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1. ACCOMPLISHMENTS

What are the major goals of the program?

The goals of the Center for Transportation, Environment, and Community Health (CTECH) are to pursue research and education innovations to support sustainable mobility of people and goods, while preserving the environment and improving community health. It leverages behavioral and economic sciences, information technology, and environmental and transportation sciences and technologies to address critical issues falling under the FAST Act's priority area of Preserving the Environment: greenhouse gas reduction, use of alternative fuels and energy technologies, environmentally responsible planning, and impacts of freight movement.

To address these challenges, the Center organizes its research activities through six thrusts: 1) Behavior, Active Transportation, and Community Health, which studies the links between travel behavior, active transportation, the built environment, and health; 2) New Transportation Technologies and Business Models, which explores how mobility-on-demand services can be used to improve environmental sustainability and human health; 3) Green Multimodal Transportation Systems, which leverages new mobility technologies to promote sustainable and health-enhancing modal integration; 4) Freight Transportation and Community Health, which explores new vehicle technologies and operation paradigms to reduce human exposure to truck exhaust; 5) Data-Driven Transportation-Health Informatics, which leverages Smart City and IoT (Internet-of-Things) technologies to develop community-based and personalized transportation-health indices for promoting heathy mobility choices; and 6) Energy, Technology and Policy Pathways, which studies the impact of different combinations of energy, technology and policy pathways on the environment and community health. The consortium, consisting of Cornell University (Cornell), University of California, Davis (UCD), University of South Florida (USF), and The University of Texas at El Paso (UTEP), aims to advance transportation sustainability in its broader human and environmental contexts through multi-level, multidisciplinary and cross-sector collaborations.

The Center leverages existing strengths of partner universities to create an innovative, multidisciplinary education program capable of training a workforce that will meet the complex challenges at the intersection of transportation, environment, and community health. Beyond the multidisciplinary curriculum designed in parallel with its research, the Center is developing programs to attract motivated undergraduates and high school students to transportation, particularly from underrepresented groups.

CTECH's research targets deliverables in the following areas:

- Advancing methods for the holistic representation of user behavior/response;
- Data-driven cyber-informatics modeling-management models/tolls accounting for built environment-users and systems interactions;
- Computationally efficient algorithmic techniques for multimodal transportation systems management and community health;
- Scientific and engineering solutions for large scale integration of community health into transportation policy and planning; and
- Improved transportation-environment-community health nexus by linking fundamental scientific discovery with innovative practices.

The unique aspect of the work is that researchers focus on informing, influencing, and changing policy (i.e., legislation, regulations, programs, ordinances, and protocols) at the nexus of transportation, environment and community health. Dissemination of research outcomes and education are critical components of technology transfer to subsequently influence policy and human behavior. The main products from our center's research activities will be in the form of insights, knowledge, tools, and models that are instrumental to our stakeholders and practitioners as well as to policy development and

analysis. The development of technologies to license and/or commercialize can also be outcomes and is highly encouraged.

What was accomplished under these goals?
While providing critical services for the mobility, health, economic well-being, and security of communities, transportation presents challenges that also define modern society, with issues such as accessibility, air quality and energy efficiency, safety, health impacts, equity, and infrastructure vulnerability that must be confronted to sustain healthy living and economic growth. Successful solutions call for innovative cross-disciplinary research and education, and integrated technologies and approaches that meet goals in mobility alongside goals in environmental and health protection. In this reporting period, focused on FAST Act's priority area of Preserving the Environment, CTECH continued to use its fundamental research activities as the driving force to create downstream innovations, practices, and to enhance education programs for workforce development. The center's activities are organized and the accomplishments reflected along three tracks: 1) the fundamental knowledge track comprises research activities, development of methodologies and tools, and collection and analyses of data; 2) new policy recommendations and innovative practical implications/guidelines that translate and promote research outcomes into transportation, environmental and community health practices/policies; and 3) education, outreach/engagement, and workforce development that trains students and professionals on the findings and insights of the research, as well as the tools used and lessons learned in best practices. We continued to engage stakeholders (government agencies, private industry, the public, etc.) in all of these processes to create broader impacts. Via accomplishments along these tracks, we progress towards our goal of building a unique platform for synergistic and multidisciplinary research and education at the nexus of Transportation, environment, and community health, where new opportunities are explored to develop methods, tools and technologies to support sustainable multi-modal transportation and promote healthy mobility choices.

Research projects accomplished during this reporting period cover topics such as air quality and health impacts assessment of future freight transportation, evaluation of association between patient health outcomes and built environment, health implications of shared mobility service for transit access, vulnerable road user protection, and possible technology (e.g., smart sensors for emission reduction) and design (e.g., tunnel ventilation and air quality control) solutions for transportation health considerations. In particular, the following research projects were completed.

- The air quality and health impacts of projected long-haul truck and rail freight transportation in the United States in 2050
- Aerodynamic Equilibrium and Stability in Ventilation and Air Quality Control of Complex Urban Tunnels
- Examining Individual Health and Healthcare Utilization Patterns at the Intersection of Transportation, Environment and Communities
- Estimating Activity and Health Impacts of First and Last Mile Transit Access Programs for Work and Shopping Trips Using Shared Mobility Services in a Metropolitan Area
- Tracking Shoreline Conditions to Protect Infrastructure
- Vulnerable Road User Safety Enhancements for Transportation
- Smart Sensors to Reduce Pollutant Emissions in Transportation

How have the results been disseminated?
Formal research related oral presentations during the period are detailed below, followed by other dissemination activities.

10-24-18 Zhang, H.M., Institute of Transportation Studies, **Traffic routing and control in a Connected and Autonomous Vehicle Environment**, Davis, CA.

11-6-18 Li, S., INFORMS 2018 Annual Meeting, **Integrating Mobility-on-Demand Services with Mass-**

Transit, Phoenix, AZ.

11-16-18 Zhang, H.M., NSF, **Matching Parking Supply to Travel Demand towards Sustainability: A Cyber Physical Social System for Sensing Driven Parking**, Alexandria, VA.

11-19-18 Zhang, Y., Pasco Suncoast Transit Authority (PSTA), Meeting with PSTA on the **Electric Bus Charging** Problem, St. Petersburg, FL.

11-25-18 Gao, H.O., Urban Transitions 2018 Global Summit Elsevier IS Global, **Session on Cities-travel Behavio**r, Transport Emissions and Urban Design, Barcelona, Spain.

11-26-18 Gao, H.O., Urban Transitions 2018 Global Summit Elsevier IS Global, **Future mobility in urban transition – Systems engineering and data analytics linking urban transport innovation, air pollution, and health**, Barcelona, Spain.

11-28-18 Li, S., Boston University, **Transportation Policies and Equilibrium Sorting**, Boston, MA.

11-30-18 Li, S., Montréal Workshop in Environmental and Resource Economics, **Transportation Policies and Equilibrium Sorting**, Montréal, Québec, Canada.

12-3-18 Li, S., National Renwable Energy Laboratory, **Improving Urban Mobility with Transit Centric On-demand Services**, Golden, CO.

1-13-19 Zhang, Y., Transportation Research Board NCFRP 50, Workshop on **Freight Resiliency Research Practices and Approaches**, Washington, DC.

1-17-19 Zhang, H.M., University of California, Irvine, **The morning commute problem with ridesharing**, Irvine, CA.

2-4-19 Zhang, Y., Department of Transportation and Stormwater Services, **Resiliency Working Group** Meeting of the City of Tampa, Tampa, FL.

2-15-19 Zhang, Y., New York City College of Technology, **Data-driven Evidence from Electronic Health Records for Clinical Decision Support: Examples from Two Care Settings**, New York, NY.

2-18-19 Gao, H.O., CARTEEH, **Systems Integration of Transportation, Environment, and Health Planning: Models, Tools, and Insights**, Austin, TX.

2-21-19 Cheu, R.L., City of El Paso, TX, **CTECH and Parking Research at UTEP**, El Paso, TX.

3-1-19 Li, S., Institute for Pure and Applied Mathematics Workshop on Autonomous Vehicles, **Network level implications of Autonomous Mobility-on-Demand Systems: Challenges and Opportunities**, Los Angeles, CA.

3-12-19 Gao, H.O., Department of Urban Studies and Planning at the Massachusetts Institute of Technology, **Systems Integration of Transportation, Environment, and Health Planning: Models, Tools, and Insights**, Boston, MA.

3-13-19 Chintalapalle, R., The Minerals, Metals, and Materials Society (TMS) 2019 Meeting and Exhibition, **Advanced Materials for Sensors in Engine Applications**, San Antonio, TX.

