TOMNET Transportation Center
Teaching Old Models New Tricks

UTC Semi-Annual Progress Report (SAPR#3)

ASU Arizona State University

Georgia Tech

UNIVERSITY of WASHINGTON

UNIVERSITY of SOUTH FLORIDA

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Center Director:	Ram M. Pendyala, Professor, Arizona State University ram.pendyala@asu.edu, 480-727-4587
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Submitting Official:	Ram M. Pendyala, Director of TOMNET UTC Professor, Arizona State University 480-727-4587; ram.pendyala@asu.edu
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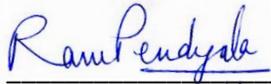
INTRODUCTION

This document constitutes the UTC Semi-Annual Progress Report (SAPR) for the Center for Teaching Old Models New Tricks (TOMNET), a Tier 1 University Transportation Center sponsored by the US Department of Transportation. The center commenced operation on November 30, 2016, and has been active during the period of December 1, 2016 to March 30, 2020. This SAPR covers work accomplished, collaborations with academic, government, and industry partners, and the center outputs, outcomes, and impacts for the period of October 1, 2019 to March 30, 2020.

1. ACCOMPLISHMENTS

The TOMNET University Transportation Center's mission is to advance the state-of-the-art and state-of-the-practice in transportation demand modeling by collecting and incorporating data about human attitudes, behavioral processes, perceptions, values, and preferences in travel models. The center collects comprehensive datasets by administering in-depth surveys regarding users' attitudes, perceptions, and behaviors in the present and in the future, considering all of the recent and expected transformative changes in transportation systems. Additionally, the center leverages a number of methods and tools to advance its mission, including the application of data fusion and machine learning algorithms to integrate data sets with disparate information thus facilitating the development of comprehensive models of travel demand that reflect the effects of attitudinal variables.

What are the major goals of the program?

Previous Semi-Annual Progress Reports (SAPR) provide information about the goals, and hence the information is not repeated in this report in the interest of brevity and to avoid redundancy in presentation from one progress report to the next. The *research* mission of TOMNET is to advance the science of activity-travel behavior modeling by developing new methods for incorporating the effects of people's attitudes, values, preferences, and perceptions in transportation demand forecasting models. The *education* and *workforce development* mission of TOMNET is to train a transportation planning and modeling workforce for the future that is capable of solving complex multi-disciplinary challenges confronting the profession. In addition, a critical mission of TOMNET is to attract a *diverse body* of students into the transportation profession by undertaking a number of K-12 school outreach activities, particularly in under-represented communities. Finally, TOMNET aims to empower the current transportation workforce by offering a number of workshops, continuing education (short) courses, symposia, and professional development seminars/webinars on cutting edge topics and methods that will help professionals address emerging and complex transportation issues. The *technology transfer* mission of TOMNET is to disseminate information about research findings, methods, tools, and data to a global audience of transportation professionals, students, researchers, policymakers, and the broader public. The overall goal of the center is to move advanced data fusion approaches and modeling methods into practice.

What was accomplished under these goals?

Within the reporting period, TOMNET researchers made excellent progress on a number of research projects. Projects launched in 2017 and 2018 have been completed or are continuing into their subsequent phases. Annual project reports for the accomplished projects are being reviewed for posting on the center website in the next reporting period. The list of all active and accomplished TOMNET projects is provided in Table 1 with the active time period for each project. The status column indicates whether the project is accomplished with the project report under review, or if the project is in progress. For the multi-phase projects (project numbers 4, 14, 15, 18, and, 22) annual research reports have been received and are being formatted and finalized through a rigorous review process. The multi-phase

projects are continuing and in progress. Further information about the in-progress projects that made substantial progress during the reporting period can be found following the table. Information regarding the completed projects and the scopes of the active projects will be available on the TOMNET UTC website very shortly.

