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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/tools 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 travelers' 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.

- Impacts of Transportation Emissions on the Risk of Mortality: Findings from the Literature and Policy Implications
- Air quality implications of COVID-19 in California
- Impacts of COVID-19 on Transportation Engineering Education and Research

How have the results been disseminated?

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

4-10-20 Gao, H.O., eCornell, **Keynote Panel Discussion on Supply Chain Post COVID-19**, Virtual.

4-28-20 Dogan, T., Ministry of Public Works and Housing Development (KemenPUPR) of Indonesia, **Environmental Performance and mobility simulation for urban design – applications for the design of Indonesia's new capital city**, Jakarta, Indonesia.

6-28-20 Gao, H.O., City University of Hong Kong, **Quantitative modeling and analysis of urban transportation, environment, and public health**, Virtual.

8-7-20 Zhang, H.M., University of California Institute of Transportation Studies, **Briefing of differential speed limit policy in California**, Virtual.

8-18-20 Zhang, Y., Transportation Research Board, **TRB Executive Committee Policy Session**, Virtual.

8-20-20 Reina Ortiz, M., Pontificia Universidad Catolica del Ecuador Sede Esmeraldas (PUCESE), **COVID-19: current status and future perspectives**, Virtual.

8-27-20 Samaranayake, S., Emerging Mobility Systems and Services Seminar Series, **Emerging Mobility Systems: A transit centric viewpoint for enabling sustainable and equitable personal mobility**, Virtual.

9-20-20 Samaranayake, S., IEEE International Conference on Intelligent Transportation Systems (ITSC), **Network Impacts of Emerging Mobility Trend: Operational challenges for high-capacity ridepooling**, Virtual.

9-20-20 Samaranayake, S., IEEE International Conference on Intelligent Transportation Systems (ITSC), **Emerging (Autonomous) Mobility Systems: A transit centric viewpoint for enabling sustainable and equitable personal mobility**, Virtual.

On April 29, 2020, Oliver Gao hosted a panel discussion on emerging trends in transportation, mobility, and urban technology at the virtual Cornell Tech NYC organized Jacobs Technion-Cornell Institute Urban Tech Workshop: Transportation and Mobility.

CTECH co-supported a web conference on May 1, 2020 out of NewYork-Presbyterian where the COVID-19 Dashboard for Hospital Use was shared. CTECH researcher, YiYe Zhang, presented.

Yu Zhang co-organized a virtual seminar entitled *A Transit-Oriented Highway* on September 18, 2020. Mr. Ming Gao discussed the regional bus transit project, a major project of Tampa Bay Next for providing more mobility options for trips across Tampa Bay. Mr. Ming Gao, P.E. is the Modal Development Administrator for the Florida Department of Transportation, District 7. He has been with FDOT for over 28 years. His previous experience in FDOT includes traffic operations, drainage design, project management, environmental management, and planning. In his current role, he is responsible for the development and implementation of the district's public transportation programs that support aviation, rail, seaport, transit, freight, and intermodal connections. He is a graduate of USF and is a licensed Professional Engineer in the state of Florida.

Yu Zhang also coordinated a Virtual talk on September 25, 2020 entitled *The Status and Outlook of Infrastructure and Mobility of the City of Tampa.* Jean Duncan, the Infrastructure and Mobility Administrator of the City of Tampa gave a brief talk about the City's recent innovations in this area.

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.

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
C2SMART	New York, NY	Collaborative Research
California Department of Public Health	Sacramento, CA	Personnel exchanges
California Department of Transportation (Caltrans)	Sacramento, CA	Financial Support, Collaborative Research, and Personnel exchanges
Center for Urban Transportation Research (CUTR)	Tampa, FL	Financial Support, Facilities, Collaborative Research
City of El Paso	El Paso, TX	In-kind Support, Facilities, Collaborative Research
City of El Paso Parks and Recreation Department	El Paso, TX	In-kind Support, Facilities, Other – data source, feedback

City of Ithaca	Ithaca, NY	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 and policymaker advisory support
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
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
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	Collaborative Research, 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
Qualtrics	Salt Lake City, UT	Collaborative Research
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 laboratory testing
Tompkins Consolidated Area Transit (TCAT)	Ithaca, NY	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 and technical support
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)
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

Yu Zhang is collaborating with USF Associate Professor Maya Trotz and a large group of professors to submit a preliminary proposal responding to an NSF Engineering Research Center (ERC) solicitation. The title of the proposal is *Engineering Research Center for Innovating Inclusive Infrastructures with/in urban Black Communities (INFABS)*. The proposed ERC focuses on an engineered system comprised of testbeds and inclusive engineering innovation ecosystems developed in partnership with urban Black communities in California, Florida, Illinois, Ohio, Massachusetts, Texas, and Washington D.C. Research in three, interconnected thrusts will drive convergence to three overarching goals: 1) Inclusive Infrastructures to design and develop built places and spaces that meet community aspirations and eradicate inequitable outcomes, 2) Inclusive Systems to propose mathematical models and strategies for optimizing equitable outcomes in social systems, and 3) Inclusive Computing to design and develop computing tools, including a novel AI-based framework, to lower and ultimately eliminate racial bias in the delivery of computing services. The work has the potential to simultaneously stimulate scientific curiosity in urban Black communities and foster groundbreaking collaborations that lead to orchestrated community-led innovations in areas like stormwater management, urban agriculture, informed decision making, and personalized learning.

Qing Lu is collaborating with Mingyang Li, an assistant professor in the Department of Industrial and Management Systems Engineering at USF, on research on the performance modeling of pavement infrastructures used in the life cycle analysis of pavement for environmental benefit, as well as worked together on several proposals submitted to NSF and other sponsoring agents.

Kelvin Cheu engaged in discussions about ideas for future parking projects with potential collaborators at Texas A&M Transportation Institute's El Paso, Texas office.

Kelvin Cheu is editing a special issue of Tongji's International Journal of Transportation Science and Technology on pandemics for Tongji University in Shanghai, China.

Ricardo Daziano is collaborating with Ricardo Hurtubia from Santiago, Chili to provide advice for the consideration of cycling conditions.