3-14-19 Gao, H.O., MITRE, **Future Transportation in Urban Transition – Scalability, Sustainability and Effectiveness of Urban Infrastructure, Environment, and Health**, McLean, VA.

3-21-19 Daziano, R., C2SMART, **Exploring the Use of Immersive Virtual Reality Environments for Travel Behavior Analysis**, New York, NY.

Co-PI, Michael Zhang, co-supervised the UC Davis Autonomous Vehicle Student Club with Professors Chen-Nee Chuah and Dipak Ghosal from Electrical and Computer Engineering and Computer Science, respectively. CTECH partially supported their effort and the faculty worked weekly with the students throughout the fall 2018 semester to develop a prototype autonomous vehicle with a model car.

On October 30, 2018, Sirietta Simoncini, facilitated and hosted student presentations at a Cornell University Sustainable Development (CUSD) Summit with the Tompkins Consolidated Area Transit

(TCAT), the Town of Lansing, and the Village Solar Apartments (Lansing, NY) to present a bus shelter system design and to discuss/explore the possible location for the implementation of the first Sustainable Mobility student designed bus shelter.

On November 1, 2018, USF's Women in Transportation Lecture Series hosted Cassandra Borchers, AICP, Chief Development Officer of the Pinellas Suncoast Transit Authority. She gave a lecture focusing on operations, innovation, and leadership. Her lecture was followed by questions from the audience and a discussion that provided valuable insights into the challenges of transit operation, public involvement, and policies.

In November 2018, our first center-wide meeting was held at the University of California, Davis. There were approximately fifty attendees for a full day of talks, an advisory board panel session, and 19 presented posters, all showcasing the diverse research activities in transportation, environment, and community health across our four partner institutions (agenda attached). The following day, the Center's Executive Committee met with advisory board members to discuss the Center's strategic goals.

H. Oliver Gao organized the first early morning session on November 25, 2018 at the Urban Transitions 2018 Global Summit Elsevier IS Global, on Cities-travel Behavior, Transport Emissions and Urban Design in Barcelona, Spain.

The Cornell University Sustainable Mobility Student Group (M.Eng. and undergraduate students) held a final fall semester Expo on December 2, 2018 to showcase their project outcomes. It was a public event sponsored by Cornell University Sustainable Design (CUSD). The CUSD team, mentored by Sirietta Simoncini, presented final deliverables on providing Tompkins Consolidated Area Transit (TCAT): 1) a Bus Shelter System Design and Shelter Masterplan; 2) recommendations for their forthcoming electric fleet; 3) recommendations for optimizing Lansing, NY routes; and 4) a recommendation to the City of Ithaca for optimizing Collegetown mobility.

Co-PI, Yu Zhang, gave a luncheon talk during the 2nd Annual Institute of Transportation (ITE) Student Leadership Summit at the University of South Florida on February 9, 2019. She introduced CTECH's research scope, thrust, and the multidisciplinary nature of research teams and projects. CTECH was one of the event sponsors.

The USF Engineering Expo is an annual, two-day event that seeks to educate K-12 students on the importance of Science, Technology, Engineering, and Mathematics (STEM) in their lives. To familiarize K-12 students with research at the nexus of transportation, environment, and community health, the USF CTECH team set up a fun and educational activity booth on February 15-16, 2019. Prior to the event, faculty researchers created a series of questions intended to share information with participants about the relationships between transportation and environment/community health (e.g., How does transportation affect water quality?). Eight graduate students served as volunteers and asked K-12 students questions, subsequently explaining the answers. Students that answered a question correctly had a chance to spin the wheel for a variety of prizes. About 570 K-12 students actively engaged, introducing young minds to how transportation, while often providing mobility and freedom, impacts the environment and health.

On March 1, 2019, the USF Student Chapter organized a talk in Tampa, Florida, by Dr. Yafeng Yin, entitled Macroscopic Modeling of Ride-sourcing Systems: Regulation and Fundamental Diagram. Research findings from a series of studies conducted by the Lab for Innovative Mobility Systems were presented, aiming to investigate the operations of ride-sourcing services, understand their impacts and implications, and develop policies to guide their deployment and manage their operations.

On March 8, 2019 at UTEP in El Paso, Texas, Ramana Chintalapalle facilitated the Euro-UTEP Workshop where faculty and student researchers presented their work on materials, bio-materials, and smart sensors as they relate to transportation. Co-PI, Kelvin Cheu, gave an overview of CTECH efforts as part of a panel discussion on Environment, Transportation, and Community Health.

On March 12, 2019, Francis Vanek participated in a panel discussion at the Sierra Club, Tompkins County Chapter, in Ithaca, NY, on the House of Representatives "Green New Deal" Resolution. Approximately 75 attendees from academic, non-profit, the public, and K-12 were in attendance.

On March 13, 2019, students in Design Thinking for Complex Systems, taught by Sirietta Simoncini, that were tasked with redesigning the Cornell campus mobility system – presented their concepts to the stakeholders.

During the previous reporting period in Washington, DC, Amy L. Stuart participated in a skill building workshop that was designed to build education/training and practice approaches that move policy in support of both health and the environment. Air pollution exposure was used as an example for policy and action in this workshop.

What do you plan to do during the next reporting period to accomplish the goals?
No change.

2. PARTICIPATING AND COLLABORATING ORGANIZATIONS

Listed below are organizations that CTECH has partnered with during the reporting period.

Atkinson Center for a Sustainable Future	Ithaca, NY	Collaborative Research
Associated Asphalt	Tampa, FL	Other – materials provided for laboratory testing
Beijing Transportation Institute	Beijing, China	Collaborative Research, Other – support on data collection and policy guidance
California Department of Transportation (Caltrans)	Sacramento, CA	Financial Support, Facilities, Collaborative Research
Center for Transportation Infrastructure (CTIS)	El Paso, TX	Collaborative Research
Center for Urban Transportation Research, USF	Tampa, FL	Collaborative Research
China Automobile Technology Center	Tianjin, China	Other – data support and industry expertise
City of El Paso Bridge Department	El Paso, TX	Other – parking management idea exchange
City of Tampa, Department of Transportation and Stormwater Services	Tampa, FL	In-kind Support, Collaborative Research, Other – provide information on their green infrastructure implementation plan
City of Temple Terrace	Tampa, FL	Other – provided stormwater GIS data for the Temple Terrace area
Cornell University – Transportation, Facilities, and Campus Services	Ithaca, NY	Other – task giver, data source, feedback, potential implementer
Environmental Defense Fund (EDF)	Washington, DC	Collaborative Research
Florida Department of Transportation Central Office	Tallahassee, FL	In-kind Support
Florida Department of Transportation District 7	Tampa, FL	Other – project discussions
Hillsborough County MPO	Tampa, FL	In-kind, Collaborative Research
Hillsborough County Public Works Department	Tampa, FL	Other – provided GIS data and input on the modeling process
King County Metro	Seattle, WA	Collaborative Research
Kohn Pederson Fox Architects	New York, NY	Collaborative Research
NYMTC (The New York Metropolitan		

Transportation Council)	New York, NY	Collaborative Research
Optimus Technologies	Pittsburgh, PA	Collaborative Research
Tampa Pavement Constructors	Tampa, FL	Other – provide aggregate samples for laboratory testing
Tompkins Consolidated Area Transit (TCAT)	Ithaca, NY	Other – task giver, data source, feedback, potential implementer
Town of Lansing	Lansing, NY	Other – task giver, data source, feedback, potential implementer
Weill Cornell Medicine/NewYork-Presbyterian Hospital	New York, NY	Collaborative Research

Other collaborators or contacts with involvement in CTECH are listed or described below.

ARUP	New York, NY	Investigating transportation electrification collaboration opportunities
C2SMART	New York, NY	Partner (UTEP)
Cornell-Unibo Center for Vehicle Intelligence	New York, NY	H. Oliver Gao is Co-PI of Cornell-Unibo Center
John Swanson	The Villages, FL	Donor – Biodiesel Project
Vehicle for Change	Halethorpe, MD	Facilities and Other – data sharing

H. Oliver Gao is working with Yanyan Liu, a Senior Research Fellow at the International Food Policy Research Institute toward using Commercial Microwave Links (CML) to estimate rainfalls. The Inspire Challenge is an initiative to challenge partners, universities, and others to use CGIAR data to create innovative pilot projects that will scale. They look for novel approaches that democratize data-driven insights to inform local, national, regional, and global policies and applications in agriculture and food security in real time; helping people, especially smallholder farmers and producers to lead happier and healthier lives. This proposal was selected as a 2018 winner, with the team receiving $100K to put their ideas into practice.