Table 1. TOMNET Research Projects

	Project Topic/Title	Lead Institution (Institution PI)	Active Period	Status
1.	Development of an Integrated Model of Daily Activity-Travel Behavior and Well-Being	ASU (Pendyala)	Aug 2017- July 2018	✓
2.	To What Extent Are Millennials Really Different in Their Vehicle Miles of Travel Compared to Generation X?	ASU (Pendyala)	Aug 2018- July 2019	✓
3.	Do Attitudes Affect Behavioral Choices or Vice-Versa: Uncovering Latent Segments within a Heterogeneous Population	ASU (Pendyala)	Aug 2019- Present	⚙
4.	Attitudes Towards Mobility Options/Technologies – A Multi-region Survey Design and Data Collection Effort	ASU (Khoeini)	Oct 2017- Present	⚙
5.	Assembling Integrated Data Sets for Analyzing Connections between Travel Behavior, Attitudes, and the Built Environment	ASU (Salon)	Aug 2017- July 2018	✓
6.	Heterogeneity in the Relationship Between the Built Environment and Bicycling	ASU (Salon)	Aug 2018- July 2019	✓
7.	The role of transport in how we choose where to live: A qualitative investigation of residential location choice in the Phoenix, AZ region	ASU (Salon)	Aug 2018- July 2019	✓
8.	Comprehensive Review of Attitudes-Travel Behavior Literature	ASU (Salon)	Aug 2018- July 2019	✓
9.	The impact of non-transportation attitudes, preferences, and personality characteristics on residential location and travel choices	ASU (Salon)	Aug 2019- Present	⚙
10.	Investigating Attitudinal and Behavioral Changes in U.S. Households Before, During, and After the COVID-19 pandemic	ASU (Salon)	Aug 2019- Present	⚙
11.	Consumer Attitudes and Behavioral Implications in the New Era of Shared Mobility	ASU (Zhang)	Aug 2019 - Present	⚙
12.	Emerging Approaches to Autonomous Vehicles in Transportation Policy and Planning	ASU (Thad Miller)	Aug 2019 - Present	⚙
13.	Consistency Guarantee of Transportation Modeling Calibration and Validation Using Multi-Source Data in a Computational Graph Approach	ASU (Zhou)	Aug 2019 - Present	⚙
14.	Attitudes Towards Mobility Options/Technologies – A Multi-region Survey Design and Data Collection Effort	GT (Circella)	Oct 2017- Present	⚙
15.	An Investigation of the Contribution of Targeted Marketing Data to the Prediction of Attitudes	GT (Mokhtarian)	Oct 2017- Present	⚙
16.	Latent Vehicle Type Propensity Segments: Considering the Influence of Household Vehicle Fleet Structure	GT (Mokhtarian)	Aug 2018- July 2019	✓
17.	Combining Disparate Surveys across Time to Study Satisfaction with Life	GT (Mokhtarian)	Aug 2019 - Present	⚙
18.	Attitudes Towards Mobility Options/Technologies – A Multi-region Survey Design and Data Collection Effort	USF (Maness)	Oct 2017- Present	⚙
19.	An exploration of contemporary issues in highway safety, evolving transportation alternatives, and activity and travel behavior modeling	USF (Maness)	Aug 2019- Present	⚙
20.	Investigation of the Role of Attitudinal Factors on Adoption of Emerging Automated Vehicle and Vehicle Safety Technologies	USF (Mannering)	Aug 2017- July 2018	✓
21.	Emerging econometric and data collection methods for capturing attitudinal and social factors in activity and travel behavior modeling	USF (Mannering)	Aug 2018- July 2019	✓
22.	Attitudes and Trust in Leveraging Integrated Sociotechnical Systems for Enhancing Community Adaptive Capacity	UW (Chen)	Oct 2017- Present	⚙

ASU = Arizona State University; GT = Georgia Institute of Technology; USF = University of South Florida; UW = University of Washington. ✓ = Accomplished; ⚙ = In progress.

