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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 healthy 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 traveler's behavior, new technology, land use and transport policy, community-based programs, etc., all in the context of, and with implications for, the environment and community health. In particular, the following research projects were completed.

- Active Transportation and the emotion-stress-health link: virtual reality for assessing perceptual responses by pedestrians and to the built environment
- 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
- How do car donation programs effect travel, income, and healthcare access among poor families?
- The effects of land-use policy on commuting distance and road related adverse health outcomes
- Potential impacts of electric vehicles on air quality and health endpoints in the Greater Houston Area in 2040
- Do Special Bike Programs Promote Public Health? A case study of New York City's Citi Bike bike sharing program
- Active Transportation and Community Health Impacts of Automated Vehicle Scenarios: An Integration of the San Francisco Bay Area Activity Based Travel Demand Model and the Integrated Transport and Health Impacts Model (ITHIM)
- Implementation of a Community-Based Public Health Buddy Program for Transportation-Disadvantaged Older Adults
- Exploring Social Connectivity and Transportation Needs of the Seniors Through a Mobile Smartphone Application
- Smart Sensors to Reduce Pollutant Emissions in Transportation, Phase II

### ***How have the results been disseminated?***

Formal research related oral presentations during the period are detailed below, followed by other dissemination activities.

10-4-19 Barwick, P., University of Texas at Austin, **From Fog to Smog: Evidence from China's Recent Air Quality Disclosure**, Austin, TX.

10-12-19 Dogan, T., Urbano Webinar, Online <https://www.performance.network/courses/urbano-mobility-modelling-and-simulation-in-grasshopper3d>.

10-23-19 Zhao, D., INFORMS Annual Meeting, **Large Electric Vehicle Sharing Fleet Management System Interfacing Transportation and Power Systems**, Seattle, WA.

10-23-19 Zhang, Y., INFORMS Annual Meeting, **Hybrid Rebalancing with Dynamic Hubbing for Free-floating Bike Sharing Using Multi-objective Simulation Optimization**, Seattle, WA.

10-24-19 Kwon, C., INFORMS Annual Meeting, **Traffic Equilibrium Tools in the Julia Language: Trafficassignment.jl and Complementarity.jl**, Seattle, WA.

11-8-19 Li, S., University of Kentucky, **From Fog to Smog: The Value of Pollution Information**, Lexington, KY.

11-12-19 Gao, H.O., C2SMART, Center for Urban Science and Progress (CUSP) and the Tandon School of Engineering, **Paradigm shift towards smart and healthy cities – systems innovation at the nexus of transportation, climate/environment, and public health**, New York, NY.

11-13-19 Gao, H.O., International Parking and Management Institute, **Paradigm shift towards smart and healthy cities – systems innovation at the nexus of transportation, environment, and public health**, New York, NY.

11-19-19 Gao, H.O., AASHTO, **Paradigm shift towards smart and healthy cities – systems innovation at the nexus of transportation, climate/environment, and public health**, Washington, DC.

11-19-19 Gao, H.O., George Mason University, **Paradigm shift towards smart and healthy cities – systems innovation at the nexus of transportation, climate/environment, and public health**, Washington, DC.

11-19-19 Zhang, M., California Department of Transportation, **An evaluation of travel times from different data sources**, Sacramento, CA.

11-20-19 Gao, H.O., Georgetown University **Paradigm shift towards smart and healthy cities – systems innovation at the nexus of transportation, climate/environment, and public health**, Washington, DC.

11-20-19 Gao, H.O., TRB Executive Office, **Paradigm shift towards smart and healthy cities – systems innovation at the nexus of transportation, climate/environment, and public health**, Washington, DC.

11-21-19 Gao, H.O., EDF's Leveraging High-Resolution Transportation Data for Healthier Cities, **State of the Science Part 2: Using full-chain assessment to connect the dots**, New York, NY.

11-22-19 Zhang, Y., American Medical Informatics Association, **Association between the built environment and ejection fraction changes among heart failure patients in an urban retrospective cohort study**, Washington, DC.

12-1-19 Li, S., MIT, **Policy Options to Promote Electric Vehicles**, Boston, MA.

12-5-19 Daziano, R., University of Chile, **Immersive Cycling Experiments**, Santiago, Chile.

12-10-19 Daziano, R., Catholic University of the North, **Immersive Cycling Experiments**, Antofagasta, Chile.

1-12-20 Zhang, Y., TRB, **Planning future on-demand urban air mobility**, Washington, DC.

1-12-20 Zhang, Y., Big Data to Biomedical Informatics Program, **Data-driven Evidence from Electronic health Records for Clinical Decision Support: Examples from Two Care Settings**, New York, NY.

On October 4, 2019 CTECH co-sponsored a student competition entitled USF ITE & CTECH Shark Tank Competition where students pitched their research idea or project on transportation to sharks (judges) in a presentation format. The presentations were followed by questions from a panel of USF faculty members.

October 16, 2019, Yu Zhang attended a meeting for local transportation agencies to discuss how to evaluate performance of the e-scooter sharing program in the City of Tampa that was launched in May of 2019. There were approximately 20 attendees from state/local governments, industry, and academia.

November 14, 2019, niche.com organized a Science Fair at the Radford School (K-12 private school) in El Paso, Texas and Ph.D. student Okan Gurbuz served as a poster competition judge. Approximately 50 students participated, and an estimated 30 were from underrepresented minority groups.

On November 20, 2019, Ricardo Daziano invited members of public and non-profit cycling group to participate in in-lab Immersive Cycling Experience experiments. Of the 20 that participated, five were underrepresented minorities.

November 21-22, 2019, the Environmental Defense Fund (EDF) hosted the workshop “Leveraging High-Resolution Transportation Data for Healthier Cities,” in partnership with CTECH and the Texas Transportation Institute (TTI). The workshop was held at the Cornell ILR NYC facility with participants from government, MPOs, and academia. It brought together major stakeholders in urban transportation planning and evaluated how high-resolution modeling of transportation impacts on air pollution and health can facilitate city and regional policymaking. The goal was to identify new opportunities for transportation planning, with an aim to embed air quality and health benefits in shaping real-world policy decisions. The collaboration continues via a working group and research papers summarizing the proceedings, including: (1) an evaluation of the enablers and barriers for full-chain health impact analysis implementation in policy and decision making; (2) recommended best practices for how policymakers, academics and other stakeholders can optimize efforts to collaborate in efforts to leverage high-resolution transportation data to design policies that maximize health benefits from reductions in traffic-related emissions and associated air pollution exposures; and (3) key opportunities where new collaborations across sectors (public and private) and academic disciplines can facilitate scientific innovation that supports implementation and adoption of these best practices. There is an enormous amount of data relevant to the transportation sector that is available to city, regional, and state officials, including telematics, traffic light and streetlight-mounted technologies, air quality monitoring data and satellite data, alongside opportunities for new data collection. Experts in the academic sector are using diverse data sets and sophisticated modeling to provide insight into how transportation emissions are distributed in urban areas, and what impact those emissions have on air quality and health outcomes. Looking to the future, transportation planners are seeking to meet critical priorities like optimizing traffic flow, improving safety and reducing climate emissions, while local governments are developing plans to accommodate multimodal transportation and disruptive technologies like electric and autonomous vehicles. As the transportation sector undergoes these seismic shifts, there is a critical need for good data and robust modeling. By considering the real-world health impacts of transport choices, planners can help create equitable cities that are not only more connected and efficient but are also cleaner and healthier.