H. Oliver Gao's collaborated with Yunsoo Choi in the Department of Earth and Atmospheric Sciences, University of Houston, on two important studies, 1) Potential impacts of electric vehicles on air quality and health endpoints in the Greater Houston Area in 2040, and 2) The air quality and health impacts of projected long-haul truck and rail freight transportation in the United States in 2050.

In addition, Shanjun Li, is collaborating with Andrew Waxman, The University of Texas at Austin, Lyndon B. Johnson School of Public Affairs, on traffic congestion relief research and housing markets. Timur Dogan has a joint NFEWS NSF proposal pending with Professor Christopher Reinhart, MIT Building Technology and Ricardo Daziano has been in discussions with Owen Waygood, Associate Professor of Civil, Geological and Mining Engineering a*t* Polytechnique Montréal, about ways of eliciting preferences for emission reductions.

3. OUTPUTS

To measure the impact of emerging transportation technologies on community equity in economy, environment and public health, Yu Zhang, Xiaopeng Li, and Amy Stewart developed a new taxonomy system based on a three-step assessment framework that was generally adopted in existing studies and uses disaggregate data. The equity assessment framework is divided into three components—population measure, cost/benefit measure, and equity measure—which are commonly applied in the reviewed literature. Gaps found in existing literature needing further investigation, included: Assessment of other emerging technologies; Proposition of station-free measurements; Consideration of the operation characteristics of emerging transportation services; Assessment under a multimodal transportation system

context; Integrated assessment with respect to economy, environment, and public health; and Disaggregate measures with high-resolution inputs.

Closely related, bikesharing has become increasingly popular in urban areas as an alternative active transportation mode that can help relieve congestion, mitigate negative environmental impacts, and improve public health through increased physical activity. As part of the project entitled Health Perception on the Adoption and Acceptance of Shared Mobility: From Now to Future, Yu Zhang, Siwon Jang, and Neil A. Lewis designed a survey questionnaire including, not only the typical set of socio-demographic variables, but also health-related variables such as height, weight and self-reported health status that can help minimize unobserved heterogeneity and potential omitted-variables bias in statistical-model estimation. Using the survey results, they developed econometrics models and analytical tools for identifying the factors influencing how often registered users use bikesharing, and assess whether and how much their bikesharing use is displacing an auto trip. Their estimated statistical models provide insights into how various survey respondents behave with regard to bikesharing decisions.

Traffic safety is another important dimension at the nexus of transportation and health. In an urban setting, interactions between vehicles and pedestrians at signalized intersections give rise to potential conflicts when vehicles make a right or permissive left turn and pedestrians simultaneously use the crosswalk. California's Department of Transportation (Caltrans) suggested a prototype device to enhance the pedestrian signal indications with yellow LED ring border that activates when the call button is pushed. To evaluate the safety benefit of the yellow pedestrian border (YPB) signal in a more diverse setting, researchers measured and compared different type of conflicts, violations, and extra-push events for before and after YPB installations. Forty prototype YPB modules were manufactured to conduct the evaluations at five intersections, and data for each location was collected by video and reviewed for before and after condition for seven consecutive days, 16 hours each day. The study revealed that YPB signals have significant impact on the pedestrians' behavior by reducing the overall no-push, extra-push, and violation events. The cumulative average of no-push, extra-push, and violation events with respect to pedestrian volume showed a decrease of 22%, 34% and 45%, respectively. Thus, from the pedestrian safety perspective, the addition of YPB significantly improves pedestrian behavior.

Caltrans Crew installing the YPB.

It is also crucial that transportation asset management (TAM) decision-making incorporates the needs of all users, particularly Vulnerable Road Users (VRUs) including pedestrians, cyclists, motorcyclists, and persons with disabilities, in order to promote safe transportation options that foster healthy lifestyles, as well as reduce greenhouse gas emissions. A recent project developed a methodology framework that incorporates VRU safety into TAM decisions, and provides guidelines to practitioners for its implementation. A Vulnerable Road User Safety Index (VRUSI) has been developed for the evaluation of the safety of road infrastructure components from the perspective of the pedestrians. This VRUSI currently represents pedestrians level of comfort, pedestrian level of traffic stress, and the pedestrian intersection safety index, which can be expanded to other user groups. This VRUSI is recommended as a main input to rank projects and allocate budgets in TAM programs. The Dynamic Bubble Up (DBU)

technique is adopted as the ranking approach to prioritize transport infrastructure projects that could achieve the greatest benefits of VRU safety and service.

Publications

Journal publications

1) Ma, R., Zhang, H.M., The Morning Commute Problem of Heterogeneous Ridesharing Travelers, *Transportation Science*, Under Review.
2) Menon, N., Barbour, N., Zhang, Y., Pinjari, A., Mannering, F., Shared Autonomous Vehicles and their Potential Impacts on Household Vehicle Ownership: An Exploratory Empirical Assessment, International *Journal of Sustainable Transportation*, 2018, DOI: 10.1080/15568318.2018.1443178.
3) Hu, Y., Zhang, Y., Shelton, K.S., Where are the Dangerous Intersections for Pedestrians and Cyclists: A Colocation-Based Approach, *Transportation Research Part C: Emerging Technologies*, 2018, Volume 95, Pages 431-441, DOI: 10.1016/j.trc.2018.07.030.
4) Barbour, N., Zhang, Y., Mannering, F., A Statistical Analysis of Bikesharing Use and Its Potential as an Auto-Trip Substitute, *Journal of Transport Health*, 2019, Volume 12, Pages 252-262, DOI: 10.0.3.248/j.jth.2019.02.004.
5) Kastner, P., Dogan, T., A Cylindrical Meshing Methodology for Annual Urban Computational Fluid Dynamics Simulations for the Built Environment, *Journal of Building Performance Simulation*, Under Review.
6) Gurram, S., Stuart, A.L., Pinjari, A.R., Agent-based modeling to estimate exposures to urban air pollution form transportation: Exposure disparities and impacts of high-resolution data, *Computers, Environment, and Urban Systems*, 2019, Volume 75, Pages 22-24, DOI: 10.1016/j.compenvurbsys.2019.01.002.
7) Chen, Z., Guo, Y., Stuart, A.L., Zhang, Y., Li, X., Exploring the equity performance of bike-sharing systems with disaggregated data: A story of Southern Tampa, *Transportation Research Part A: Policy and Practice*, Under Review.
8) Guo, Y., Chen, Z., Stuart, A.L., Zhang, Y., Equity assessment for economic, environmental, and public health outcomes of transportation; From conventional to emerging technologies, *Transport Reviews*, Under Review.
9) Xu, X., Schreiber, D.S.P., Lu, Q., Zhang, Q., A GIS-Based Framework creating Green Stormwater Infrastructure Inventory Relevant to Surface Transportation Planning, *Sustainability*, Volume 10, Page 4710, 2018, DOI: 10.3390/su10124710.

Books or other non-periodical, one-time publications

Nothing to report.

Other publications, conference papers and presentations

1) Gurbuz, O., Jauregui, X. Cheu, R.L., Development of Demand and Pricing Models for University Campus Parking, TRB Annual Meeting Extended Abstract, 2019.
2) Kastner, P., Dogan, T., Streamlining meshing methodologies for annual urban CFD simulations, ESIM Conference, 2018.
3) Kastner, P., Dogan, T., Towards High-Resolution Annual Outdoor Thermal Comfort Mapping in Urban Design, International Building Performance Simulation Association Conference, 2019, Under Review.
4) Dogan, T., Samaranayake, S., Saraf, N., Urbano-A New Tool to Promote Mobility-Aware Urban Design, Active Transportation Modeling and Access Analysis for Amenities and Public Transport, SimAUD, 2018.
5) Guo, X., Liu, Y., Samaranayake, S., Solving the School Bus Routing Problem at a Scale via Compressed Shareability Network Authors, 2018 IEEE International Conference on Intelligent Transportation Systems, 2018, DOI: 10.1109/ITSC.2018.8569656.
6) Gurbuz, O., Jauregui, X., Cheu, R.L., Development of Demand and Pricing Models for University Campus Parking, TRB Annual Meeting Extended Abstract, 2019.
7) Li, W-W., Chavez, M., Jeon, S., Ramirez, I., Urbina, A., Vallamsundar, S., Farzaneh, R., Contribution of traffic emissions to near-road $PM_{2.5}$ air concentrations as implied by urban-scale background monitoring, TRB Annual Meeting Conference Proceedings, 2019.
8) Li, W-W., Jeon, S., Chavez, M., Ramirez, I., Rangel, A., Urbina, A., Vallamsundar, S., Farzaneh, R., Determination of background $PM_{2.5}$ concentrations for a potential transportation project site, TRB Annual Meeting Conference Proceedings, 2019.