Project Title: Do Attitudes Affect Behavioral Choices or Vice-Versa: Uncovering Latent Segments within a Heterogeneous Population
PI: Ram Pendyala, ASU; Co-PI: Sara Khoeini, ASU
Description: This project is concerned with unraveling the contemporaneous relationship that exists between attitudes and choice behaviors. Attitudes, perceptions, and preferences may shape behaviors; likewise, behavioral choices exercised by individuals may offer experiences that shape attitudes. While it is likely that these relationships play out over time, the question of whether attitudes affect behaviors or behaviors affect attitudes at a specific cross-section in time remains unanswered and a fruitful area of inquiry. This study utilizes a data set that includes attitudinal variables to examine relationships among attitudes towards transit, residential location choice, and frequency of transit use (the latter two variables constituting choice behaviors). Results suggest that there is considerable heterogeneity in the population with the contemporaneous causal structures in which behaviors shape attitudes more prevalent than those in which attitudes affect choice behaviors. These findings have important implications for transport modeling and policy development. The resulting research paper has been submitted to *Transportation*. The TOMNET researchers are now working on revising the paper in response to the first round of the reviewers' comments.

Project Title: Attitudes Towards Emerging Mobility Options and Technologies
PIs: Sara Khoein, ASU; Giovanni Circella, GT; and, Michael Maness, USF
Co-PIs: Ram Pendyala, ASU; Patricia Mokhtarian, GT; and Fred Mannering, USF
Description: The pilot phase of data collection was conducted during fall 2018 and the full deployment was conducted during summer and fall 2019 at the three participating universities. While the pilot phase of data collection was conducted only in Phoenix metro area with a sample size of 262 respondents, the full deployment has been conducted in three southern metro areas (Phoenix, Atlanta, and Tampa) to understand how the market may perceive, adopt, and adapt to transformative transportation technologies such as autonomous vehicles and mobility-on-demand services. The full deployment in the Phoenix metro area yielded a sample size of 1071 completed responses, collected through an online platform and recruited through both email and mailed postcard invitations. Similar data collection in Atlanta yielded a sample size of 1021 completed responses. In Tampa, the sample size collected as of April 2020 is 281 completed responses recruited via only email addresses. Moreover, the University of Texas at Austin, who has been our close collaborator for many years, also conducted the same data collection yielding an additional sample of 1367 completed responses, collected using an online platform and recruited with random email and Facebook advertisements (supported by the D-STOP University Transportation Center). The full survey deployments across the four southern metro areas produced a dataset consisting of 3,740 completed responses collected over summer and fall 2019.

While ASU and GT reached the survey goal of collecting at least 1000 completed responses at each metro area, the TOMNET team at USF did not reach this target goal yet. Therefore, over the third phase (current phase) of the project, the research team plans to obtain additional responses through alternative sampling methods (e.g., internet advertisements). This also will entail modifying the survey to account for the current COVID-19 crisis as responses to some of the questions about prevailing travel behavior and demographics will be affected by the pandemic.

After data collection, data extraction and data cleaning have been conducted. Furthermore, the dataset has been weighted to reflect the attributes of the general population residing in each of the associated metro areas. Another data processing step during this phase is the geocoding of all addresses and locations provided in the survey responses. Once a clean sample was prepared for each participating metro area (Phoenix, Atlanta, Tampa, and Austin), the datasets have been aggregated and a unique full/pooled dataset has been prepared for research analyses and modeling. The comprehensive analysis

of the data including development of econometric models to understand people's perceptions and potential behavior toward new transport technologies will be conducted during the remaining of the third phase of the project.

For presenting and disseminating results to the broader community of academics, practitioners, and government a one day webinar will be held to cover various research questions that this survey is intended to address. The event will be held on June 12, 2020. More detailed information will be available on the TOMNET website.

