universities.

On the outreach front, NYU will be hosting the Transportation Camp in the fall. We have also started to work with UTRC @ CUNY and other Universities on the 6th CAV Symposium. First in the last six years, we are planning to involve Universities that are outside Region 2 in the organization of this symposium to reflect the nation-wide reach of the C^{2}SMART consortium.

During our kick-off meeting in May, C^{2}SMART consortium members decided to organize and offer a monthly webinar series. We will report on the progress of this important outreach / technology transfer effort in the next reporting period as well.

The UW team plans to make signification progress on the two proposed projects, advising graduate students on research activities, reach out to public and industry partners on research and educational activities, and publish/present research results at leading national/international journals and conferences, and disseminate the findings to public agencies, private sectors, and academia. The UW team also plans to seek collaborations for research and proposal developments.

2 PRODUCTS

A. Publications

Sample Journal Papers

Bartin, B., **Ozbay, K.**, Wang, H. and Maggio, M. (2017). "Work Zone Coordination Tool." *Transportation Research Record: Journal of the Transportation Research Board*. DOI: 10.3141/2617-08.

Djavadian, S., and **Chow, J.Y.J.** (2017). An agent-based day-to-day adjustment process for modeling 'Mobility as a Service' for a two-sided flexible transport market. *Transportation Research Part B* 104, 36-57.

Kachroo, P., Agarwal, S., Piccoli, B., and **Ozbay, K**. (2017). "Multi-scale Modeling and Control Architecture for V2X Enabled Traffic Streams," *IEEE Transactions on Vehicular Technology*, in press.

Mendes, L.M., Bennàssar, M.R., and **Chow, J.Y.J.** (2017). Simulation experiment to compare light rail streetcar against shared autonomous vehicle fleet for Brooklyn Queens Connector. *Transportation Research Record*, in press, doi: 10.3141/2650-17.

Xie, K., **Ozbay, K.**, Kurkcu, A., and Yang, H. (2017). Analysis of Traffic Crashes Involving Pedestrians Using Big Data: Investigation of Contributing Factors and Identification of Hotspots. *Risk Analysis*, 1-18. doi:10.1111/risa.12785

Zhu, Y., Xie, K., **Ozbay**, K., Zuo, F., and Yang, H. (2017). Data-Driven Spatial Modeling for Quantifying Network-wide Resilience in the Aftermath of Hurricanes Irene and Sandy. *Transportation Research Record* 2604, 9-18. doi:10.3141/2604-02

Sample Conferences Papers

Gao, J., and **Ozbay, K.** (2017). A Data-Driven Approach to Estimate Double Parking Events Using Machine Learning Techniques. Transportation Research Board 96th Annual Meeting, Washington D. C. TRB committee ABJ70 Standing Committee on Artificial Intelligence and Advanced Computing applications. https://trid.trb.org/View/1438603

Kurkcu, A., Zuo, F., Gao, J., Morgul, E. F., and **Ozbay, K.** (2017). Crowdsourcing Incident Information for Disaster Response Using Twitter. Transportation Research Board 96th Annual Meeting, Washington D. C. TRB committee ABJ50 Standing Committee on Information Systems and Technology. https://trid.trb.org/View/1438605

Mejia, D., Villanueva-Rosales, N., Torres, E. and **Cheu, R.L**. (2017). "Integrating Heterogeneous Freight Performance Data for Smart Mobility." Accepted by The 2017 IEEE International Conference on Smart City Innovations (IEEE SCI 2017), August 4-7, 2017, San Francisco.

Mudigonda, S., **Ozbay, K.**, and Bartin, B. (2017). Evaluating Resilience and Recovery of Public Transit System Using Big Data: Case Study from New Jersey. Transportation Research Board 96th Annual Meeting, Washington D. C. TRB committee AP000 Public Transportation. https://trid.trb.org/View/1439216

Reports

There is nothing to report in this reporting period.

Sample Presentations

Bartin, B., **Ozbay, K.**, Yang, H. (2017). Evaluation of Mobile Ticketing Technologies for Public Transit. Transportation Research Board 96th Annual Meeting, Washington D. C. TRB committee AP020 Standing Committee on Emerging and Innovative Public Transport and Technologies.

Cheu, R. L., Balal, E. and Sarkodie-Gyan, T. (2017). "A lane changing decision model based on fuzzy inference systems." Presented at the University of Nevada at Las Vegas on 17 May 2017.

Correa, D., Xie, K., **Ozbay, K.** (2017). Exploring the Taxi and Uber Demand in New York City: An Empirical Analysis and Spatial Modeling. Transportation Research Board's 96th Annual Meeting, Washington, DC. TRB committee AP060 Standing Committee on Paratransit.

Demiroluk, S., **Ozbay, K.**, Bartin, B., Maggio, M. D., **Nassif, H.**, Hesslein, D. L. (2017). WeatherEVANT: Real-Time Weather Related Event Visualization and ANalytics Tool. Transportation Research Board's 96th Annual Meeting, Washington, DC. TRB committee AHD65 Standing Committee on Winter Maintenance.

Mendes, L.M., Bennàssar, M.R., **Chow, J.Y.J.** (2017). Simulation experiment to compare light rail streetcar against shared autonomous vehicle fleet for Brooklyn Queens Connector. Presented at the 96th Annual Meeting of the Transportation Research Board.

Xu, B., **Ban, X.**, Bian, Y., Wang, J., and Li, K. (2017). V2I based Cooperation between Traffic Signal and Approaching Automated Vehicles. In Proceedings of the IEEE *Intelligent Vehicle Symposium*, June 11-14, 2017, Redondo Beach, CA. (2nd Prize Best Paper Award of the Symposium)

B. Databases

Nothing to report.

C. Websites

The C2SMART website was developed and it is now available at: http://c2smart.engineering.nyu.edu/

3 PARTICIPANTS AND COLLABORATING ORGANIZATIONS

Partner University	Agency Sponsor	Location	Funded Project(s)	Contribution	Other Collaborators	Role
New York University		Brooklyn, NY	2	Research		Research
Rutgers University		Piscataway, NJ	1	Research	NYU	Research
University of Washington, Seattle		Seattle, WA	2	Research	NYU	Research
University of Texas, El Paso		El Paso, TX	1	Research	NYU	Research
The City College of New York		New York, NY	1	Research	NYU	Research

We do not have a project to report yet. We are however working with various agencies to continue existing projects or start new ones under the umbrella of C^{2}SMART's research and education program. We will report our progress on these efforts with agency funded projects in our next report.

Projects by Partners		
Partner	**Projects**	
New York University	City-scalable Destination Recommender System for On-demand Senior Mobility	Sustainability of Urban Consumption Practices
Rutgers University	Monitoring and Control of Overweight Trucks for Smart Mobility and Safety of Freight Operations	
University of Washington, Seattle	Traffic signal optimization and coordination in connected cities	Designing and Managing Infrastructure for Shared Connected Electric Vehicles
University of Texas, El Paso	Development of A Mobile Navigation Smartphone Applications for Seniors in Urban Area	
The City College of New York	Integrative Vehicle Infrastructure Traffic System (iVITS) Control in Connected Cities	

4 IMPACTS

C²SMART Center has become operational since March 2017. We are currently in the process of setting up the Center and initiating first year projects, and establishing relationships with State and local transportation agencies as well as private companies. We are also recruiting graduate students and full time researchers to conduct various research and education projects described in our proposal. We expect to report quantifiable impacts in our next report.

5 CHALLENGES / PROBLEMS

There is nothing to report at this time.

6 SPECIAL REPORTING REQUIREMENTS

There is nothing to report at this time.