As former Immediate Past President of the Chinese Overseas Transportation Association (COTA), Yu Zhang organized the December 6-10, 2019 COTA Global Future Transportation Development Forum in Hangzhou, Jiangsu province, China. Internationally recognized researchers were invited to discuss the trend of future transportation and related policy implications.

On December 7, 2019, student mobility project teams led by Dr. Simoncini, reported their progress to the Cornell University Sustainable Design community (approximately 100). On December 13, 2019, student

teams, also led by Dr. Simoncini, presented their work to stakeholders in an event organized by Systems Engineering at Cornell. Of the two Planning and Shelter teams, one is mapping and studying Cornell campus areas where pedestrian mobility and car traffic are in tension and the other is working on a bus shelter masterplan with a focus on the Cornell campus shelter system, as well as the progress on the bus shelter system design for which they have started a real scale prototype of the medium size shelter. The Garage team reported on the design progress of the City of Ithaca garage signage system in order to get stakeholder feedback before proceeding with the testing phase. The Design Thinking for Complex Systems course, comprised of a mix of Systems Engineering, Regional Planning and Design and Environmental Analysis students, presented their design proposal for a complete review of the Ithaca downtown pedestrian wayfinding system. The design concept was well received, and the project will become an official "Mobility group" M.Eng. project in Fall 2020. This will ensure further development and implementation.

On December 16, 2019, Michael Zhang organized a meeting of CTECH researchers with the California Department of Public Health's Injury and Violence Prevention (IVP) Branch's experts to discuss the use of California Crash and Medical Outcomes Data to collaborate on transportation related health research.

In El Paso, Texas on January 10, 2020, FIRST (For Inspiration and Recognition in Science and Technology) and LEGO organized the FIRST LEGO League (FLL) Competition. FLL is an international competition organized for elementary and middle school students. The students work in teams on solutions to problems related to the theme. The theme of competition in this round was civil engineering. It was held on two Saturdays, and CTECH students Emilliano Ruiz and Fernie Briones, volunteered as advisors of the transportation aspect of the competition as well as acted as judges of the project presentations. Attendance was estimated to be around 100 participants with approximately 80 from underrepresented minority groups.

Rachel Carpenter, Chief Safety Officer from Caltrans organized a briefing on March 24, 2020 where CTECH researchers from UC Davis informed the Chief Safety Officer, the Traffic Safety Program Manager, as well as the legislative director of the California Department of Transportation and their colleagues on their traffic speed limit study, including the setting traffic speed limits on trucks and passenger cars and its impact on traffic fatalities.

***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.

Air Sage	Atlanta, GA	Collaborative Research
Associated Asphalt	Tampa, FL	Other – materials provided for laboratory testing
Atkinson Center for a Sustainable Future	Ithaca, NY	Collaborative Research
Bikewalk Tompkins	Ithaca, NY	In-kind Support, Other – provided mailing list to recruit participants
California Department of Public Health	Sacramento, CA	Personnel exchanges
California Department of Transportation (Caltrans)	Sacramento, CA	Financial Support, Personnel exchanges
Center for Urban Transportation Research (CUTR)	Tampa, FL	Financial Support, Facilities, Collaborative Research
China Automotive Technology Research Center	Tianjin, China	Personnel exchanges
City of El Paso	El Paso, TX	In-kind Support
City of El Paso Parks and Recreation Department	El Paso, TX	In-kind Support, Facilities, Other – data

City of Ithaca	Ithaca, NY	source, feedback Other – task giver, data source, feedback, potential implementer
City of St. Petersburg	St.Petersburg, FL	Collaborative Research In-kind Support, Other – feedback, potential implementer
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 Cooperative Extension Tompkins County	Ithaca, NY	In-kind Support, Other – provided mailing list to recruit participants
Cornell University – Transportation, Facilities, and Campus Services	Ithaca, NY	Other – task giver, data source, feedback, potential implementer
Downtown Ithaca Alliance	Ithaca, NY	Other – task giver, data source, feedback, potential implementer
El Paso Metropolitan Planning Organization	El Paso, TX	Collaborative Research
Environmental Defense Fund (EDF)	Washington, DC	Collaborative Research, Personnel exchanges
Florida Department of Health	Tampa, FL	Other – project contributions
Florida Department of Transportation Central Office	Tallahassee, FL	In-kind Support
Florida Department of Transportation District 7	Tampa, FL	Other – project contributions
Hillsborough Area Regional Transit Authority (HART)	Tampa, FL	In-kind Support, Other – data source, feedback
Hillsborough County MPO	Tampa, FL	In-kind Support, Collaborative Research
Hillsborough County Public Works Department	Tampa, FL	Other – provided GIS data and input on the modeling process
Indian Institute of Science	Karnataka, India	Collaborative Research
Joint Advisory Committee for improving the air quality in El Paso Sunland Park, and Ciudad Juárez	El Paso, TX	Personnel Exchanges, Other – data source, feedback, potential implementer
Kohn Pederson Fox Architects	New York, NY	Collaborative Research feedback, implementer
Lime	San Francisco, CA	Collaborative Research, Other – data sharing agreement, participant recruitment
Lyft	San Francisco, CA	Collaborative Research, Other – data sharing agreement, participant recruitment
New York Metropolitan Transportation Council (NYMTC)	New York, NY	Other – data source,
New York-Presbyterian Hospital	New York, NY	Collaborative Research
Optimus Technologies	Pittsburgh, PA	Collaborative Research
Pinellas Suncoast Transit Authority (PSTA)	St.Petersburg, FL	Collaborative Research, In-kind Support, feedback, potential implementer
Spin	San Francisco, CA	Collaborative Research, Other – data sharing agreement, participant recruitment
Tampa Bay Area Regional Transit (TBARTA)	Tampa, FL	In-kind Support
Tampa Pavement Constructors	Tampa, FL	Other – provide aggregate samples for

Tompkins Consolidated Area Transit (TCAT)	Ithaca, NY	laboratory testing Other – task giver, data source, feedback, potential implementer
Uber	San Francisco, CA	Collaborative Research, Other – data sharing agreement, participant recruitment
USF Water Institute	Tampa, FL	Other – data exchanges
Weill Cornell Medicine	New York, NY	Collaborative Research

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

CARTEEH	College Station, TX	Partner (UTEP)
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

Michael Kleeman is collaborating with Peggy Reynolds, Ph.D., MPH, an Adjunct Professor in the Department of Epidemiology and Biostatistics and the University of California, San Francisco. She will assist the Kleeman Group in helping to analyze the health impact of transportation sources.

Qing Lu is collaborating with Hao Wang, Associate Professor of Civil and Environmental Engineering at Rutgers University. Dr. Wang has research experience in the same field and has provided inputs towards the literature review and model development.