Policy Papers
Two policy papers were completed, The air quality and health impacts of projected long-haul truck and rail freight transportation in the United States in 2050, and Potential impacts of electric vehicles on air quality and health endpoints in the Greater Houston Area in 2040.

The first addressed diesel emissions from freight transportation activities that are a key threat to public health. This study examined the air quality and public health impacts of projected freight-related emissions in 2050 over the continental United States. Three emission scenarios were considered: (1) a projected business-as-usual socioeconomic growth with freight fleet turnover and stringent emission control (CTR); (2) the application of a carbon pricing climate policy (PO); and (3) further technology improvements to eliminate high-emitting conditions in the truck fleet (NS). The PO and NS cases are superimposed on the CTR case. Using a WRF-SMOKE-CMAQ-BenMAP modeling framework, we quantified the impacts of diesel fine particulate matter ($PM_{2.5}$) emissions change on air quality, health, and economic benefits. In the CTR case, we simulate a widespread reduction of $PM_{2.5}$ concentrations, between 0.5-1.5 μg m-3. This translates into health benefits of 3,600 (95% CI: 2,400 – 4,800) prevented premature deaths, corresponding to $38 (95% CI: $3.5 – $100) billion. These results support that a combination of continuous adoption of stringent emission standards and strong improvements in vehicle technology and fuels are necessary, as well as rewarding, to meet the sustainable freight and community health goals.

In the second study, multiple scenarios were developed to understand how future fleet electrification and turnover of both gasoline and diesel vehicles affect air quality and health in the Houston area. These scenarios considered increased vehicle activity and various configurations of emissions controls. Comparing to a base year of 2013, model predictions for 2040 indicated a ~50% emissions increase in the Business As Usual (BAU) case, and ~50%, ~75%, and ~95% reductions in the Moderate Electrification (ME), Aggressive Electrification (AE), and Complete Turnover (CT) cases, respectively. Health impact results suggest that increased O_3 and $PM_{2.5}$ concentrations from the BAU case will lead to 122 additional premature deaths with respect to 2013. However, reduced emissions for the control cases will prevent 114-246 premature deaths. Additionally, about 7,500 asthma exacerbation and 5,500 school loss days will be prevented in the ME case, benefiting younger individuals. The economic costs (benefits) generally followed the same trends as health impacts. The electricity projections for Texas indicate an increasing share of renewables. Hence electrification could avoid fossil fuel sources. States that rely on fossil electricity (e.g., Northeast) would need to adapt to cleaner sources to minimize the air quality impacts.

Website(s) or other Internet site(s)
Websites http://ctech.cee.cornell.edu/, https://urbano.io/, and https://www.hbuddy.org/ are continuously being updated. Three new project videos were created, all seven produced to-date can be found at http://ctech.cee.cornell.edu/project-videos/. Amy L. Stuart completed a video highlighting her passion for environmental health which can be found at https://www.youtube.com/watch?v=yeCSD-FEDQQ&list=PL61EAAC2BB13A965Eo&index=1. In addition, H. Oliver Gao produced the following systems conversation YouTube videos that are relevant to transportation, environment, and community health.

https://www.youtube.com/watch?v=840lrJLS6iY
https://www.youtube.com/watch?v=qQk2l9SybcE&t=25s
https://www.youtube.com/watch?v=74eiSyBUMbY
https://www.youtube.com/watch?v=BKDwYijR_CE&t=123s

New methodologies, technologies or techniques
While considering a road-ban problem in hazardous materials (hazmat) transportation, researchers led by Changhyun Kwon, formulated the problem as a network design problem to select a set of closed road segments for hazmat traffic and obtained a bi-level optimization problem. While modeling probabilistic route-choices of hazmat carriers by the random utility model (RUM) in the lower level, we considered a

risk-averse measure called conditional value-at-risk (CVaR) in the upper level, instead of the widely used expected risk measure. Using RUM and CVaR, the research team quantified the risk of having hazmat accidents and large consequences, and designed the network policy for road-bans accordingly. While CVaR has been used in hazmat routing problems, this research project is the first attempt to apply CVaR in risk averse hazmat network design problems considering stochastic route-choices of hazmat carriers. The resulting problem is a mixed integer nonlinear programming problem, for which we devised a line search approach combined with Benders decomposition.

An integrated modeling system (WRF-SMOKE-CMAQ-BenMAP) was established in the Gao Research Group to incorporate the Weather Research and Forecasting (WRF) model, the Sparse Matrix Operator Kernel Emissions (SMOKE) system, the USEPA Community Multi-scale Air Quality (CMAQ) model and Environmental Benefits Mapping and Analysis Program (BenMAP) model. By considering fleet turnover, climate policy, and technology evolution, this study examined the air quality and public health impacts of projected freight emissions in 2050 over the continental United States. We quantified the impacts of changes in diesel fine particulate matter ($PM_{2.5}$) emissions on air quality, health, and economic benefits.

The Gao Group also proposed a scalable, non-myopic atomic game for a new smart parking mechanism which seeks to reduce cruising for parking at multiple parking facilities with infinite horizon look-ahead. A non-myopic atomic game is formulated to address parking competition issues through allocating travelers to candidate parking facilities which considers travel time difference for the vehicles, walking time, dynamic pricing, cruising time and parking facility occupancy. This study integrates a social efficiency price which accounts for customer waiting time while searching for parking. We involve the network travel time variation into our dynamic policy and make the game model reflect reality better by the competition of vehicles in both road resources and parking spaces. Results of numerical simulations based on actual San Francisco City parking data indicate that parking lots and parking garages supported by the proposed model increases the average social welfare per vehicle by up to 7%, decreases the number of cruising vehicles and average walking distance per vehicle by up to 80% and 17%, respectively.

Qing Lu's research on pavement rehabilitation methods for reduced life-cycle cost and environmental impact based on multiple pavement performance measures has determined that deterioration of pavement condition will increase both vehicle operating costs and greenhouse gas (GHG) emissions significantly. This project develops a methodology to assist road agencies in selecting optimized flexible pavement overlay strategies that are based on both life cycle cost analysis (LCCA) and life cycle assessment (LCA) of environmental impact. To achieve the objective, three questions are addressed: how to (1) quantify the effect of asphalt overlay design on long-term pavement roughness progression, (2) evaluate the life-cycle environmental and economic impacts of different pavement overlay strategies, and (3) optimize pavement overlay policy for environmental and economic sustainability?

In Michael Zhang's project, Optimal driving of autonomous vehicle platoons on arterial streets to reduce fuel consumption, researchers explored the opportunities offered by connectivity and automation to develop new ways to control traffic on arterial streets to reduce fuel use and travel delays. We consider the case that Connected and Autonomous Vehicles (CAVs) organize in platoons before they enter an intersection, and move like a train. Thanks to infrastructure to vehicle connectivity, the leading CAV in the platoon learns of the signal timing plan just after it enters the approach segment. We then develop an optimization framework to determine the best driving pattern (vehicle trajectory) for the CAV platoon from the time it enters the upstream of the intersection to the time it leaves the intersection, with minimal fuel use and no stopping at the intersection. The numerical results demonstrate that the new control method has better performance than semi-optimized driving and purely human driving, particularly when CAVs have enough space and travel time to smooth their trajectories. The reduction of travel time and

fuel consumption can be as high as 40% and 30% on average, respectively, in the studied cases. This research sheds light on the potential benefits of Autonomous Vehicles and Connectivity on transportation fuel use and travel time savings. The savings on both can be significant, as indicated by our case studies.

Inventions, patents, and/or licenses
H. Oliver Gao filed two invention disclosures, 1)CU PPS-The Next Generation Web-based Post-Processor Integrating MOVES and Travel Demand Models for Transportation Emissions Estimation and Conformity Assessment, and 2) a scalable non-myopic atomic game for smart parking mechanism.

Other products, such as data or databases, physical collections, audio or video products, application software or NetWare, analytical models, educational aids, courses or curricula, instruments, equipment, or research material
In automotive engines, sensors are used to measure and/or monitor the oxygen partial pressure in the combustion process. Therefore, oxygen sensors play a vital role in improving a vehicle's fuel efficiency and minimizing its emissions. Oxygen sensors should be stable in high temperature environments and sensitive to minor variations in oxygen levels. In the past two decades, various materials have been studied for oxygen sensor applications. Doped perovskite materials exhibiting temperature independent conductivity, potentially has great advantages over traditional doped metal oxides. Ramana Chintalapalle led researchers to design, develop, characterize, and demonstrate the feasibility of smart sensors for utilization in advanced transportation and pollution reduction. The project objectives are to: (1) fabricate oxygen sensors made of doped perovskite for combustion engines, and (2) demonstrate the temperature independent and smart characteristic features of doped perovskite sensors for emission control and fuel efficiency. The project team developed perovskite ceramics for sensing applications. A fine balance between Ta and Fe on A and B sites of barium oxide was instrumental in this project.