Michael Zhang is collaborating with Professors Chen-Nee Chuah and Dipak Ghosal, Electrical and Computer Engineering at UC Davis, to co-advise graduate students and post docs on connected and automated vehicles research, and most recently also advising them on AI technologies to control traffic systems to reduce fuel use and emissions.

3. OUTPUTS

With the impending issues regarding global warming, urban design is considered a key driver to improve the microclimate in cities. For public spaces, studies suggest that outdoor thermal comfort may be a proxy for space usage, and in turn, its attractiveness to people. Although the topic has gained interest in recent years, the discussion so far has focused on computing the metrics rather than deriving interventions from them. In their study on Predicting Space Usage by Multi-objective Assessment of Outdoor Thermal Comfort Around a University Campus, CTECH researcher Timur Dogan and Ph.D. student Patrick Kastner use the tool Eddy3D to model and analyze the outdoor thermal comfort of a designated area around a university campus. Further, they demonstrate how to estimate space usage from those results. Finally, they conducted a spatial sensitivity analysis of the underlying results as a step towards decision aiding. Their study provides: 1) Discussion of the first-order, second-order, and total spatial sensitivity of the UTCI metric; 2) Implementation of the Radiance-based Two-Phase (DDS) method for irradiance estimation into a decision-making tool called Eddy3D; 3) Estimation of the annual outdoor thermal comfort around the Engineering Quad of the Cornell University campus; and 4) Evaluation of first-order, second-order, and total spatial sensitivity of annual outdoor thermal comfort simulations around the Cornell University campus. The study represents a novel step in this direction by visualizing the spatial sensitivity of the UTCI and exemplifies how to derive the outdoor space used as a proxy for the attractiveness of outdoor spaces. It demonstrates how decision-makers may derive areas where interventions will likely have the largest impact on outdoor thermal comfort performance.

In 2017, NASA embraced the concept of urban air mobility (UAM) and called for a market study of this transportation mode. The UAM concept proposed in recent years is based on a new type of electric aircraft that can take off and land vertically, known as electric vertical take-off and landing vehicles (eVTOLs). One of the biggest challenges faced by UAM on-demand service is building a well-distributed ground infrastructure to support eVTOL aircraft operations. For on-demand UAM serving passenger needs, the main ground infrastructure is vertiports (or skyports) from which eVTOL aircraft take off and land, board or disembark passengers, and get charged. In her recent study on Modeling and Evaluating Multimodal Urban Air Mobility, CTECH researcher Yu Zhang aimed to determine optimal locations of vertiports, user allocation to vertiports, and vertiport access and egress mode choices with consideration of interactions between vertiport locations and potential UAM travel demand. She also analyzed key incentives for potential UAM demand from the supply side and different pricing strategies for UAM operators. A deterministic integer programming model was formulated by combining the modeling structure of the traditional hub-and-spoke problem and mode choice modeling of individual travelers. By analyzing the nature of the network design problem and UAM trip characteristics, an additional constraint was proposed and preprocessed along with other constraints to largely reduce the feasible region of the IP problem. Optimization results show significant time savings due to the introduction of UAM service and non-uniform distribution of demand at different vertiports. Sensitivity analyses were conducted to explore the effects of critical factors from the supply side of UAM adoption and service performance. It was observed that although increasing the number of vertiports improves vertiport accessibility and, thus, UAM adoption rates, the case study shows that when the number exceeds 80, the marginal effect becomes insignificant. Also, the increase of transfer time between ground modes to UAM drastically discouraging travelers to switch from ground to UAM and UAM service performance. Furthermore, different pricing schemes were tested and revealed significant impacts on UAM adoption rates and revenue generation. Combined analysis of the effects of the number of vertiports and pricing strategies indicates that price imposes greater influence, from system performance to revenue generation. A case study based on simulated disaggregate travel demand data of the Tampa Bay area in Florida was conducted to demonstrate the effectiveness of the proposed model.

Publications

Journal publications

1) Zhang, Y., Tayarani, M., AlAref, S., Sholle, E., RoyChoudhury, A., Gao, H.O., Pathak, J., Liu, Y., Ancker, J.S., Using Electronic Health Records for Population Health Sciences: A Case Study, *Journal of the American Medical Informatics Association Open*, Accepted.
2) Zhang, Y., Wang, S., Hermann, A., Joly, R., Pathak, J., Development and validation of a machine learning algorithm for predicting the risk of postpartum depression among pregnant women, *Journal of Affective Disorders*, 2021, Volume 279, Pages 1-8, DOI: 10.1016/j.jad.2020.09.113.
3) Chavez, M., Li, W., Comparison of Modeled-to-Monitored $PM_{2.5}$ Exposure Concentrations Resulting from Transportation Emissions in Near-Road Community, *Transportation Research Record*, 2020, Pages 1-14, DOI: 10.1177/0361198120951189.
4) Dogan, T., Yang, Y., Samaranayake, S., Saraf, N., Urbano: A Tool to Promote Active Mobility Modeling and Amenity Analysis in Urban Design, *Technology | Architecture + Design*, 2020, Pages 92-105, Volume 4, DOI: 10.1080/24751448.2020.1705716.
5) Natanian, J., Kastner, P., Dogan, T., Auer, T., From energy performance to livable Mediterranean cities: An annual outdoor thermal comfort and energy balance cross-climatic typological study, *Energy and Buildings*, 2020, Volume 224, DOI: 10.1016/j.enbuild.2020.110283.
6) Romero-Espinosa, D., Sarrias, M., Daziano, R., Are preferences for city attributes heterogeneous? An assessment using a discrete choice experiment, *Papers in Regional Science*, 2020, DOI: 10.1111/pirs.12566.
7) Daziano, R., Waygood, E.O.D., Patterson, Z., Feinberg, M., Wang, B., Reframing greenhouse gas emissions information presentation on the Environmental Protection Agency's new-vehicle labels to increase willingness to pay, *Journal of Cleaner Production*, 2021, Volume 279, DOI: 10.1016/j.jclepro.2020.123669.
8) Klein, N.J., Subsidizing Car Ownership for Low-Income Individuals and Households, *Journal of Planning Education and Research*, 2020, DOI: 10.1177/0739456X20950428.
9) Reina Ortiz, M., Sharma, V., Modeling the COVID-19 outbreak in Ecuador: Is it the right time to lift social distancing containment measures?, *medRxiv*, 2020, DOI: 10.1101/2020.05.21.20109520.
10) Han, X., Ma, R., Zhang, H.M., Energy-aware trajectory optimization of CAV platoons through a signalized intersection, *Transportation Research Part C: Emerging Technologies*, 2020, Volume 118, DOI: 10.1016/j.trc.2020.102652.
11) Gurbuz, O., Cheu, R.L., Estimating Total Demand and Benchmarking Base Price for Student Parking on University Campuses, *Journal of Transportation Engineering*, 2020, Volume 146, DOI: 10.1061/JTEPBS.0000439.
12) Hou, Z., Zhang, X., Zhang, H.M., A Comparative Analysis of Alternative Travel Time Data Sources on I-80 Freeway, *Transportation Research Record*, Under Review.
13) Ma., R., Zhang, H.M., The First-Best System Optimum of The Morning Commute Problem with Ridesharing Travelers, *Transportation Research Part C: Emerging Technologies*, Under Review.
14) Baghestani, A., Tayarani, M., Allahviranloo, M., Gao, H.O., Evaluating the traffic and emissions impacts of New York City cordon pricing, *Sustainability*, 2020, Page 3655, Volume 12, DOI: 10.3390/su12093655.
15) Sayarshad, H., Du, X., Gao, H.O., Dynamic post-disaster debris clearance problem with a re-positioning of clearance equipment items under partially observable information, *Transportation Research Part B: Methodological*, 2020, Pages 352-372, Volume 138, DOI: 10.1016/j.trb.2020.05.011.
16) Pan., S., Jung, J., Li, Z., Hou, X., Roy, A., Choi, Y., Gao, H.O., Air Quality Implications of COVID-19 in California, *Sustainability*, 2020, Page 7067, Volume 12, DOI: 10.3390/su12177067.
17) Cheu, R.L., Rincones, R., Ruiz, E., Impacts of COVID-19 on Transportation Engineering Education and Research in the United States, *International Journal of Transportation Science and Technology*, Under Review.