Ricardo Daziano is working with Bilal Farooq, an Associate Professor of Civil and Environmental Engineering at Ryerson University in Toronto, Canada, running virtual reality experiences. Daziano is also working with Charisma Choudhury, an Associate Professor at the Institute for Transport Studies and School of Civil and Environmental Engineering at the University of Leeds, United Kingdom, where he leads the Choice Modeling Research Group. Daziano visited both of their labs to check how the virtual cycling experiences are being implemented.

Michael Zhang is working with Jiong-Shi Pang and Maged Dassouky, both from Los Angeles, on a Caltrans funded research project to evaluate the impact of ridesharing and carpooling on the daily travel patterns and the impact of ridesharing and carpooling on the daily travel patterns in the last six months.

Shanjun Li worked on the project and publication “Does subway expansion improve air quality?” with Yanyan Liu, a Senior Research Fellow at the International Food Policy Research Institute.

Shanjun Li worked on a joint research project with Yatang Lin, Assistant Professor at the *Hong Kong* University of Science and Technology that examines the impact of high-speed rails in China.

### 3. OUTPUTS

Active transportation – cycling and biking – not only are sustainable travel modes with zero environmental impact, but also have associated health benefits. However, in comparison with motorized transportation, the motives underlying demand for active transportation – particularly beyond recreational purposes – is poorly understood, especially because the standard tradeoff between travel time and cost does not apply to active modes (as it is virtually free and usually takes longer). In their project on “Active Transportation, Environment, and Health”, Ricardo A. Daziano and So-Yeon Yoon investigated the factors that explain demand for active transportation with a focus on cycling for utilitarian (commuting) and recreational (leisure) purposes. They have thus described the increasing role of using non-



instrumental attributes, non-standard observed attributes, and extended decision rules. To integrate non-instrumental attributes (attitudes and perceptions) they have proposed an extension to the hybrid choice model (HCM) that considers data coming from virtual-reality environments. In fact, they designed and implemented virtual, immersive city blocks to analyze valuation of cycling infrastructure. Other outputs from the project include: identified roles of non-instrumental attributes (attitudes and perceptions) in explaining demand for active transportation; characteristics of the built environment, such as cycling infrastructure provisions and design, are essential to encourage adoption of active transportation as a regular mode; the use of controlled virtual reality environments is proposed to address the modeling difficulty of the multidimensionality of the built environment characteristics.

Along a closely related line of research, Yu Zhang and Hadi Charkhgard studied “Design of a Hybrid Rebalancing Strategy to Improve Level of Service of Free-Floating Bike Sharing Systems”. For bike sharing systems, the flow of customers can completely change the temporal and spatial distribution of the bikes and cause an imbalance of demand and supply in the system. Thus rebalancing/redistribution of bikes is critical to ensure the efficiency of bike sharing systems. A hybrid rebalancing method is developed in this project by combining a user-based incentive program and operator-based rebalancing to take the advantage of both in free floating bike sharing systems. This method has been featured by a multi-objective technique to optimize the system based on two objectives, cost and service level, which helps decision makers have a better knowledge about the trade-off between these two objectives caused by their decision. In addition, capability of used tools in this method guarantees its applicability on real world scale problems. This technique has been successfully applied on the data collected from Share-A-Bull system at USF.

## Publications

### Journal publications

- 1) Song, H., Lewis, Jr., N., Ballew, M., Bravo, M., Davydova, J., Gao, H.O., Garcia, R.J., Hiltner, S., Naiman, S.M., Pearson, A.R., Romero-Canyas, R., Schuldt, J.P., What counts as an “environmental” issue? Differences in issue conceptualization by race, ethnicity, and socioeconomic status, *Journal of Environmental Psychology*, 2020, Volume 68, Page 101404, DOI: [10.1016/j.jenvp.2020.101404](https://doi.org/10.1016/j.jenvp.2020.101404).
- 2) Amirgholy, M.P., Shahabi, M., Gao, H.O., Traffic automation and lane management: communicant, autonomous, and human-driven vehicles, *Transportation Research Part C: Emerging Technologies*, 2020, Volume 111, Pages 477-495, DOI: [10.1016/j.trc.2019.12.009](https://doi.org/10.1016/j.trc.2019.12.009).
- 3) Sayarshad, H., Mahmoodian, V., Gao, H.O., Non-myopic dynamic routing of electric taxis with battery swapping stations, *Sustainable Cities and Society*, 2020, Volume 57, DOI: [10.1016/j.scs.2020.102113](https://doi.org/10.1016/j.scs.2020.102113).
- 4) Dongfang, Z., Li, X., Cui, J., A simulation-based optimization model for infrastructure planning for electric autonomous vehicle sharing, *Computer-Aided Civil and Infrastructure Engineering*, 2019, Volume 34, Page 19, DOI: [10.1111/mice.12506](https://doi.org/10.1111/mice.12506).
- 5) Yang, Y., Saraf, N., Samaranayake, S., Dogan, T., Urbano: A tool kit to promote active mobility modeling and amenity analysis in urban design, *Technology | Architecture + Design*, 2020, Awaiting Publication.
- 6) Barbour, N., Menon, N., Mannering, F., Shared automated vehicles: A statistical analysis of consumer use likelihoods and concerns, *Transport Policy*, 2019, Volume 80, Pages 86-93, DOI: [10.1016/j.tranpol.2019.05.013](https://doi.org/10.1016/j.tranpol.2019.05.013).
- 7) Guo, Y., Chen, Z., Stuart, A.L., Li, X., Zhang, Y., A systematic overview of transportation equity in terms of accessibility, traffic emissions, and safety outcomes: From conventional to emerging technologies, *Transportation Research Interdisciplinary Perspective*, 2020, DOI: [10.1016/j.trip.2020.100091](https://doi.org/10.1016/j.trip.2020.100091), In Press.
- 8) Menon, N., Zhang, Y., Pinjari, A., Mannering, F., A statistical analysis of consumer perceptions towards automated vehicles and their intended adoption, *Transportation Planning and Technology*, 2020, Volume 43, Pages 253-276, DOI: [10.1080/03081060.2020.1735740](https://doi.org/10.1080/03081060.2020.1735740).
- 9) Lin, P., Guo, R., Bialkowska-Jelinska, E., Kourtellis, A., Zhang, Y., Development of countermeasures to effectively improve pedestrian safety in low-income areas, *Journal of Traffic and Transportation Engineering*, 2019, Volume 6(2) Pages 162-174, DOI: [10.1016/j.jtte.2019.02.001](https://doi.org/10.1016/j.jtte.2019.02.001).
- 10) Chavez, M., Ramirez, R., Li, W., Comparison of Modeled-to-Monitored PM<sub>2.5</sub> Exposure Concentrations resulting from transportation emissions in near-road community, *Journal of Transportation Research Board*, Accepted.