While improving technologies on the supply side is important for cleaner and healthier transportation, human behavior and demand management are even more important, given that transportation is a demand-driven service. Designing virtual reality experiments for analyzing demand for active transportation is an emerging technique in travel behavior research. The expectation is that, by pioneering in this area we will have an impact on how experiments are designed in the field. The Daziano Research Group has developed 28 virtual cycling conditions in urban areas that will be used to simulate behavioral experiences for research experiments. In parallel, Timur Dogan and Samitha Samaranayake developed a new, circular meshing approach for the Urbano software toolkit for simplified, automated, and accelerated mobility simulations in design that explicitly take into account human behavior with the provision of air pollution exposure information using computational fluid dynamics (CFD).

Electronic health record (EHR) data have emerged as a longitudinal data source to uncover the associations between the environment and health. Researchers aim to identify built environmental factors that are associated with heart failure (HF) progression using EHR. They are doing so by first building a unique and rich database. Leveraging the 10-year EHR data from a health system in New York City (NYC), researchers linked HF patients' longitudinal clinical information in EHRs with public data on air pollution, transportation, land use, and accessibility. This study is among the first to use EHRs to study the association of HF progression and built environment risk factors. A cohort of HF patients in NYC who initially had normal ejections were identified. Patients' EHR data were linked with public data on transportation, air quality, land use, and accessibility to identify built environment risk factors for HF progression across NYC and within NY Boroughs. Out of this project researchers have developed a longitudinal database containing patient health information extracted from the EHR at 53 sites of Weill Cornell Medicine and two campuses of the NewYork-Presbyterian Hospital. It contains over 1,566,917 patients from 2012 to 2018. The number of unique clinical classes and drug classes are 1814 and 486, respectively. Data are updated every three months to provide new encounter information in the database. The database is stored in a Microsoft SQL server, securely managed by Weill Cornell Medicine's Information Technology Services. This database has been used to explore the opportunity for integration

with the EHR's clinical decision support system. While healthcare service providers may not be familiar with the individual neighborhoods that patients reside in, information about the land use and availability of resources are readily available through governmental agencies. These insights may allow early identifications of HF patients who can benefit from more monitoring and support to improve healthcare delivery and patient outcomes.

Our efforts continue toward engaging students, specifically K-12, females, and underrepresented minorities. On this front, Ricardo Daziano trained a female, engineering undergraduate student to support running behavioral cycling experiments; Urbano is credited for Dogan's successful recruiting of a female graduate student, Yang Yang, to the M.S. degree program in Art, Architecture, and Design; and YiYe Zhang and Jyotishman Pathak are hosting high school seniors for a 2019 summer internship where they will be studying the impact of the built environment and postpartum depression.

Additional products include:

- A video recording system developed by Michael Zhang for five intersections in California to record vehicle-pedestrian interactions and study the safety impact of a new traffic control device called Yellow Pedestrian Border.
- A database of parking data from 208 universities, obtained from the internet, that was used to develop models in a project led by Kelvin Cheu, entitled Characterization of University Parking Systems.
- A new summer course was developed by Yu Zhang entitled Airport Management. It will cover the planning, design, and operation of sustainable airports, considering the environmental and health impacts of airports to local communities, as well as to climate change.
- 13 video lectures were developed by Francis Vanek to support a 'flipped classroom' course at Cornell entitled Introduction to Transportation Engineering.
- Ricardo Daziano teaches graduate level course Microeconomics of discrete choice every fall semester. However, for the first time, elements of modeling active transportation were included in the course content in this reporting period.
- Sirietta Simoncini developed a project for the course Design Thinking for Complex Systems that was focused on local campus mobility issues. The object was to propose sustainable solutions that would align with the Cornell campus mobility goal of carbon neutrality by 2035.
- YiYe Zhang incorporated environment and health impacts in teaching the design of health information systems. She also provides health data for a Ph.D. student, Leo He, in predicting health outcomes using the built environment.
- Yu Zhang worked with the Pasco-Hernando State College (PHSC), a community college, on a pathway for PHSC students to transfer to USF if they meet the requirements for the College of Engineering.
- Cornell University transportation graduate students were TAs for CEE5900 Project Management. H. Oliver Gao, was an advisor for Sustainable Mobility student projects and for System Engineering and Computer Science M.Eng. student projects that incorporate environmental dimensions.
- Qiong Zhang received a GAANN fellowship as a co-PI, supported by the Department of Education, with the focus of water and transportation infrastructures. The program will support Ph.D. students, especially underrepresented minorities, conducting research at water-transportation nexus. This GAANN fellowship will train Ph.D. students for impactful career paths in higher education and/or research that will influence how we design and manage water and transportation infrastructures.

T2 Plan Output One - dissemination activities - number of seminars and/or webinars – goal of 8 annually and T2 Plan Output Two – number and stakeholder mix in dissemination activities – number of stakeholder attendees at seminars and webinars – goal of 200 annually.

To-date, over 100 individuals have either watched the broadcasts, or attended in person or in group viewings, the new **Impacts of Transportation and Urban Systems on Health and the Environment Webinar Series**. At the first, Multimodal Planning for Florida's Strategic Intermodal System (SIS), Florida Department of Transportation (FDOT) Systems Implementation Office Manager Huiwei Shen, SIS Planning Manager Chris Edmonston, and SIS Administrator Jennifer King shared how the SIS plans for multimodal facilities. SIS represents the state's largest and most significant transportation facilities including airports, spaceports, seaports, rail corridors, passenger terminals, transit, waterways, and highways, and serves as the primary avenue for implementing Florida's long-range transportation vision.

The second, Where Matters: Health and Economic Impacts of Where We Live, was presented by Dr. Lawrence D. Frank, University of British Columbia. He shared new evidence that links features of the built and natural environment with physical activity, obesity, diabetes, cardiovascular disease, stress, and sense of community were presented. These finding were based on large scale health surveillance databases (40,000-50000 N) with address information spatially linked with detailed measures of regional transportation accessibility, walkability metrics, and green space. Results have been integrated into decision-support scenario planning tools (California and National Public Health Assessment Models) designed to predict health impacts of contrasting land use and transportation investment proposals at the neighborhood, corridor, and regional scale.

The third, The Equal Distribution of Freedom, was presented by Beth Alden, Director Hillsboro MPO. She discussed the intersection of access, public health, safety, and multimodal transportation investments in Tampa and Hillsborough County, reflecting on the use of tools such as scenario planning and performance-based programming to collaboratively reshape priorities in our community.

4. OUTCOMES

CTECH researchers applied the equity analysis framework to evaluate the equity impact in terms of economy, environment and public health of the Coast Bike Share System in South Tampa. The main findings and outcomes of the case study include the following: 1) From the horizontal perspective, the distribution of bike-sharing accessibility is highly skewed among both the population and the geographic space in southern Tampa, with both Gini indexes higher than 0.95. Geographic mapping analysis reveals that the accessibility is concentrated in areas within and around downtown Tampa; 2) From the vertical perspective, the bike-sharing accessibility is not evenly distributed among different sociodemographic groups. Overall, the bike-sharing accessibility is higher for whites, Asians, non- Hispanic, male, middle and upper income classes, and people aged between 18 and 45 and over 65. However, the distributions change substantially with the accessibility level for some individual attributes, such as race, income level and age; 3) The bike-sharing accessibility in southern Tampa is relatively low due to its low density and the large portion of long-distance travel. By considering the "walking-cycling-walking" process in a bike-sharing trip and the trip chaining in individuals' travel itinerary, the proposed method avoids overestimating the bike-sharing accessibility. This finding demonstrates the necessity and importance of the proposed tour-based modeling approach; and 4) The disaggregated data enable us to analyze the horizontal and vertical equity at the individual level, which unveils many important messages that might be absorbed with existing methods using aggregated data. Indeed, aggregated data (e.g., mean) may dilute the disparities among individuals, which might mislead our understanding of the equity issue from both the horizontal and vertical perspectives. Thus, it is helpful to incorporate disaggregated data into transportation equity analysis.