Books or other non-periodical, one-time publications

Nothing to report.

Other publications, conference papers, and presentations

1) Kastner, P., Dogan, T., Predicting Space Usage by Multi-Objective Assessment of Outdoor Thermal Comfort around a University Campus, *2020 Society for Modeling and Simulation International (SCS) SimAUD*, May 2020, http://simaud.org/2020/proceedings/89.pdf.
2) Yang, Y., Samaranayake, S., Dogan, T., An Adaptive Workflow To Generate Street Network and Amenity Allocation for Walkable Neighborhood Design, *2020 Society for Modeling and Simulation International (SCS) SimAUD*, May 2020, http://simaud.org/2020/proceedings/64.pdf.

3) Xin, C., Lu, Q., Sustainable flexible pavement overlay policy for reduced life-cycle cost and environmental impact, *Pavement, Roadway, and Bridge Life Cycle Assessment 2020 Proceedings of the International Symposium on Pavement, Roadway, and Bridge Life Cycle Assessment 2020*, 3-6 June 2020, Sacramento, CA, Pages 343-353, DOI: 10.1201/9781003092278.

Policy Papers

1) The renting of personal vehicles for monetary compensation (peer-to-peer carsharing or abbreviated as P2P carsharing) has become increasingly popular in the U.S. In applications, the fleet of peer-to-peer carsharing vehicles typically consists of personally owned vehicles identified and coordinated by a third-party company. However, little is known about the attitudes, perceptions, and decision processes through which individuals decide to offer their car for rent in such peer-to-peer carsharing. To explore individuals' attitudes and perceptions regarding the act of supplying a personal vehicle to peer-to-peer vehicle fleet, a stated preference survey was designed and disseminated between February and April of 2018 where survey respondents were asked how likely they would be to rent their car (extremely unlikely, unlikely, unsure, likely, extremely likely). The survey questionnaire collected detailed socio-demographic information, as well as data on travel behavior and travel patterns. These data were then used to estimate random parameters in an ordered probit model of their likelihood of renting their car.

   This research offers some initial perspectives on factors affecting people's willingness to share their personal vehicles. It explores the role of socio-demographic characteristics coupled with travel patterns and travel behavior factors to identify the key variables that play a role in the likelihood of renting a personal vehicle to others. Caucasian female respondents who live in one-person households and have less than five- minute one-way travel time but more than one-mile distance to a grocery store had a higher probability to be extremely unlikely to rent their personal vehicle to receive monetary compensation in exchange. In contrast, respondents who indicated to be registered users of a bikesharing system were found to have a lower probability to be extremely unlikely to rent their personal automobiles. The variables that found to have heterogeneous effects across respondents (as reflected by the presence of statistically significant random parameters) were age (at least 40 years old), high annual household income (above $200,000), and households that owned only one motor-vehicle.

   From an insurance perspective, some insurance companies currently exclude coverage if insured vehicles are used for peer-to-peer carsharing, which forces vehicle suppliers to take on alternate insurance or purchase additional coverage. The lack of affordable insurance policies may clearly be a detriment to the expansion of peer-to-peer carsharing. Additionally, peer-to-peer carsharing companies are in direct competition with traditional rental-car companies that operate at airports and other locations where they need to rent office space and enough area to store their vehicles. Peer-to-peer carsharing operators also deliver vehicles to customers at the airports, but they are not burdened with such overhead costs and therefore may have an inherent competitive advantage. While there have been attempts to regulate this issue, a national policy has not yet been established. Finally, there is clearly environmental, economic, and social value in utilizing individuals' personal resources and the findings of this study suggest that the motivation to share such resources is not driven wholly by financial reasons, which opens up additional policy dimensions. For example, the findings indicate that female respondents are more likely to be extremely unlikely to rent their personal vehicles, and thus potentially miss out on opportunities for additional income. [Barbour, N., Zhang, Y., Mannering, F., Individuals' willingness to rent their person vehicle to others: An exploratory assessment of peer-to-peer carsharing, *Transportation Research Interdisciplinary Perspectives*, 2020, Volume 5, DOI: 10.1016/j.trip.2020.100138.]