- 11) Han, X., Ma, R., Zhang, M., Energy-aware Trajectory Optimization of CAV Platoons through a Signalized Intersection, *Transportation Research Part C: Emerging Technologies*, Awaiting Publication.
- 12) Li, S., Liu, Y., Purevjav, A., Yang, L., Does subway expansion improve air quality?, *Journal of Environmental Economics and Management*, 2019, Volume 96, Pages 213-235, DOI: [10.1016/j.jeem.2019.05.005](https://doi.org/10.1016/j.jeem.2019.05.005).
- 13) Behnood, A., Mannering, F., Time-of-day variations and temporal instability of factors affecting injury severities in large-truck crashes, *Analytic Methods in Accident Research*, 2019, Volume 23, Page 100102, DOI: [10.1016/j.amar.2019.100102](https://doi.org/10.1016/j.amar.2019.100102).
- 14) Barbour, N., Zhang, Y., Mannering, F., An exploratory analysis of the role of socio-demographic and health-related factors in ridesourcing behavior, *Journal of Transport and Health*, 2020, Volume 16, Page 100832, DOI: [10.1016/j.jth.2020.100832](https://doi.org/10.1016/j.jth.2020.100832).
- 15) Amirgholy, M., Nourinejad, M., Gao, H.O., Optimal traffic control at smart intersections: Automated network fundamental diagram, *Transportation Research Part B: Methodological*, 2019, In Press. DOI: [10.1016/j.trb.2019.10.001](https://doi.org/10.1016/j.trb.2019.10.001).
- 16) Vanek, F., Mode and commodity perspectives on U.S. freight energy consumption and CO<sub>2</sub> emissions: Insights and directions for improvement, *International Journal of Sustainable Transportation*, 2019, Volume 13, Pages 741-760, DOI: [10.1080/15568318.2018.1512690](https://doi.org/10.1080/15568318.2018.1512690).

#### Books or other non-periodical, one-time publications

Nothing to report.

#### Other publications, conference papers and presentations

- 1) Kastner, P., Dogan, T., Towards High-Resolution Annual Outdoor Thermal Comfort Mapping in Urban Design, Building Simulation 2019, At Rome, Italy, April 2020, DOI: [10.26868/25222708.2019.210458](https://doi.org/10.26868/25222708.2019.210458).
- 2) Yang, Y., Samaranayake, S., Dogan, T., Using Open Data to Derive Local Amenity Demand Patterns for Walkability Simulations and Amenity Utilization Analysis, Proceedings of the 37th eCAADe and 23rd SIGraDi Conference - Volume 2, University of Porto, Porto, Portugal, 11-13 September 2019, Pages 665-674 [http://papers.cumincad.org/cgi-bin/works/Show?ecaadesigradi2019\\_627](http://papers.cumincad.org/cgi-bin/works/Show?ecaadesigradi2019_627).

#### Policy Papers

- 1) “What counts as an “environmental” issue? Differences in issue conceptualization by race, ethnicity, and socioeconomic status” addressed how racial/ethnic minorities and lower-socioeconomic (SES) groups in the U.S. face disproportionate environmental risks, which may hold implications for how these groups construe environmental issues, relative to other segments of the public. DOI: [10.1016/j.jenvp.2020.101404](https://doi.org/10.1016/j.jenvp.2020.101404)
- 2) “Shared automated vehicles: A statistical analysis of consumer use likelihoods and concerns” addressed shared automated vehicles’ potential to revolutionize future transportation mode choices. Because shared automated vehicles could be a disruptive transportation modal alternative, understanding the factors that may affect the likelihood of using and possible concerns is extremely important. To do so, a survey of American Automobile Association members asked whether or not survey respondents were willing to use shared automated vehicles if they became available. They were also asked their main concerns associated with this technology (safety, privacy, reliability, travel time or travel cost). Two random parameter logit models were estimated to gain insights into the likely usage/concerns processes. Some of the key variables playing statistically significant roles in the willingness to use shared automated vehicles were ethnicity, household size, daily travel times, and vehicle crash history. Respondents from one vehicle households, that were in close proximity to grocery stores, and had previously been involved in a vehicle crash, were found to be more willing to use shared automated vehicles. Other variables significant in the analysis were the high education indicator and driving alone for commute indicator. With regard to shared automated vehicle concerns, the characteristics of respondents who were more or less likely to be concerned with safety, reliability, privacy, and travel time/travel cost were identified. While the opinions and perceptions towards shared automated vehicles are likely to fluctuate in the coming years as more and more information

relating to the potential of such sharing becomes available, the findings provide an important initial assessment before this technology becomes widely available to the public. The more that is known about shared automated vehicles and their early adopters, the better and more seamless the potential modal transition can be. Learning what groups of people are more or are less willing to use this technology will help to improve the overall mobility of all. Combining the significant variables provides a rough profile description of early users of shared automated vehicles and their environment. This helps to prioritize possible investments and allows the policy and auto makers to identify the critical needs of the users. This initial assessment provides the characteristics of early adopters and their travel behaviors. The model estimation results clearly show that different socio-demographic groups value different aspects and have different concerns relating to shared automated vehicles. DOI: [10.1016/j.tranpol.2019.05.013](https://doi.org/10.1016/j.tranpol.2019.05.013)

#### **Website(s) or other Internet site(s)**

Websites <http://ctech.cce.cornell.edu/>, <https://urbano.io/>, and <https://www.hbuddy.org/> are continuously being updated. Two new project videos were created, “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” and “Smart Sensors to Reduce Pollutant Emissions in Transportation”. They can be found at <http://ctech.cce.cornell.edu/project-videos/>.

#### **New methodologies, technologies, or techniques**

The advent of autonomous driving technologies has created a crucial need for upgrading conventional traffic control and lane management strategies in large cities. In the Gao Group’s recent paper titled “Traffic Automation and Lane Management: Communicant, Autonomous, and Human-Driven Vehicles”, published in Transportation Research Part C: Emerging Technologies, they designed an optimal lane management strategy for corridors with a heterogeneous demand of human-driven, autonomous, and communicant autonomous vehicles (HVs, AVs, and CAVs). In a monocentric city setting, they dynamically control the inflow of the network by optimizing the size of CAV platoons in the corridors based on the instantaneous condition of the integrated system. These corridors can potentially have three types of lanes for vehicles with different levels of automation technology. They model the multiple lane type corridors as sets of parallel bottlenecks with general distributions of multiclass demand. The dynamics of the congestion in the network was also modeled using the macroscopic network fundamental diagram (MNFDD). To study the impacts of the rise in the penetration rate of AVs and CAVs on the performance of the system, they derived a closed-form representation of the model. They showed that the increase of the delay in the network with the rise in the penetration rate of AVs and CAVs can have a stable, an unstable, or a hybrid pattern. To optimize the system, they minimized a weighted summation of the experienced delay in the corridors and the total travel time in the urban network by optimizing the number of lanes of each type and the dynamic size of the CAV platoons. The results of the San Francisco case study showed that implementing an optimal lane management strategy can reduce the experienced delay in the corridors up to 78% with a rise in the AV/CAV penetration rate. By dynamically controlling the size of the CAV platoons in the automated highway of the Bay Bridge, they limit the increase of the travel time in the downtown network to as low as 5%.