Results from the health perception study of bikesharing provide scientific-foundation for development of understanding and guidance for bikesharing mechanism design. Household composition and vehicle ownership were found to be some of the key factors in decisions related to bikesharing behavior. It was also found that the lingering effects of auto reliance (reflected by respondents who indicated that most

often commuted by driving alone) adversely affected the likelihood of a registered bikesharing user using bikesharing frequently or substituting their bikesharing trip with a non-auto mode. Finally, the model estimations did not show that self-reported health-related factors other than BMI played a significant role in bikesharing use and behavior. While the self-reported health question was unable to produce statistically significant results, variables derived from actual detailed health data may still prove valuable in future research on bikesharing behavior.

On traffic safety, the yellow pedestrian border (YPB) signal is a new traffic control device intended to improve pedestrian safety at signalized intersections developed by Caltrans. The CTECH study confirmed that the YPB has a positive impact on traffic safety in the sense that it significantly reduced signal violations by pedestrians.

For policy lessons in urban and transportation planning, researchers found new evidence of the impacts of environmental and social determinants on heart failure in New York City. Evaluating the role of the built environment in public health in a more accurate and comprehensive way, the study intends to find what built environment factors should be planned for that favor improving public health. Among the built environment factors, land use, traffic, and air pollution measures significantly increase the risk of death in heart failure patients by 47.2%, 35% and 14%, respectively. The results have two major implications, 1) combining smart growth strategies with technology solutions such as fleet electrification in order to balance out the benefits of placing people close to high amounts of pollution, and 2) urban infrastructure can enhance public health if blended in the early planning stages so the complex interactions are accounted for.

Additional outcomes include:

- Nicholas Klein studies changes in poor families' lives when they receive a car from the largest vehicle donation program in the country. By analyzing existing survey data and interviewing the recipients of cars, his efforts increased understanding and awareness of how car donation programs improves healthcare access, enables a richer social and civic life, and expands educational opportunities. The body of knowledge from his study helps assess the changes in employment, income, and travel among low-income individuals.
- Amy L. Stuart's work increased the understanding and awareness of health and equity impacts of large-scale transportation improvement programs, as well as the awareness of tools and techniques for considering health and equity in transportation improvement programs.
- An increased understanding and awareness of the associations between health and the built environment resulted from Yiye Zhang's research. Implementation of this outcome has been through dissemination of study findings to stakeholders at Weill Cornell Medicine (WCM) and NewYork-Presbyterian Hospital, as well as at international and local conferences including the Health Informatics Research Seminar at WCM, Biomedical Big Data Symposium at New York City College of Technology, American Medical Informatics Association Annual Symposium, and INFORMS Healthcare.
- Qiong Zhang improved techniques to create green stormwater infrastructure inventory and increased the understanding of environmental benefits of transportation related green infrastructure implementation at large scale. The developed GIS framework can facilitate the creation of green stormwater infrastructure inventory for surface transportation planning in U.S. cities. The integrated hydrology and water quality modeling can assist in making decisions on strategic implementation of green stormwater infrastructure that will reduce the nutrient loading to surface water bodies and improve environmental health.
- Kelvin Cheu, and Ph.D. student Okan Gurbuz, developed two new models for university campus parking studies. Although parking is a part of transportation, and has an impact on congestion, gas consumption and community health, it is unfortunately under researched. Their work on

university campus parking has drawn attention from the City of El Paso as well as UTEP's President, who has directed his staff to provide the institutional data for continuing this research.

- Dogan's and Samaranayake's Urbano.io mobility simulation toolkit has undergone many updates and improvements and is getting close to a public release. In parallel, major breakthroughs regarding the proposed outdoor comfort simulations have been made. A proof-of-concept workflow now allows researchers to simulate perceived heat and cold stress in outdoor environments. This enables us to begin research on the impact of outdoor comfort on active mobility systems in urban environments. The Urbano toolkit and outdoor comfort simulations have been used and extensively tested under real project conditions at Kohn Pedersen Fox. The developed workflows are being used actively in several high profile urban design projects such as the Sidewalk Labs Toronto Waterfront renewal.

***T2 Plan Outcome One* – stakeholder support – number of stakeholders that collaborated with researchers on projects - goal of 8 annually.**

Out of 25 collaborators during the reporting period, thirteen stakeholders formally collaborated on research projects. Stakeholders and their contributions are detailed in the second section above.

***T2 Plan Outcome Two* – cited works – number of reports in media - goal of 8 annually.**

We had two Bloomberg citations, one for Yu Zhang from January of 2018 (not previously reported) by Bloomberg in an article entitled Watch Out, Airlines. High Speed Rail Now Rivals Flying on Key Routes. https://www.bloomberg.com/news/articles/2018-01-09/high-speed-rail-now-rivals-flying-on-key-global-routes. The second was for Nicholas Klein in March of 2019, also by Bloomberg, in an article entitled Don't Expect Car Ownership to Become Obsolete https://www.bloomberg.com/opinion/articles/2019-03-27/millennials-aren-t-making-car-ownership-obsolete.

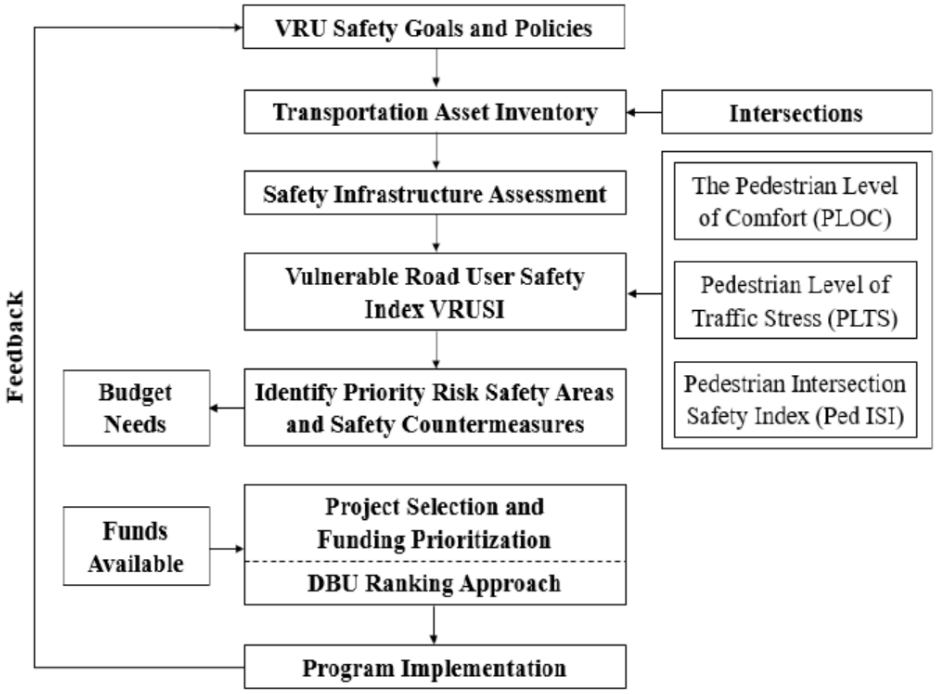
Also, Yu Zhang was cited in an article in Slate on February 12, 2019, entitled There's Nothing Ridiculous About Trains Replacing Planes https://slate.com/business/2019/02/high-speed-rail-in-california-and-the-green-new-deal-it-could-work-in-america-but-were-screwing-it-up.html.

5. IMPACTS

The equity assessment methodology developed for assessment of emerging transportation technologies can be used to evaluate the impact of multiple emerging technologies, such as carsharing, ridesharing, and ridesourcing. The findings from the case study illustrate the importance for policy makers to work with service providers to improve the accessibility of emerging bike sharing program in low-income areas. Yu Zhang, one of the co-PIs on this project will lead a project titled "Performance Evaluation of E-Scooter Sharing Pilot Program in the City of Tampa". She participated in the discussion of the bidding process and conveyed the findings to the City. Thus, in the coming e-scootering sharing pilot program in the City of Tampa, the Request for Application included specific requirements asking prospective service providers to locate certain stations in designated areas to ensure the equal accessibility of sharing system to different social-demographic population.

In addition, the health perceptions study of bikesharing filled in the gaps in existing literature, i.e., how health status or perceived health status affect users' choices of using a bike sharing program. This data expansion was an attempt to minimize unobserved heterogeneity and potential omitted-variables bias in statistical-model estimation. A paper titled "A statistical analysis of bike sharing usage and its potential as an auto-trip substitute" has been published in the Journal or Transport and Health. The survey questionnaire developed in this study is posted online and will continuously receive the inputs from users. The survey questionnaire has also been shared with researchers who are working in this area.