2) When making infrastructure policies, decisionmakers insufficiently consider negative consequences for the environment or health. This lack of multi-sectorial awareness in

policymaking triggers poor public health outcomes. To illustrate this issue, this interdisciplinary work presents evidence for the association of road infrastructure investment (as infrastructure policy) with the incidences of deaths due to transport accidents, chronic obstructive pulmonary disease, and pneumonia using nationally aggregated data from the Organisation for Economic Co-operation and Development for 27 countries over an 18-year period (1995-2012). We conducted an explorative analysis using descriptive statistics and fixed-effects panel-data regression models that include the interaction of the policy variable with the Environmental Policy Stringency Index, which proxies the awareness of the negative consequences of policies. We showed that countries that never achieved a score of three or higher for the Environmental Policy Stringency Index had higher levels of standardized death rates. This is supported by Pearson's correlation coefficients and by the results of t-tests for deaths due to transport accidents. Following the fixed-effects analysis, we found that an increase in road infrastructure investment of 1% of gross domestic product is associated, on average, with about three additional deaths per 100,000 population due to transport accidents and about 18 fewer deaths per 100,000 population due to chronic obstructive pulmonary disease using standardized death rates. A one unit increase in the Environmental Policy Stringency Index is related to about seven fewer deaths per 100,000 population due to chronic obstructive pulmonary diseases. Marginal effects of the interaction of road infrastructure investment and the Environmental Policy Stringency Index are significant for standardized death rates due to transport accidents and chronic obstructive pulmonary disease. Multi-sectorial awareness in infrastructure policy mediates health effects for deaths due to transport accidents and chronic obstructive pulmonary disease. [von Grafenstein, L., Gao, H.O., Infrastructure policy and public health: Evidence from OECD countries, *Science of the Total Environment*, 2021, Volume 750, DOI: 10.1016/j.scitotenv.2020.141157.]

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. Two new project videos were created, "Assessing Children's Spatiotemporal Exposure to Transportation Pollutants in Near-Road Communities" and "Exploring Social Connectivity and Transportation Needs of Seniors Through Mobile Smartphone Applications". They can be found at http://ctech.cee.cornell.edu/project-videos/.

New methodologies, technologies, or techniques
Changhyun Kwon expanded the hybrid agent-based simulation model by incorporating both documented and undocumented disease transmission cases among an urban population and considering various preventive measures to minimize disease transmissions through ride sharing.

Timur Dogan expanded the Urbano.io framework to address the following high-level questions: How does a specific design choice influence active mobility and transit use, and what kind of health and sustainability impacts will stem from that? During this reporting period they made the following major advances:

1) Integration of different mobility modes including bikes, on-demand services, transit, and taxi.
2) Validation of outdoor comfort simulations using field measurements in Ithaca. They have now collected almost a year's worth of microclimate data at four different locations on Cornell's Ithaca Campus. This data was used to validate the outdoor comfort simulation methods that have been prototyped in this and previous reporting periods. Preliminary results look promising and show that we can predict annual wind velocity fields and mean radiant temperatures with sufficient accuracy. Both variables are the dominant inputs for outdoor thermal comfort.
3) Adapting statistical and behavioral models from the transportation literature to incorporate street quality and comfort-aware active mobility mode choices over others. We implemented a discrete choice model (Logit) that predicts mode and destination choice in one pass. The

model is trained with mobility data from Safegraph.com (for NYC) and a validation of predicted pedestrian count as well as a and breakdown of other mobility choices is underway. They obtained data from StreetlightData.com to compare our model predictions with their data that is derived from cell phone tracking. Preliminary results show that mobility patterns with high spatial and temporal resolution can be predicted well with Urbano.io. Accuracy of the results is, however, highly dependent on the completeness of the training dataset and all acquired data sets from Google, SafeGraph, StreetlightData, and OpenStreetMaps which show significant inconsistencies and data gaps. Therefore, more data must be acquired, and more work is needed to create one consistent dataset that can be used for training and validation.

4) Development of high-level metrics that predict mobility related public health, economic, environmental, and energy parameters for urban design proposals: Mobility (Vehicle miles, walkability), public health (daily activity), economic (amenity utilization), environmental (energy and carbon footprint), and social (street segment, park and public space utilization). The details of the metric system will be developed in close collaboration with urban designers at KPF and the NYC Department of City Planning to capture the insight of major stakeholders in urban design projects. They submitted a pending NSF CIVIC proposal with NEWLAB and NYCDOT that proposes to use Urbano.io to improve active mobility within NYC. Urbano will be used to find problem areas, mobility choke points, and mobility opportunities. Together with NYCDOT they are planning to implement a pilot study and a sensor network that would allow the verification of the effectiveness of the urban design interventions and that would provide additional data to validate Urbano.io predictions for proposed design alterations of the city fabric and mobility network.
5) KPF launched a COVID-19 related NYC Sidewalk Crowding Analysis tool that is built on Urbano.io pedestrian count predictions (https://sidewalk.kpfui.dev). More information can be found at https://medium.com/@kpfui/sidewalk-crowding-in-the-age-of-covid-19-3ca9d20039a7.
6) Further, they were able to solicit funding from Cornell Atkinson to pilot a study that uses Urbano.io data to better understand urban design parameters such as density, access to amenities and services, as well as mobility patterns and their relationship to epidemic resilience. We established a new collaboration with Yihong Li, DDS, MPH, DrPH of the Cornell Public Health program as well as Nathaniel Huppert of Weill Cornell Medical.

Samitha Samaranayake developed an agent-based system for simulating infections disease propagation in environments such as university campuses.