Electric vehicles (EVs) have a key aspect in reducing the greenhouse gas effect, maintenance, and energy expenditures of drivers. A type of integration of the electric vehicle (EV) charging infrastructure is emerging based on the premise of battery swapping. Drivers can exchange their empty batteries quickly with full batteries from any battery swapping station. The limited battery capacities of electric taxis require visiting the swapping stations during pickup and drop-off tours, which entails choosing the route more effectively to avoid customer delay. In the Gao Group’s recent paper “Non-myopic dynamic routing of electric taxis with battery swapping stations” published in Sustainable Cities and Society, they proposed the dynamic routing of electric taxis with a look-ahead policy using a Markov decision process (MDP) for assigning an electric taxi fleet to customers with the assumption of elastic demand. This is the first model that focuses on the design of a non-myopic routing of electric taxis that considers the limited

battery capacity through serving customers, detours of the taxi drivers to battery swapping stations (BSS), and integration of customers' delay and the system cost into a dynamic non-myopic pricing policy under the objective of maximizing social benefit. Using battery recharging locations and taxicab trip data in New York City, they showed an improvement in average social welfare, due to use of clean and smart taxi routes based on the proposed dynamic non-myopic routing policy, by up to 8% compared to the routing problem without a look-ahead policy.

Dogan and Samaranayake continue to develop <https://urbano.io/> which is the tool for mobility modeling and simulation in Rhinoceros and Grasshopper. New active mobility related design metrics were introduced for use in urban design as part of the "Urbano.io" active mobility, free and open, modeling software. Significant advances in modeling outdoor comfort and thermal stress in urban environments were made. Urbano has been released publicly and, to-date has been downloaded more than 2,000 times. Urbano is an easy-to-use, urban design tool that can import and translate urban data into actionable urban design feedback using active mobility simulations. The tool evaluates accessibility and utilization of amenities, streets, and public spaces and introduces two new urban design metrics called Streetscore and Amenitiescore, and an expanded version of the well-known Walkscore. The tool and metrics have been tested in a series of academic case studies as well as in industry with Kohn Pederson Fox Architects (KPF). The research that led to this tool advances the understanding of the mobility systems during the urban design process through user-friendly computational modeling, visualization interfaces that can cope with spatial and temporal data sets. Given the enormous construction and planning efforts needed in light of urbanization and population growth, the potential impact of the proposed tool that facilitates the design of better urban environments is significant if widely adopted. Further, this research is expanding the scientific workforce capable of studying and managing mobility systems as it lowers the barrier of entry to complex simulations. Urbano is used in classes taught in Architecture Art Planning (Cornell) and in other universities. In addition, this research aims to yield directly applicable results and hence closely collaborates with design practitioners to solicit their feedback and to test research outcomes on real-world projects and problems. The KPF-Cornell collaboration led to several implementations of Urban in design and a joint project conducted with Sidewalk Labs in Toronto.

Yiye Zhang's Group has developed a prediction model for postpartum depression that leverages electronic health records and patients' social determinants of health. They have also subtyped pregnant women using electronic health records and studied the association between subtype membership and the built environment. They are currently developing an algorithm to extract mother-infant information from electronic health records to enable follow up studies on the built environment influence on maternal and infant health. Lastly, they are building a dashboard that can display relevant information to care providers. All of this increases the understanding and awareness of the associations between the built environment and maternal and infant health.

In the research project "Design of a Hybrid Rebalancing Strategy to Improve Level of Service of Free-Floating Bike Sharing Systems", the Zhang Group at USF proposed a new rebalancing method for bike sharing systems by combining incentive program and operator-based rebalancing operations. This method could significantly reduce the GHG emissions caused by operator-based bike rebalancing, mainly relying on crew members driving vehicles to pick up and drop off bikes to balance the demand and current locations of bikes. Studies in existing literature show that the GHG emissions caused by operator-based rebalancing dominate the life cycle GHG emissions of bikes. In their study, the hybrid method first designs an incentive program, determining the time of day when the incentive program will start and what the incentive level is. With this incentive program, users will help put bikes back into areas that potentially have more demand than supply. At the end of the day, if there is still a mismatch between the demand in the early morning of next day and the location of bikes at the end of current day, operators will use the vehicles to perform a static complete rebalancing. Experimental results show that the hybrid

method with daily dynamically determined hub locations (areas with concentrated imbalance) could significantly reduce GHG emissions of free-floating bike sharing systems.

Michael Zhang's Group developed a new control method to reduce fuel consumption for a platoon of autonomous vehicles through an intersection. It uses optimal control theory and a traffic flow model for autonomous vehicles and demonstrates substantial fuel and travel time savings in the simulation tests (up to 40%).

Ricardo Daziano and So-Yeon Yoon have designed and implemented a protocol for discrete choice experiments with immersive virtual experiences. They have also created a set of 28 virtual cycling scenarios, with corresponding videos. These videos are part of the immersive in-lab experience to collect behavioral data. 24 of the cycling scenarios have been implemented in a discrete choice experiment. 55 Cornell students have participated in the immersive experience and completed an online survey. Analysis and modeling of the data is underway.

### **Inventions, patents, and/or licenses**

The USF team developed a dynamic and time-continuous optimization model seeking a near-optimum design of charging station locations and EV (electric vehicles) operations. By discretizing the model, they proposed a Monte Carlo simulation model to evaluate the total system cost for a study area and the associated vehicle operation policies in an EV sharing system. An intellectual property disclosure was submitted at USF and resulted from a year four CTECH project entitled "Vehicle-based Sensing for Energy and Emission Reduction".

### **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**

Additional products include:

- Ricardo Daziano incorporated two case studies involving analysis of demand for active transportation as part of his Cornell graduate course, Microeconometrics of Discrete Choice; both were part of graded homework assignments.
- In a course entitled Transportation and Energy Systems at Cornell, Oliver Gao gave a guest lecture on linking transportation and public health.
- Sara Brammell, President and Qualified Airport Wildlife Biologist for Blue Wing Environmental where she focuses her efforts on wildlife hazard management, assessments, and training. She held a seminar at USF on November 1, 2019 titled "Aviation and the Environment: A focused look at Wildlife Hazards at Airports".
- Amit U. Raysoni, Ph.D., M.P.H., presented a seminar at UTEP titled "Air Pollution Issues in the Rio Grande Valley Region of South Texas."
- Amy Stuart gave a talk about research on environmental and health impacts of urban and transportation design in a course titled Transportation and Land Use at USF.
- Michael Zhang incorporated the environmental and health impacts in the performance measures to evaluate transportation systems beyond the traditional travel delay measures into two existing courses at UC Davis, Transportation Systems Operations and Urban Congestion and Control.
- Jorge Martinez, Manager of Walter P Moore's El Paso office gave a seminar to the ITE Student Chapter at UTEP on his experience as a contributor toward several local transportation projects. Martinez also volunteers his time as an industrial mentor for the transportation components of a two semester, senior design course that is mandatory for graduating civil engineering seniors at UTEP. Students work in groups of five to design facilities such as schools, libraries, parking garages, museums, recreation centers, warehouses, hotels, etc. They typically have to design



foundation, structural, drainage, parking, traffic circulation, traffic impact assessment and mitigation, construction arrangement elements while taking sustainability into consideration. Volunteers like Jorge Martinez serve on panels, typically one in each sub discipline in civil engineering to provide practical, real-world advice.