Based on the safety study of yellow pedestrian border (YPB) signals, Caltrans is considering to have YPB included in California's manual of traffic control devices. The adoption in California could lead to YPB being eventually adopted in the MUTCD used nationwide. For vulnerable user protection, the DBU-VRUSI analysis framework serves as a guideline for State Departments of Transportation (DOTs), Metropolitan Planning Organizations (MPOs), and local agencies to prioritize TAM projects and allocate funds that would result in the maximum benefits on VRU safety. Enhancing the safety and quality of the walking mode will lead to positive outcomes on the overall community health. The Figure below shows the Integrated DBU-VRUSI framework.



Additional impacts include:

- Tompkins Consolidated Area Transit (TCAT) is completing the implementation of the new bus stop signage system covering their entire territory. The signage system was designed by students in Design Thinking for Complex Systems, Spring 2017, taught by Sirietta Simoncini, and the Cornell University Sustainable Design - Sustainable Mobility 2017-18 students. The project was awarded with the TOGO award (see above) and has had a big impact in the community. It has promoted awareness of the relevance of our local transit system and facilitated its use. It has contributed to fortifying the liaison between Cornell, local authorities/service providers, and the community at large, where all come together to work toward the achievement of a healthier built environment. In addition, students are exposed to real world complex mobility issues that the local community is currently experiencing. They learn - via a hands-on experience - how to address such complexity in innovative ways, by working in an inclusive/interdisciplinary environment, by addressing both final users' needs and requirements set by local authorities/stakeholders, and by producing sustainable solutions that promote a healthy built environment. A big strength of these projects is that they are all suggested by real stakeholders and therefore they all have potential for quick implementation. Students are asked to constantly interact with the stakeholders, and use the feedback to produce relevant recommendations that can be quickly implemented and make an impact.
- Continual and deliberate improvements over recent years to incorporate content aimed at influencing the environment and community health, and thereby improving the quality of

engineering education in Cornell's School of Civil and Environmental Engineering's introductory course on transportation engineering has led Francis Vanek to say "In my interaction with Cornell engineering students, I perceive that they are becoming more engaged with the challenges and solutions aimed at better outcomes for the impact of transportation on the environment and community health."

T2 Plan Impact One –software applications – number of algorithms, codes, software used by practitioners – goal of 6 annually.

Five practitioners in the modeling group NYMTC used the web-based emissions post-processing software, CU-PPS, developed by the Gao Research Group. It uses the EPA's Motor Vehicle Emission Simulator (MOVES) in conjunction with the New York Metropolitan Transportation Council's (NYMTC's) Best Practice travel demand model. The CU-PPS integrates the US EPA's state-of-the-art emission model and activity-based travel demand model for emissions inventory estimation at a finely resolved link-by-link scale. The most distinguished feature of the PPS includes its Web-based software architecture and its full integration with a Database Management System (DBMS). The web-based architecture allows remote concurrent access to the same software from multiple users, increasing consistency and reducing client resource burden. The use of a DBMS facilitates effective scenario management, better programmability and relational-algebra-based computational optimization techniques. This computational efficiency consequently enables the software to provide a highly-resolved, link or Traffic-Analysis-Zone-level emission inventory to support visualization on GIS systems. The software was recently updated to account for the emission reduction benefit of ITS and signal projects. The updated software continues for official use of transportation conformity assessment in the NYMTC region.

The Dogan and Samaranayake Research Groups shared a pre-release version of Urbano, A New Tool to Promote Mobility-Aware Urban Design, Active Transportation Modeling and Access Analysis for Amenities and Public Transport, with Kohn Pedersen Fox's Urban Interface group, hence it is currently being used by one practitioner (and seven researchers), A public release of Urbano is planned for Summer 2019.

T2 Plan Impact Two – impact on practice – number of research recommendations implemented - goal of 7 annually.

Two of Dogan's and Samaranayake's research recommendations were implemented that resulted from projects entitled *Mobility Aware Integrated Urban Design* and *URBANO: A computational tool-kit for integrated urban design incorporating active transportation, pollution, and outdoor comfort models to facilitate the design of healthy and sustainable urban habitats*. One was a proof of concept outdoor comfort (UTCI) simulation algorithm and the other was a simple, active mobility simulation framework (Urbano.io).

At a Cornell University Community Relations organized Town-Gown (TOGO) Award Ceremony on December 8, 2018 that celebrated the connections between the university and local communities, the CUSD Sustainable Mobility Project, mentored by Sirietta Simoncini, received the TOGO award for the implemented bus route signs project. About 60 engineering Master's degree and undergraduate students, studying design thinking in systems engineering, work on collaborative projects with TCAT each year. In 2018, these students worked with Simoncini and TCAT Service Manager, Matt Yarrow, to design new route signs throughout the TCAT system. About 30 of these students were recognized in person.

6. CHANGES/PROBLEMS

None to report.

7. SPECIAL REPORTING REQUIREMENTS

CTECH Specific Metric: Overarching goals of the Center include the development of a metric for community health that incorporates mobility and health indicators; mobility on-demand models including environmental sustainability indicators; large-scale models to promote environmental sustainability, community health, and environmental justice. During the reporting period, researchers Miguel Jaller et al. took a systems approach to estimating activity and health impacts of first and last mile transit access programs for work and shopping trips using sharing mobility services in the metropolitan area. The advent of pooled ridesharing services provides an opportunity to mitigate the impacts of low occupancy rates, and the revolution brought about by these new service providers seems to be able to overcome the limitations of decade long pool-type strategy efforts. However, the ideals have not fully materialized and there is a general lack of research regarding their effectiveness. Technology and the shared economy have enabled these services with real-time matching of on-demand requests to drivers. There are a number of urban and rural regions in the U.S. studying and pilot testing the integration of these services in the multi-modal transport system, specifically as part of transit access systems. These studies are trying to determine the feasibility and impacts through partnerships between the agencies and shared mobility providers. This project expanded the previously developed simulation and optimization framework to evaluate the program, and assess the health impacts with a case study in the San Francisco Bay Area. In general, the new framework has four main components. The first component includes a macro-simulation of long- and short-term travel decisions using the Metropolitan Transportation Council Activity-based Travel Model One (MTC-ABM). The second is an optimization tool that identifies the pick-up and drop-off (PUDO) and allocates the demand. The third uses the Multi-Agent Transport Simulation (MATSIM) model to simulate the movements from origins to PUDOs, and then to BART stations. Finally, the framework uses the Integrated and Health Impacts Model (ITHIM) to estimate system-level health impacts. The results show that while there could be a modest shift to the service, especially from drive alone users, still the impacts are very small, which translates into almost negligible health impacts. Nevertheless, there could be localized health and emission impact reductions.

Along a similar research line on the topic of ride sharing, researchers Ma et al. conducted a study of the integrated parking and ridesharing pricing/incentives and their social and environmental impacts in metropolitan areas. This research formulates a continuous-time dynamic ridesharing problem for a single bottleneck in the morning commute. Travelers' choice of departure-time and ridesharing mode as groups with heterogeneous values of travel time. Parking is introduced in our analysis for system optimum from the perspective of the system management, where the parking charge is shared among the driver and passengers in a same vehicle. Dynamic parking pricing strategies to achieve the system optimum with no queues at the bottleneck is then derived. The morning commute problem is then converted into a differential complementarity system (DCS), so that the discretized problem can be solved numerically. It is found that in the ridesharing scenario, the travel time can be a piecewise linear function for each early and late arrival time segment of every heterogeneous group, and the corresponding demand rate is a piecewise step function for each group. Such performance is much more complicated, compared to the linear travel time function and constant demand rate for each arrival time segment in solo driver scenario in the literature. The analysis and numerical results further show that under different ridesharing payment policies, the system performances, such as group-specific costs, vehicle-miles-traveled, vehicle-hours-traveled, total costs, would be quite different, which suggests that the ridesharing payment policies should be properly designed to achieve the social, economic and environmental goals.