Ricardo Daziano created 14 bike land virtual cycling scenarios that were proposed and incorporated in the virtual environment representing New York City. The length of a bike ride was approximately 120 meters (394 ft.) for a 20-second-long ride at 15.5 km/h (9.6 mph) speed. Each bicycle lane scenario was tested for cyclist experience in two traffic volume conditions; one was with fewer cars running faster at 40 km/h (25 mph), and the other was with more cars running slower at 12 km/h (7 mph). The first condition represents traffic congestion in NYC, with more cars moving very slowly versus the second condition which represents less traffic with increased speed. The virtual NYC environment was created to look believable with high-rise buildings and sidewalks along with two to three vehicle lanes based on the images of NYC. The three-dimensional model of the environment was created in Autodesk 3D Studio Max, 3D modeling software. Then, the model was imported into VR authoring software Twinmotion for dynamic features such as moving vehicles, pedestrians, and cyclists in addition to trees and city street assets. Twinmotion is an Unreal Gaming Engine based real-time immersive 3D visualization platform that allows automated objects to follow a programmed path, speed, and density.

Michael Zhang developed a new method to study the ridesharing problem for a single-bottleneck corridor with traveler groups whose value of time differ from each other. Using differential equations and optimality conditions, the method provides the traveling flow patterns for these different groups that minimize the total system travel cost, which include delay costs and scheduling costs. The so-called first-best flow patterns shed light on what can best be achieved in the morning commute when there is a mix of solo and shared driving.

Inventions, patents, and/or licenses
Nothing to report.

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

- Xiofan Xu developed a GIS database (including the information of type, size, and location) of candidate green stormwater infrastructure (GSI) for future implementation in the City of Tampa.
- Xiofan Xu developed a multi-objective optimization model to identify the optimal allocation (i.e., location, size, and type) of GSI implementation with the objectives of minimal system-level environmental impacts and costs under the constraint of nutrient discharge.
- Xiofan Xu introduced the GSI strategy for transportation stormwater management to the course ENV 2930 Introduction to Environmental Engineering in the semester of Spring 2020 at Florida Polytechnic University.
- Through Michael Zhang's travel time project for Caltrans, they assembled a travel time dataset for a stretch of Interstate 80 near Sacramento, which includes travel time data from three vendors (HERE, WAZE, and INRIX) and Bluetooth travel time data from Caltrans. This dataset enabled them to compare travel time quality from different sources and they advised Caltrans on their future data acquisition practices.
- Kelvin Cheu served as the advisor to the UTEP ITE Student Chapter.
- Ricardo Daziano taught a Special Topics in Environmental Engineering course focused on data analytics around energy demand, including in the transportation sector, and sustainability.
- Qing Lu incorporated environment and health impacts of asphalt mixture design and pavement management into teaching the asphalt and asphalt mixes to graduate students at USF.
- Xiaopeng Li developed a simulation tool for shared electric vehicles.
- Xiaopeng Li also developed CUBE and MATsim based system analysis tools for evaluation of mobility, access, and equity of transportation systems.

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

The following four CTECH webinars were facilitated during the reporting period and can be viewed at http://ctech.cee.cornell.edu/events-2/impacts-of-transportation-and-urban-systems-on-health-and-the-environment-webinar-series/. Smart Cities and Public Health and Considering Technology and resilience in the Florida Transportation Plan drew the largest 'live' attendance (59 and 54 unique viewers, respectively) for CTECH webinars to-date.

Considering Technology and Resilience in the Florida Transportation Plan held April 10, 2020 – Florida Department of Transportation, Office Policy Planning Statewide Planning Coordinator, Jim Halley, A.A.E., ACE presented a talk about how technology is constantly evolving and changing the way people interact with one another, work, do business, travel, and even how they buy groceries. New and emerging technologies offer the potential for a safer, more efficient transportation system; more connectivity globally and locally; and streamlined business practices. However, increased reliance on

technology brings other challenges to the forefront like cybersecurity and data privacy. Transportation partners need to make wise decisions today to prepare for this future. He also addressed the fact that natural hazards, cyberattacks, and other events can have significant and unexpected impacts on Florida. Simultaneously, trends such as sea level rise and global economic shifts can lead to progressive challenges. These events and trends can result in unanticipated transportation system disruptions and increasing constraints on infrastructure, impeding access to reliable mobility. The impact on the lives of residents and visitors and the flow of business and trade can be extensive. Preparing Florida's transportation system to be adaptive in the face of these events and trends is critical. Florida's efforts toward planning for resilience leverages our understanding of potential hazards to mitigate risk, make wiser investment decisions, and provide more reliable transportation.

Smart Cities and Public Health held on April 24, 2020 – Miroslav Svítek, Professor, Faculty of Transportation Sciences at Czech Technical University introduced the concept of smart cities and shared his experience on several projects in Europe, Asia, and South America that use the smart cities implementation to promote smart healthcare. He also discussed how technologies such as data analytics, smart sensors, wearable devices, connected and automated ambulances, virtual doctors, smart hospital rooms, etc. are being applied to crisis management, clusters identification, contact tracing, transportation of patients, automated testing, diagnosis and monitoring of patients and citizens on quarantine during a pandemic.

California and the State of Freight held on May 8, 2020 – the Deputy Secretary for Transportation Planning for the California State Transportation Agency, Avital Barnea, spoke about the complexity of the network of the freight transportation system that carries everything from cars to petroleum to bananas and more. On ships, airplanes, trains, trucks, and bicycles, cargo often moves across multiple modes before it reaches its final destination. In addition, the rise of e-commerce, trade tariffs, and even COVID-19 are rapidly reshaping the freight industry. This presentation provided an overview of current freight trends and a discussion of California's role in the national and international freight sector.

Building Trust to Enhance Preparedness: An Analysis of Community Perceptions held on May 15, 2020 – Assistant Professor Johanna Amaya Leal of the Department of Supply Chain Management at the Iowa State University Ivy College of Business addressed that even though communities are considered a critical responder after disasters, the subject of community perceptions and trust in response agencies have not received much attention in preparedness research. The study presented seeks to fill this gap by analyzing how the attitudes and perceptions of individuals in potentially disaster-impacted communities, as well as their socio-economic characteristics, can affect both the roles of trust in emergency response agencies and risk perception in disaster preparedness.