- Timur Dogan incorporated the Urbano.io tool into his lecture class and architecture and urban design students at Cornell used urbano.io in studio projects. In addition to Cornell, Urbano.io was also used at Polytechnique Montreal, The University of Tokyo, Bauhaus University Weimar, Architectural Association London, Universidad Nacional de Trujillo, Beijing University of Technology, HafenCity Uni, University of Kansas, FH Joanneum Graz, Texas A&M University, Chalmers University Of Technology, National and Kapodistrian University of Athens, German University in Cairo, Cal poly pomona, Lund University, Carleton University, University of the Philippines Diliman, University of Edinburgh, The University of Texas at Austin, Carnegie Mellon University, and the Singapore University of Technology & Design.
- A UC Davis Ph.D. student, Shenyang Chen, guest lectured to high school students in the UC Davis COSMOS program about using drones to collect pedestrian and bike traffic data.
- Changhyun Kwon developed a hybrid agent-based simulation model combined with a SIR compartmental epidemiology model to study the impact of ridesharing on disease transmission.
- Kelvin Cheu added features in Urban Connector smartphone application to include daily travel survey questions.
- Yiye Zhang has created a datamart of Weill Cornell Medicine (WCM) patients age 0 to 89 who visited WCM between 2007 and 2019, with their home location geocoded and linked with available longitudinal health information.

***T2 Plan Output One - dissemination activities - number of seminars and/or webinars – goal of 8 annually.***

The following seven CTECH webinars were facilitated during the reporting period and can be viewed at <http://ctech.cce.cornell.edu/events-2/impacts-of-transportation-and-urban-systems-on-health-and-the-environment-webinar-series/>. Interest and attendance continue to steadily increase.

**Heterogeneous traffic flow: how agent interactions shape collective properties** held November 1, 2019 - Research Assistant Professor, Jia Li from Texas Tech University presented recent research about how the collective properties of traffic flow, such as its equilibrium, aggregate dynamics and stability, are determined by attributes of agents (i.e., drivers/vehicles) as well as how the agents interact.

Understanding connections between the two is crucial to control and operations, e.g., towards designing mechanisms to make mixed traffic flow of autonomous and human-driven vehicles self-organize and self-stabilize. Li provided an explicit characterization of equilibriums attainable by heterogeneous traffic flow in multilane settings, where one class of agents are “type-sensitive”, a property that autonomous vehicles may likely be endowed with. Li also presented simulation evidence along with a heuristic analysis towards explaining spontaneous platoon formation in heterogeneous traffic flow and the role of opportunistic agent behaviors. Finally, Li discussed implications of these results from a control perspective.

**Health Co-benefits of Active Transportation for Greenhouse Gas Mitigation** held November 8, 2019 - Visiting Researcher Neil Maizlish from the Department of Human Ecology at the University of California, Davis discussed the Integrated Transport and Health Impacts Model (ITHIM), which is a scenario-based risk assessment tool that quantifies the health benefits and harms of physically active travel (walking and cycling), road traffic injuries, and fine particulate air pollution in urban transportation systems.

**Safety in Numbers for pedestrians and bicyclists: Implications for public policy** held November 15, 2019 - professional engineer, Peter Jacobsen, spoke about the fact that researchers were surprised to learn

that motorists are a lot less likely to hit someone walking or bicycling if more people walk or bicycle. In contrast, the number of car crashes increases proportionally with the number of cars. The evidence of a prevalence effect implies that injury risk is more than just a matter of physics, and that something occurs with human physiology or psychology. Safety in Numbers likely occurs because humans have difficulty detecting rare items. That injury risk decreases with more walking and biking creates opportunity for implementing public policies for reducing damage to the climate and improving health. This non-linear risk also explains why the recent NTSB recommendation for compulsory bicycle helmet laws could increase injury risk.

**Caltrans' Pedestrian and Bicyclist Safety Program** held November 22, 2019 - Pedestrian and Bicycle Safety Branch Chief from the California Department of Transportation, Rachel Carpenter, discussed California's Strategic Highway Safety Plan's (SHSP) recommendation to develop a pedestrian and bicyclist safety improvement program. She provided an overview of what has been completed since the program's inception in 2016, as well as next steps. Specifics about the 2016 (Pilot) Pedestrian Collision Monitoring Program, the 2018 (Pilot) Bicyclist Collision Monitoring Program, the 2020 Pedestrian Collision Monitoring Program, pedestrian and bicyclist safety training, and modifications to California Manual on Uniform Traffic Control Devices (CA MUTCD) related to pedestrian and bicyclist safety and operations were shared.

**Population-based strategies to improve driving safety** held February 7, 2020 – Professor Linda Hill from the Department of Family Medicine and Public Health at the University of California, San Diego spoke about driving behaviors and driving safety involving complex interactions between the driver, their vehicle, and the environment. Driving behaviors account for approximately 95% of crashes, but interventions to reduce known risks often do not reach the target audience. Professor Hill discussed strategies employed by the UC San Diego Center for Human and Urban Mobility to improve driving safety.

**Vision Zero in San Francisco: Advancing Public Health and Equity** held February 14, 2020 - Director, Program on Health, Equity & Sustainability and Co-Chair, San Francisco Vision Zero Task Force Environmental Health Branch, Population Health Division San Francisco Department of Public Health, Megan L. Wier, provided an overview of San Francisco's Vision Zero policy to eliminate traffic deaths and reduce severe injuries on city streets. Six years into San Francisco's Vision Zero commitment, this presentation provided insights into what it will take to eliminate traffic deaths, the critical need to elevate equity in traffic safety initiatives, and the key role of public health data and evidence.

**The Evolving Freight Demand** held March 27, 2020 - Associate Professor in Civil and Environmental Engineering at Rensselaer Polytechnic Institute, Xiaokun (Cara) Wang, talked about the impacts of technologies on freight agent behavior and demand pattern in the near future. She discussed the special features of the new freight demand, and how to get prepared for these new trends from the perspectives of data acquisition, modeling, and policy making.

**T2 Plan Output Two – commercialization of research outputs – number of patents filed – goal of 4 annually.**

Yiye Zhang filed a provisional patent (U.S. Serial No. 62/853,507) for a risk prediction algorithm on postpartum depression. Discussion on technology transfer based on the above algorithm is currently under discussion at the Center for Technology Licensing at Cornell University (CTL).

#### **4. OUTCOMES**

Technologies from novel road pavement materials to CAVs have great potential to improve environment and health implications of transportation systems. For example, porous asphalt mixture can be placed on pavement to reduce hydroplaning-related traffic accidents, reduce traffic noise, and mitigate heat-island effect in urban areas. However, due to its thermoplastic and high porosity nature, the material generally

has low durability in the field. Qing Lu at USF aimed to improve the durability and sustainability of porous asphalt mixture by formulating bio-based epoxy asphalt binder (BEAB) and improving its mixture design. In the study, a BEAB formula was firstly developed through a uniform experimental design. Then, the performance of porous asphalt mixture containing BEAB was tested and evaluated along with traditional porous asphalt mixture. Finally, a simple ranking approach was introduced to improve the current mixture design approach. Based on laboratory test results and analysis, the optimum BEAB formula was developed: the optimum bio-based binder formula is identified as 7% epoxidized soybean oil (ESBO), 5% maleic anhydride (MA), and 88% base asphalt; the mixing temperature during pavement construction is suggested as 145°C and its mixing sequence is to mix MA with asphalt first and then followed by mixing with ESBO; relative to the base asphalt, the formulated asphalt binder is validated to improve the strength, durability, and environmental sustainability (by introducing a biobased modifier) of porous asphalt mixture without reducing its permeability and cracking resistance. In practice, to achieve balanced pavement performance for water permeability, mixture durability, strength, and cracking resistance, a small aggregate size gradation with an optimum binder content was recommended. The developed BEAB-based porous asphalt mixture can promote the applications of porous asphalt pavement (“green pavement”) and open-graded friction course (OGFC) in various scenarios, particularly in those related to community health and development, such as runoff water quality control, traffic safety improvement, traffic noise abatement, and urban heat-island effect mitigation.