As a key issue in community health and environmental justice, children living in near-road communities are constantly exposed to traffic-related air pollutants. Their health could be severely impacted by these pollutants both chronically and acutely. Children's health-outcome research typically builds associations between time-resolved pollutant concentrations and specific health outcomes measured at a specific time. A temporal and spatial characterization of children's exposures would fill the data gap between the

exposure concentrations and health outcome measurements. Wen-Whai Li led a project assessing children's spatiotemporal exposures to transportation pollutants in near-road communities. This research characterizes community exposures for three traffic-related air pollutants ($PM_{2.5}$, NO_2, and ozone) with the objectives to 1) develop spatial and temporal pollutant concentration variation patterns, and 2) apportion the differences in exposure concentrations to background concentrations and contributions from major highways. Researchers have (1) conducted air pollution measurements at 3 locations including a near-highway elementary school, a second near-highway location across the highway, and a community location in the project area (Figure * shows air pollution measurement instrument at one of the three locations); (2) obtained traffic information for interstate-highway and arterial roads in the project area of 1.0 mile by 1.0 mile; traffic data includes deployment and collection of tube-counter data at three major roads in the project area (Pershing and Trowbridge Drives, and Altura Avenue), car counting from Texas DOT video footage of US-54, and El Paso MPO's Travel Demand Model estimates for various arterial roads in the project area; field data was used to calibrate Travel Demand Model estimates and create diurnal patterns for weekday, Saturday, and Sunday; (3) calculated emissions rates estimates using EPA's MOVES model to quantify emissions from vehicles during four weekday/weekend time periods: morning peak (AM), midday (MD), evening peak (PM), and overnight (ON); (4) estimated $PM_{2.5}$ background concentrations for the study domain from regional air quality monitors; (5) established a domain of links and diurnal emissions rates for all links analyzed using the EPA's AERMOD dispersion model to create microscale concentration surfaces to study the total exposures in the community.

With the demographic trend of the aging population, improving quality of life for transportation disadvantaged older adults has become imperative. Through a Community-Based Healthy Buddy Program, Siwon Jang's work pairs trained, college-age student volunteers with transportation-disadvantaged older adults in Hillsborough County, Florida. Volunteers meet with an older adult "buddy" to discuss their transportation challenges and individual health and help them identify existing community resources that may improve their mobility and overall quality of life. The program supports the self-efficacy of Hillsborough County's aging population by creating an accessible, personalized web page (https://www.hbuddy.org/) or a printout, containing information on the community transportation and health resources that best fit the needs of the older adult participant. A needs assessment of older adults and a community resource evaluation provided key information for the continued development of the Healthy Buddy Program, in order to better meet the needs of local, transportation-disadvantaged older adults. The needs assessment was accomplished through a combined methodology, including a review of the literature and in-depth, qualitative interviews of a sample of fourteen older adults in the community. Finally, a search of free and low-cost transportation opportunities, health resources, and aging community services, informed the creation of a comprehensive database of resources for older adults in Hillsborough County. These outputs informed the development of the Healthy Buddy Program website.

Center for Transportation, Environment and Community Health Annual Meeting

UC Davis Conference Center, 550 Alumni Lane
November 9, 2018

8:00 a.m. **Continental Breakfast**

8:30 a.m. **Welcome and Center Update**
Felix Wu, University of California, Davis, Associate Dean, Academic Personnel and Research, College of Engineering
Oliver Gao, Cornell University, Director

9:00 a.m. **Michael Zhang, University of California, Davis** - *Transportation Overview*
Caroline Rodier, University of California, Davis - Potential impacts from autonomous vehicles and transit access programs using shared mobility services in the San Francisco Bay Area
Ricardo Daziano, Cornell University - *Active Transportation*
Carlos Chang, The University of Texas at El Paso - *Safety*

10:45 a.m. **Break**

11:00 a.m. **Yu Zhang, University of South Florida** - *Environment Overview*
Amy Stuart, University of South Florida - *Impacts of urban and transportation design on exposures to traffic-related air pollution and exposure equity*
Chintalapalli Ramana, The University of Texas at El Paso - *Smart Sensors in Transportation Systems*
Fraser Shilling, University of California, Davis - *Tracking shoreline conditions to protect infrastructure*

12:45 p.m. **Lunch**

1:30 p.m. **Kelvin Cheu, The University of Texas at El Paso** - *Community Health Overview*
Yiye Zhang, **Weill Cornell Medicine, Cornell University** - *Examining Individual Health and Healthcare Utilization Trend through the Lens of Transportation, Environment, and Communities*
Esmaeil Balal, The University of Texas at El Paso - *Development of a Comprehensive Metric for Transportation, Environment, and Community Health*
Shanjun Li, Cornell University - *Transportation Policies and Equilibrium Sorting: Evidence from Beijing*

3:15 p.m. **Break**

3:30 p.m. **Advisory Board Panel: Challenges and opportunities at the transportation-environment-health nexus**

4:30 p.m. **Natalia Barbour, University of South Florida Ph.D. Candidate** and CTECH Ph.D. Dissertation and CUTC Student-of-the Year Awardee - *Understanding Adoption Patterns of Shared Mobility and Its Interaction with Health Perception*

4:50 p.m. **Closing Comments**
Oliver Gao, Cornell University, Director

Advisory Board Panel

*Moderator - **Oliver Gao**, Director*

Veronica O. Davis, PE
Partner and Principal Planning Manager
Nspiregreen LLC

Chris Schmidt, AICP
Division Chief of Transportation Planning
California Department of Transportation, Caltrans

Lily Elefteriadou
Barbara Goldsby Professor of Civil Engineering, UFTI Director
Interim Department Chair, Industrial and Systems Engineering
Transportation Institute
University of Florida

Lianne Sheppard
Assistant Chair and Professor, Environmental and Occupational Health Sciences
Professor, Biostatistics
University of Washington

Poster Session 5:00 p.m. to 7:00 p.m.
UC Davis Conference Center, 550 Alumni Lane

Mayra Chavez and Wen-Whai Li – "Assessing spatiotemporal exposures to transportation pollutants in near-road communities using AERMOD"

Zhiwei (Nicklaus) Chen– "Exploring the Equity Performance of Bike-sharing Systems with Disaggregated Data: A Story of South Tampa"

Shuai Pan, Anirban Roy, Yunsoo Choi, ShiQuan Sun, and **H. Oliver Gao** – "The air quality and health impacts of projected long-haul truck and rail freight transportation in the United States in 2050"

Lukai Guo and Qing Lu – "Development of a New Piezoelectric-based Energy Harvesting Pavement System"

Yujie Guo, Zhiwei Chen, Amy Stuart, Xiaopeng Li, Yu Zhang – "Equity Assessment for Economic, Environment, and Public Health Outcomes of Transportation: From Conventional to Emerging Technologies"

Okan Gurbuz, Ximena Jauregui, Ruey Long Cheu – "Development of Demand and Pricing Models for University Campus Parking"

Leo He, H. Oliver Gao – "Environmental and Health Impacts of Intelligent Transportation Systems (ITS) Projects in the New York Metropolitan Area"

Zenghao Hou, H. Michael Zhang – "A model for studying the systemwise impact of walking on pooling strategy"

Siwon Jang, Chanyoung Lee, Sanghoon Park, Savana Wright, Mark Yo, Taylor LaSure, – "Development of the Healthy Buddy Program for Transportation-Disadvantaged Older Adults"

Talha K. Kocak, Robert Bertini, and Amy L. Stuart – "Investigating Air Pollution and Equity Impacts of a Proposed Comprehensive Transportation Program for Tampa"

Rui Ma and H. Michael Zhang – "An analysis of the effect of ridesharing incentives on emissions and fuel consumption in the morning commute"

Miguel Jaller and **Anmol Pahwa** – "Evaluating the Environmental Impacts of Online Shopping"

Elham Pourrahmani, Miguel Jaller, Neil Maizlish, Caroline Rodier, and Michael Zhang – "Automated Vehicles: Simulation of System-Level Travel and Health Effects Using Travel Demand Model and Health Impact Assessment Tool in the San Francisco Bay Area"

Xiaodong Qian, Miguel Jaller, and Debbie Niemeier – "Modeling Framework for Socially Inclusive Bikeshare Services"

Sarder Rafee Musabbir, H. Michael Zhang – "Pedestrian Safety Analysis with Yellow LED Border Light on the Pedestrian Signal"

Matthew Vechione, Corina Marrufo, Alex Vargas, Maria Jimenez, Okan Gurbuz, Assel Dmitriyeva, Ruey Cheu, Natalia Villanueva, Gina Nunez, and Joseph Chow – "Smart Mobility for Seniors: Challenges and Solutions in El Paso, TX and New York, NY"

Chunfu Xin and **Qing Lu** – "Evaluating Environmental and Economic Impacts of Different Flexible Pavement Rehabilitation Strategies"

Xiaofan Xu, Dylan Schreiber, Qing Lu, and Qiong Zhang – A GIS-Based Framework Creating Green Stormwater Infrastructure (GSI) Inventory Relevant to Surface Transportation Planning

Dongfang Zhao and Xiaopeng Li – "Video-based Intelligent Road Traffic Universal Analysis Tool"

Note: Poster presenter names are bolded.