Usually, organizations developing the necessary preparedness and response plans do not have a clear idea of citizens' perceptions of the response system, and how these perceptions will/can influence their level of preparedness. Knowing such perceptions would allow communities to engage in the decision of what they need instead of being passive receptors of what is sent to them in case of extreme events. This interaction will positively impact the practice community and will support their effort in building local capacity.
A structural equation modeling approach was used to analyze data from a survey applied to individuals located in towns affected by two different disasters in Colombia. The results suggested that trust in response agencies is mostly influenced by previous experience in disaster situations, education, and income. However, while females have a higher risk perception, they prepare less, even after testing for mediation. Interestingly, for two individuals with the same level of education, the one with a higher income trusts more in the response system. In the same context, for two individuals with the same level of income, the one with higher education trusts less. The seminar closed with a set of recommendations for response agencies, recommendations that consider the perceptions of the different segments of the

population to be served, so that the effectiveness of preparedness efforts and overall level of preparedness of the community increases.

***T2 Plan Output Two* – dissemination activities – Number of journal and/or conference papers published.**

18 papers were published as a result of CTECH research efforts, 13 research papers, three conference papers, and two policy papers (detailed above).

4. OUTCOMES

Electronic health record (EHR) data linked with address-based metrics using geographic information systems (GIS) are emerging data sources in population health studies. CTECH researcher Yiye Zhang's study examined this approach through a case study on the associations between changes in ejection fraction and the built environment among heart failure (HF) patients. They identified 1,287 HF patients with at least two left ventricular ejection fraction (EF) measurements that are minimally one year apart. EHR data were obtained at an academic medical center in New York for patients who visited between 2012 and 2017. Longitudinal clinical information was linked with address-based built environment metrics related to transportation, air quality, land use, and accessibility by GIS. The primary outcome is the increase in the severity of EF categories. Statistical analyses were performed using mixed-effects models, including a subgroup analysis of patients who initially had normal EF measurements. Previously reported effects from the built environment among HF patients were identified. Increased daily nitrogen dioxide concentration was associated with the outcome while controlling for known HF risk factors including gender, comorbidities, and medication usage. In the subgroup analysis, the outcome was significantly associated with decreased distance to subway stops and increased distance to parks. As in previous literature, male gender and daily NO_2 concentration were significantly associated with increased odds of the outcome. In addition, medication prescription, age, BMI, and Asian race were significant in the model. The daily NO_2 concentration remained significant in the sensitivity analyses, and in larger models that included other built environment variables. They did not find other risk factors previously reported to be significantly associated. As demonstrated in this study, the availability of more precise outcome measurements and home locations, and frequent collection of individual-level social determinants of health may further drive the use of EHR data in population health studies in understanding the effect of the built environment on health. Findings of the study have been presented in conferences including the 2019 American Heart Association Annual Meeting and will be published in the Journal of the American Medical Informatics Association Open in 2020.

The COVID-19 pandemic has caused enormous adverse impacts on human health and to the economy. To combat the spread of the virus, many regional and national governments have issued stay-at-home orders in order to improve social distancing and minimize person-to-person contact. The implementation of such practices (including telecommuting) has led to notable improvements in air quality. Several studies have assessed the impacts of the stay-at-home orders on air quality in worldwide regions. Generally, they reported reductions in concentrations of nitrogen dioxide (NO_2) and fine particulate matter ($PM_{2.5}$), and in some cases an increase in ground-level ozone (O_3). On March 19, 2020, the California statewide stay-at-home order was implemented and millions of residents have since adjusted their travel behavior in compliance. This created a valuable opportunity to evaluate the impact of changing travel behavior or lockdown on air quality and associated health effects. CTECH researchers H. Oliver Gao and post-doc associate Shuai Pan investigated the change in air quality using measurements from surface monitoring stations operated by the U.S. EPA's AirNow and Air Quality System (AQS) networks. The AirNow network stores near-real-time air quality measurements, while AQS contains historical data that has undergone quality assurance and quality control measures. Results indicated changes in fine particulate matter ($PM_{2.5}$) of -2.04 ± 1.57 μg m-3 and ozone of -3.07 ± 2.86 ppb. If the air quality improvements

persist over a year, it could potentially lead to 3970-8900 prevented premature deaths annually (Note: the estimates of prevented premature deaths have large uncertainties). Public transit demand showed dramatic declines (~80%). The pandemic provided an opportunity to exhibit how substantial human behavior could impact air quality. To address both the pandemic and climate change issues, better strategies are needed to affect behavior, such as ensuring safer shared mobility, higher adoption of telecommuting, automation in the freight sector, and cleaner energy transition.

Additional outcomes include:

- Ricardo Daziano's efforts increased the understanding of: 1) willingness to pay (WTP) for city amenities, including safety and accessibility to health infrastructure (pharmacies) (Romero et al., 2020) and 2) the influence of GHG information on new car labels and how that influence could be enhanced. Compared to the EPA's current label, willingness-to-pay for emission abatement can be increased by 2.5x when using appropriate framings. This resulted in the publication in the Journal of Cleaner Production (Daziano et al., 2021).
- UTEP's project *Exploring Social Connectivity and Transportation Needs of the Seniors through a Mobile Smartphone Application* contributed to the understanding and awareness of seniors' transportation issues as they relate to social connectivity and increased our understanding of how new technology (i.e., mobile technology) can potentially be used to address mobility issues that hinder social connectivity in seniors, while respecting users' privacy.
- From UTEP's *Impacts of COVID-19 on Transportation Engineering Education and Research* project, the survey findings will enable faculty to learn from the experiences of colleagues in other institutions and improve their teaching and research practices to better meet the challenges.
- Xiaopeng Li's newly developed knowledge and tools have been shared with stakeholders including FDOT Districts 1 and 7, Hillsborough MPOs, WSP Inc., and BCC Engineering. This work also led to new projects funded by FHWA (Task Order Proposal Request: HOIT190152: *Automated Vehicle Access, Mobility, and Affordability for System Users* collaborating with WSP) and NSF (EAGER/Collaborative Research: *Enable Elastic Capacity for Transportation Infrastructure through a Transmodal Modular Autonomous Vehicle System)*.
- Changhyun Kwon's efforts led to a better understanding of the role of ride sharing vehicles in the spread of COVID-19 in metropolitan areas. To this end, they considered a compartmental mode to capture the progression of the SARS-CoV-2 infections in urban populations and an agent-based simulation to capture the ride sharing exposure to the disease. Furthermore, it showed that effective implementation of disease outbreak control measures in ride sharing levels can almost nullify this aggravation. With a better understanding of the role of ride sharing systems in pandemic situations, our society can make the modern ride sharing services safer using effective measures.