In the U.S., federal mandates require that metropolitan planning organizations (MPOs) identify and resolve adverse health and environmental impacts of their transportation plans, particularly those on minority and low income populations. At the same time, these plans and policies should account for other changes in the system brought about by such factors as generational attitudes, new mobility options, and technological developments. Connected and automated vehicles (CAVs) are one of such critical developments, and their full impacts are not well understood. Optimistic speculations state that CAVs will bring large health benefits by crash prevention, emission and noise reduction, quality of life improvements (increased mobility and accessibility) and stress reduction (reduced driving burden). There are also studies concluding that these potentially safer and more comfortable CAVs may induce more trips, increase vehicle-miles traveled (VMT) and the associated externalities. In their recent study on health impacts of automated vehicles, CTECH researchers Miguel Jaller, Caroline Rodier, Neil Maizlish, and Michael Zhang at UC Davis provide improved understanding of potential impacts of CAVs on active travel, traffic accidents, emissions and community health. The research team builds on previous work using the San Francisco Bay Area Metropolitan Transportation Commission’s activity-based travel model (MTC-ABM) and uses the Integrated Transport and Health Impact Modeling Tool (ITHIM) to assess health impacts. The study evaluates the impacts based on changes in travel demand, safety features, and other operational characteristics of CAVs, assuming the highest level of transportation automation and full market penetration. Important outcomes from the study are summarized in the following conclusions: 1) CAVs present opportunities for health benefit by reducing traffic accident and injury, and mitigating emissions; 2) however, the appealing experiences with CAVs could shift active travel demand towards using CAVs: a shift of 11% of the walk/bike trips to single occupancy CAVs can lead to 773 disability-adjusted life years (DALYs) for physical activity related diseases and averaged 915 DALYs in combination with PM2.5 effects; 3) to offset such adverse health impacts due to mode shift, it would require approximately 25% increase in the mode split of active transportation.

Bike travel is often considered a healthy and environmentally friendly mode of travel and promoted by cities. While it is of no debate that bike travel is good for the environment, bike accidents and exposure to toxic air pollutants also negatively affect bikers’ physical wellbeing. The net health benefits of bike travel are therefore not clear cut and are worthy of study case by case. Michael Zhang at UC Davis is studying an example of a bike-sharing program in New York City called Citi Bike, and finds that the implementation of Citi Bike produces an enormous health benefit for the citizens of New York City. As a result of this study, procedures were developed to integrate and analyze transportation and health data,



and a manual on how to implement these procedures and how to use the transportation health assessment program ITHIM for similar studies is being prepared. Conventional transportation planning does not pay enough attention to the health aspects of transportation, partly because of a lack of ready-to-use tools for health impact assessment. This manual can serve as a useful guide for transportation planners and policy makers who want to assess how their policies affect public health.

Additional outcomes include:

- Two of Yu Zhang's 2019 publications, co-authored with Fred Mannering, and Ph.D. students Natalia Barbour and Nikhil Menon are placed in the top 1% of the academic field of social sciences on the Web of Science, based on a highly cited threshold for the field and publication year. The titles of the papers are "Shared autonomous vehicles and their potential impacts on household vehicle ownership: An exploratory empirical assessment" and "A statistical analysis of bike sharing usage and its potential as an auto-trip substitute". The papers advanced the literature and are highly cited by researchers who are working in bike sharing and shared automated vehicle areas.
- The Forbes article entitled "New Free Software Helps Create Walkable Cities of the Future" highlighted the Urbano.io software (<https://www.forbes.com/sites/juliabrenner/2019/11/13/new-free-software-helps-architects--city-planners-create-walkable-cities-of-the-future/#5d1d39cb98b8>).
- Cornell's Architecture Art Planning published an article entitled "Software Helps Planners Design Walkable Cities" about Dogan and Samaranayake's collaborative effort (<https://aap.cornell.edu/news-events/software-helps-planners-design-walkable-cities>).
- The Cornell Chronicle published "Smart intersections could reduce autonomous car congestion" on December 16, 2019, highlighting an article from the Gao Group published in Transportation Research Part B: Methodological entitled "Optimal Traffic Control at Smart Intersections: Automated Network Fundamental Diagram".
- Yiye Zhang participated on a panel at the American Medical Informatics Association (AIMA) 2019 Annual Symposium. She was invited to then video tape the presentation separately for web content for AMIA members' future viewing.
- NBER.org, the leading nonprofit economic research organization in the U.S., featured the work of Shanjun Li and coauthors on the demand for electric vehicles and consumer substitution between vehicles of different fuel type to highlight the importance of understanding consumer behavior in designing policies to promote electric vehicles. <https://www.nber.org/digest/jun19/w25771.shtml>

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

17 stakeholders are currently collaborating with researchers on projects during this period, including Air Sage, Atkinson Center for a Sustainable Future, City of St. Petersburg, CUTR, City of Tampa's Department of Transportation and Stormwater Services, El Paso Metropolitan Planning Organization, Environmental Defense Fund, Indian Institute of Science, Kohn Pederson Fox Architects, Lime, Lyft, New York-Presbyterian Hospital, Spin, Uber, and Weill Cornell Medicine.

***T2 Plan Outcome Two – cited works – Number of citations/requests of reports, papers, and research briefs – goal of 100 annually.***

Voxdev.org, a platform for economists, policymakers, practitioners, donors and the private sector interested in economic and social challenges in developing countries, cited the work of Shanjun Li and coauthors on the morbidity of cost of air pollution in China based on high-frequency consumer transaction data to highlight the large health cost that severe air pollution in China imposes and the need

for aggressive policies to address the issue. <https://voxdev.org/topic/health-education/impact-air-pollution-healthcare-spending-china>

Four of the five publications that Fred Mannering co-authored (listed above) have already accumulated 19 citations in Scopus. This number should increase dramatically in the next few years as the results of these papers impact practice and research.

Caltrans safety office requested the report from UC Davis' study that evaluated the safety impact of raising the speed limit for trucks on California freeways.