***T2 Plan Outcome One* – cited works – Number of reports in media – goal of 8 annually.**

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 types to highlight the importance of understanding consumer behavior in designing policies to promote electric vehicles (https://www.nber.org/digest/jun19/assessing-federal-subsidies-purchases-electric-vehicles).

USF received media attention for partnering with the City of Tampa for an eScooter Public Opinion survey (https://www.tampagov.net/news/city-tampa-teams-usf-escooter-public-opinion-survey).

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).

Yiye Zhang participated in 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.

Internally, 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) and the Cornell Chronicle published "Smart intersections could reduce autonomous car congestion", 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" (https://news.cornell.edu/stories/2019/12/smart-intersections-could-reduce-autonomous-car-congestion).

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

Yu Zhang received five requests for CTECH research papers.

5. IMPACTS

Mobile smartphone applications may assist seniors in their mobility and connect them with the community. A recent CTECH project led by Professor Kelvin Cheu involves the development of a new version of the Urban Connector application to: 1) identify a metric of social connectivity from the mobility perspective from existing literature; 2) update the Urban Connector application to consider data privacy policies when automatically collecting mobility data; and 3) design a survey and an analysis framework to gather information on how seniors use the Urban Connector application for social connectivity from a mobility perspective. The proposed social connectivity metric used five mobility-related indicators: 1) type of interactive event; 2) frequency of interactive event; 3), duration of interactive event; 4) quantity of interactions; and 5) quality of interactions. Each indicator is assigned one or two measures. Each measure can have a range of possible values. They developed a new version of the Urban Connector mobile phone application that considered best practices on data privacy. This new version also enabled the collection of mobility data (i.e., Travel Log) that can be used to calculate the proposed social connectivity metric. The management of data considering users' privacy is achieved through the following four considerations: 1) design the application to capture minimum amount of personal information; 2) sampling of traveling data (i.e., only one trip per day); 3) download/transfer only de-identified/anonymous data from the smartphone for analysis; and 4) identify privacy algorithms for the analysis of data collected in the Urban Connector application. By combining the expertise of researchers in the fields of computer science, engineering, and the social and behavioral sciences, this project investigated the role mobile technologies (e.g., smartphone applications) can have to help seniors be more

mobile and socially connected in their communities. The outcomes of this work increase the knowledge on the development of mobile technologies to support the mobility of seniors from the social connectivity perspective with privacy protection considerations.

Micromobility has gained much attention in past years, including station-based bike sharing, dockless bike sharing, and, recently, shared e-scooters. These transportation modes provide users with a convenient option for short-distance travel. Although shared e-scooters is still a very new mode, it could transform urban transportation systems to be more sustainable, but it remains challenging for many cities in terms of regulations and management. One difficulty could be limited knowledge of user behaviors. CTECH study led by Yu Zhang attempted to answer relevant questions by exploring factors that influence user frequency of riding e-scooters and replacement of auto modes (mainly private vehicles and TNC/taxi). This study also investigated whether the explanatory variables are different between males and females in terms of usage frequency. Their research results suggested that users who ride e-scooters in bike lanes are more likely to be frequent users. As a policy implication, cities may want to encourage users to use bike lanes. It was also found that users who wear helmets were more likely to be frequent users. To encourage users to ride e-scooters more frequently, e-scooter vendors could provide free helmets for new users or as a reward for users who have ridden e-scooters a specified number of times. The increased use of users would generate higher revenues for e-scooter companies, which could offset the helmet expenditure. Also, wearing a helmet provides safer riding for users and creates a positive image for the company. Compared with bike sharing, shared e-scooters add potential for reducing auto trips in cities. Shared e-scooters could be deployed in areas that have limited parking but a high demand for activities to help people move around. Cities also could increase parking fees and/or reduce parking spots to stimulate a mode shift from driving to e-scooter and encourage the use of micromobility. The research team is working with the City of Tampa to implement some of the findings and suggestions to improve the e-scooter sharing program in Tampa. Also, Zhang is helping the Director of Micromobility of the City of Tampa to start a new and comprehensive micromobility program, including not only e-scooters, but also adaptive e-scooters that could be used by disabled and disadvantaged populations, and e-bikes with no range limit that could be used by commuters with relative longer travel distances.

Additional impacts include:

- Xiofan Xu collaborated with the City of Tampa Transportation and Stormwater Services and shared the SWMM-based model and the optimization model. The application of these tools created the following expected outcomes: 1) quantifiable benefits of implementing green stormwater infrastructure (GSI) at the system-level in terms of environmental, economic, and human health impacts; 2) increased knowledge in terms of spatial configuration of GSI implementation integrated with transportation infrastructure planning, and 3) improved process for designing stormwater management plans in surface transportation planning. The City of Tampa's ability to test the usefulness of the SWMM-based model enables the assessment results to be shared with the stakeholders, increasing the knowledge of the benefits of green stormwater infrastructure implemented at the system-level. Ultimately, the environmental and human health impacts will be alleviated through improved stormwater management.
- The findings in Daziano et al. (2021) provide an improved solution to increase peoples' environmental sensitivity and gives policy suggestions to address the problem of climate change within transportation activities. The findings of this research suggest that if a carbon tax were applied, individuals who are less environmentally sensitive would have a strong reaction to that information and would therefore purchase more efficient vehicles.
- 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.

- The research at UC Davis evaluating the health benefits of the CitiBike program and the manual that was subsequently developed based on this work provides both an example and tools for other cities to evaluate their active transportation plans (e.g., biking, walking, etc.) and promote active transportation modes.
- UTEP's *Impacts of COVID-19 on Transportation Engineering Education and Research* project could potentially impact faculty in universities across the country in making transportation engineering education more accessible and lessening the negative impacts of COVID-19 on transportation research. The resulting TRB paper will be a valuable resource for university administrators to devise policies to prepare for future pandemics.
- 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.
- The modeling group at NYMTC continues to use the web-based emissions post-processing software, CU-PPS, developed by the Gao Research Group, for their transportation conformity analysis.