## 5. IMPACTS

Mobile smartphone applications may assist seniors in their mobility and connect them with the community. It is a tool that facilitates social connectedness and improves quality of life. Continuing their work in the past two years on the prototype of a smartphone application named Urban Connector, Kelvin Cheu has extended the work (1) to enhance the capabilities of the Urban Connector to perform a travel survey; (2) to explore how seniors use the Urban Connector; (3) to understand and address the data privacy concerns of the senior users; and (4) to establish a framework of data analysis that will lead to new metrics of social network connectedness. So far, the Urban Connector smartphone application has been customized with in-app travel-log survey questions for both Android and iOS. Survey instruments have been designed including In-app travel-log (like travel diary) and Exit survey. The team is working with the City of El Paso Parks and Recreation Department on recruiting seniors to test the application. The survey conducted by this research team found that all the smartphone applications for navigation are developed for regular users. None of them cater to visual and/or hearing impairments, or desired, specialized apps that would enable seniors to function more effectively and efficiently and/or toward a higher quality of life. Their earlier survey also found that many seniors did not feel comfortable providing personal information to various public and private service providers. With this knowledge, this project will lead to a senior friendly application design that addresses the user privacy concern, which is expected to increase the number of seniors who are willing to use the smartphone application.

At the macro level, integrating land-use and transportation policy is widely understood as an efficient approach to meet sustainable transport objectives, yet impacts on residential location preference may limit policy effectiveness. Even though an integrated policy strategy is often proposed as more equitable, sustainable, and economically beneficial, choosing appropriate policy measures requires weighing a set of potentially conflicting goals, such as CO<sub>2</sub> emissions, road-traffic safety, oil security, tax revenue, economic competitiveness, and consumer impact. Consequently, policy makers need to understand how combinations of land-use and transport policies affect land-use and transportation consumer behavior and whether the policies complement or contradict each other. By gaining insight into the tradeoffs between policy mixes, planners and policy makers can more effectively align policy with preference to efficiently address the needs of the current land-use and transportation system. Oliver Gao's and Christian Sprague's research reveals/argues that incorporating the effects on residential location preference is especially important for aligning policy decisions with policy goals. Using the Atlanta Regional Commission (ARC) 2011 travel survey, matched to block group characteristics, their study provides important policy implications: Policymakers seeking to align policy with preference can only satisfy two out of the three policy objectives regionally. More specifically, through changes in motor fuel tax and public transit provision, a policymaker can successfully achieve increases in tax revenue, density, and access for certain census blocks but cannot at the regional level. Any policy mix will disproportionately harm/benefit certain blocks which will have disproportionate effects on residential location preferences across the region. Policymakers therefore must define the order of importance for their policy goals and the acceptable level of loss at the aggregate for the sake of improving targeted sub-regional areas. Studying

the interactions within policy bundles and their corresponding interactions with households hence promises to enhance understanding of the greater urban policy context.

Additional impacts include:

- UC Davis researchers recommended that Caltrans should purchase the travel time data from vendors rather than deploying their own Bluetooth travel time measuring system state-wide, and Caltrans has taken their recommendation into account in developing their travel time data requisition plans. This was a direct result of a two-year project entitled “Evaluation of Freeway Traffic Data Acquisition: Technology, Quality, and Cost”.
- The 55 Cornell students that participated in the Daziano Group’s immersive in-lab experiments have become more aware of the different dimensions affecting and encouraging demand for cycling and active transportation in general. In this regard, the immersive experience has been serving as an outreach outlet as well.
- A knowledge gap exists in our understanding of the association among health, healthcare utilization, the built environment, and postpartum depression (PPD). Using electronic health record data from Weill Cornell Medicine and NewYork-Presbyterian Hospital from 2015 to 2017, Yiye Zhang and her colleagues followed pregnant women’s (n=9092) clinical progression from their first trimester of pregnancy to childbirth. Clinical events, such as physician encounters and medication treatments, were mined using machine learning algorithms to study PPD defined as mothers’ mental health status following childbirth. They discovered three clusters, which differ in the distribution of demographics, health, and healthcare utilization. The associations of cluster membership and built environment factors such as transportation volume and land use were studied using multinomial regression. The cluster with the highest prevalence of PPD had significantly different distributions of built environment profiles compared to the other two clusters, including access to bus stops, the number of intersections within the neighborhood, air quality, and neighborhood crime rates. Insights learned may benefit future work on identifying and supporting the social needs of expectant mothers at risk of PPD.

***T2 Plan Impact One –software applications – number of algorithms, codes, software used by practitioners – goal of 6 annually, and T2 Plan Impact Two –software applications – number of algorithms, codes, software used by researchers – goal of 7 annually.***

Urbano.io, is a new, easy-to-use, active mobility simulation tool that can be used in urban design. It can import and translate urban data into actionable urban design feedback using active mobility simulations. The tool evaluates accessibility and utilization of amenities, streets, and public spaces and introduces two new urban design metrics called Streetscore and Amenitiescore, and an expanded version of the well-known Walkscore. The tool and metrics are tested in a series of case studies. Practitioners from leading design industry downloaded the Urbano.io software tool. In total 68 different commercial firms were registered. Among those firms are well known international engineering and design companies such as Perkins & Will, PERKINS EASTMAN, HOK, LINK Arkitektur, WXY Studio, KPF, ZGF Architects LLP, Gensler, Henning Larsen Architects, Sasaki, Foster + Partners, Perkins+Will, Ramboll UK, BAU AB, Arup ([www.urbano.io](http://www.urbano.io)).

Five researchers used Changyun Kwon’s Complementarity.jl package for solving complementarity problems using the Julia Language, from Uppsala University, Sweden, University of British Columbia, Canada, University of Pennsylvania, Katholieke Universiteit, Leuven, Belgium, and the University of British Columbia, Canada.

Seven practitioners in the modeling group at NYMTC continue to use 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 U.S. 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.

## **6. CHANGES/PROBLEMS**

The current COVID-19 circumstance has led to delays in acquiring data from local transportation agencies (e.g., short staffed and busy with COVID-19 related issues), engaging participants from the public, and delays in fieldwork as well as laboratory experiments due to University restrictions on research. Generally, an overall slowdown of research activity.

For all the Mobility group projects, students will be unable to do fieldwork/site visits and hands-on activities for the second half of the semester. They will therefore focus on research and analytical modeling and postpone the hands-on part to Fall 2020. For example, they will be unable to keep working on the bus shelter prototype, however we will direct the second half of the semester to a more in-depth research phase (e.g., battery/solar panel component) and CAD modeling development.

Also, cancelled conferences and workshops, working from home and juggling childcare and home schooling has led to a decrease in productivity and has made it more difficult to collaborate. Summer programs are being cancelled; remote programs, for which only certain types of research can be accommodated, are being investigated and considered.

## **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. For instance, epidemiological studies rely on pollutant exposure fields to identify public health impacts associated with various sources. Regional chemical transport models can predict these pollutant exposure fields but past studies have been limited to 4km spatial resolution and/or short time periods. During the reporting period, Mike Kleeman at UC Davis developed a series of models and metrics to calculate exposure fields in California at 1km spatial resolution for a twelve-year period between 2000 and 2011. Results are produced for average PM<sub>2.5</sub> concentrations associated with on-road gasoline vehicles, off-road gasoline vehicles, on-road diesel vehicles, and off-road diesel vehicles when the model is configured with 1km resolution and 4km resolution (figures available upon request). Road networks are clearly visible in the 1km results but not at 4km resolution. These exposure fields will support health effects calculations during later stages of the analysis.