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

Qing Lu's efforts have increased the scientific knowledge in the field of acoustic performance of asphalt mixture and design variables. A microstructural model of porous asphalt mixture for sound absorption was adapted and applied to the design of asphalt surface mixtures for improved noise performance of pavement for use in the existing design procedures of porous asphalt mixtures to allow noise performance as one of the design objectives.

UC Davis researchers' recommendation that Caltrans should purchase the travel time data from vendors rather than deploying their own Bluetooth travel time measuring system state-wide was considered by Caltrans 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 software tools developed by Timur Dogan, Samitha Samaranayake, and other collaborators are being used by practitioners and other researchers, URBANO: A computational tool-kit for an integrated urban design incorporating active mobility, to facilitate the design of healthy and sustainable urban habitats www.urbano.io. The modeling capabilities developed allow urban designers to quantify the performance of mobility solutions, sustainability, public health impacts, pedestrian thermal comfort, and pollution exposure during the earliest stages of a design process. Embedded in a generative, performance-driven design process, our tools facilitate the design of healthy and sustainable urban habitats that promote active mobility. The software is published and disseminated freely and has been downloaded over 3,000 times since their release in November last year. Based on frequent conversations with specialists at large U.S.

architecture firms, we know that these tools already have an impact on the analysis capabilities and projects of these firms. Further, we are contacted by researchers from other leading universities such as MIT and TU Munich who are using the software developed with CTECH support. This led to one WIP paper with MIT researchers and one jointly published paper with the TUM (From energy performative to livable Mediterranean cities: An annual outdoor thermal comfort and energy balance cross-climatic typological study). Also, as mentioned above in greater context, and related to COVID-19, Kohn Pederson Fox launched an NYC Sidewalk Crowding Analysis tool that is built on Urbano.io pedestrian count predictions.

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

50 researchers used the gmni package in R, developed by Ricardo Daziano, for the estimation of choice models.

6. CHANGES/PROBLEMS

The current and continued COVID-19 circumstance has led to an overall slowdown in research and has resulted in the need to adapt, repurpose, and refocus. For example, faculty and staff efforts were re-deployed to focus on assisting Weill Cornell Medicine and NewYork-Presbyterian Hospital during the peak of the COVID-19 pandemic in NYC. They assisted with data analytics to report daily COVID patient volume and characteristics.

Across all four partner institutions, there were delays in acquiring data and an inability to recruit for surveys and/or engage public participants. Communications with external organizations, including stressed state and local transportation agencies, were negatively affected. Field and laboratory work were hindered due to full or partial shutdowns of college campus research for extended periods of time and/or with limitations, and it has restricted the ability to engage with students and other researchers directly.

The opportunities for in-person collaborations and to participate in conferences, meetings, or events were limited. Although there was a concerted effort to shift to virtual events, the benefits of in-person gatherings were compromised.

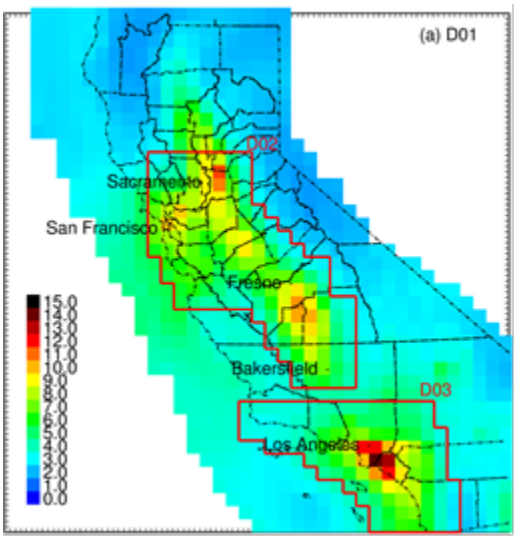
Continued challenges associated with working from home are being managed better and best practices are being shared, however juggling childcare and homeschooling continues to impact productivity.

A notable, positive impact from COVID for CTECH was that Safegraph launched an open data initiative and shared their data, which would otherwise have been behind a paywall. This data was used in validation work. In addition, this led to convincing StreetLightData to provide free (limited) data access to their cellphone-based mobility data, which is also normally behind a paywall.

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. In particular, 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 4 km spatial resolution and/or short time periods. A CTECH study led by Mike Kleeman on the public health effects of long-term exposure to mobile source PM in California calculates exposure fields in California at 1 km spatial resolution for a twelve-year period between the year 2000-11. Hourly meteorology inputs

to drive regional chemical transport models were prepared using the Weather Research and Forecasting (WRF) v3.4 model (www.wrf-model.org). Mobile source emissions were calculated based on the gridded inventory at 1 km resolution described by McDonald et al. for the year 2005. This inventory provides space- and time-varying values of gasoline and diesel fuel consumption (mass of fuel burned per unit time) by on-road vehicles. The EMFAC model was used to calculate emission factors (mass of pollutant emitted per mass of fuel burned) for CO_2, CO, NOx, SOx, NMOC, and $PM_{2.5}$ during summer and winter, respectively. Surface level $PM_{2.5}$ concentrations over California have been simulated for the years 2000-11 using the UCD/CIT air quality model. The UCD/CIT model has a number of source apportionment features that quantify contributions from target sources during the full simulation of atmospheric reactive chemical transport.



The Figure to the right illustrates average $PM_{2.5}$ mass concentrations averaged over the year 2011 using nested model domains with increasing spatial resolution ranging from 24 km (D01) through 1 km (D04, D05, D06). The highest resolution is specified over major urban areas including the regions around Sacramento, the San Francisco Bay Area, and Los Angeles. $PM_{2.5}$ mass is generally highest around the most urbanized areas, but these concentrations do not peak around major transportation corridors since there are many other sources of airborne particles including food cooking, building heating, agricultural activities, and many other commercial and industrial sources. Increasing spatial resolution brings the highest $PM_{2.5}$ mass concentrations into focus whereas the lower resolution results artificially dilute those concentrations in large grid cells. The highest $PM_{2.5}$ mass concentrations over all domains occurs in the industrial region around the Port of Los Angeles, with sharp concentration gradients and more moderate concentrations over the rest of the South Coast Air Basin.