Project Title: Investigating Attitudinal and Behavioral Changes in U.S. Households Before, During, and After the COVID-19 pandemic
PI: Deborah Salon, ASU; Co-PI: Ram Pendyala and Sara Khoeini, ASU
Description: The COVID-19 pandemic has forced rapid, large changes in U.S. households' social dynamics resulting in substantial changes in their behavior. Virtually overnight, a large fraction of U.S. households has transitioned from a reality of long commutes, in-person classes and business meetings, and in-store shopping to one of telecommuting, online classes, and business meetings, and online shopping – even for groceries. Many of these changes were happening already, but COVID-19 has pressed the fast-forward button. In this project, we are interested to know, after the threat of contagion is gone, to what extent will American society "go back" to the pre-COVID-19 way of life? Which behavioral changes will be long-lasting, and for whom? How, if at all, are the attitudes that underpinned our American lifestyle shifting in this crisis, and will these shifts be long-term? Moreover, what are the largest impacts of confinement in terms of attitudes and behavior? The team is designing a comprehensive survey that will be deployed in April 2020 and beyond, to measure changes in activities and travel behavior during and after the pandemic.

Project Title: An Investigation of the Contribution of Targeted Marketing Data to the Prediction of Attitudes
PI: Patricia Mokhtarian, GT; Co-PIs: Giovanni Circella, GT; and Kari Watkins, GT
Description: This project involves the "fusion" of two datasets collected in 2016-2017 in Georgia: the behaviorally-rich Georgia add-on to the National Household Travel Survey ("NHTS", N ~ 8,000), and the attitudinally-rich survey designed by the project team and funded by the Georgia Department of Transportation (the "GDOT survey" or dataset, N ~ 3,500, before cleaning). The goal of the current project is to use machine learning methods to develop attitude-prediction training functions on the GDOT (donor, or source) sample, which are then applied to the NHTS (recipient) sample to impute (or "transfer") attitudes into the latter. The inputs to the training function must be variables that are common, or available, to both datasets. A previous study used socioeconomic/demographic (SED) and land use (LU) characteristics as the common variables (CVs); a distinctive feature of the current study is the addition of targeted marketing (TM) variables to the CV set. TM variables can be purchased economically from third-party providers (such as the consumer credit reporting agency Experian), and include a host of indicators of lifestyle and various behaviors. The premise of the current study is that these kinds of variables may be very informative about individuals' attitudes, and thus substantially improve our ability to predict attitudes. If so, this methodology will be of great value to Metropolitan Planning Organizations, because it offers an economically viable way to obtain attitudinal variables for use in regional models.

This reporting period saw our previous efforts begin to bear fruit. We obtained "draft final" transfer functions on the GDOT sample and performed an internal validation check to see how well the observed attitude variables were predicted. We found that correlations between the observed and predicted attitudes ranged from 0.18 to 0.51, which is quite good – certainly as good as or better than many instrumental variables routinely used by econometricians. Then, we used the transfer functions to impute attitudes into the NHTS sample and performed external validation checks.

Project Title: An Exploration of Contemporary Issues in Highway Safety, Evolving Transportation Alternatives, and Activity and Travel Behavior Modeling
PI: Michael Maness, USF; Co-PI: Fred Mannering, USF
Project Description: The project team addressed several critical issues in the fields of highway safety, alternative transportation modes, and activity and travel behavior modeling. Regarding highway safety, the project team addressed the ongoing methodological debate about the use of data-driven methods (machine learning, etc.), conventional statistics, statistical models that address unobserved heterogeneity, and models of causality. The research team published a paper that provided an extensive review and assessment of these methodological alternatives and their potential application to highway safety. Next, there have been several recent studies that indicate that driver behavior is changing continuously over time in response to changing vehicle technologies, changing behavior, and utilization of social media and texting as well as other temporally shifting factors (Mannering, 2018). This has profound implications for highway safety and the development of safety policies and countermeasures. The project team has begun studying the temporal instability of driver behavior from various perspectives including the possible temporally shifting effects of aggressive driving and cellphone usage, two elements of driver behavior that are believed to be highly unstable over time.

The project team also completed work in several additional project areas. In this time period the team completed and published papers related to the adoption of and adaptation to emerging mobility services and transportation technologies. The papers are listed in subsequent sections of this report. The team has also refined the leisure activity and social capital survey and completed data collection for the survey. A new sampling plan was formulated using three different internet panel sources (Qualtrics Panels, Mechanical Turk, and Prolific). The web-based survey was also modified to tailor it to both PC and mobile users based on the platform used by the respondent. Survey data collection occurred during November and December 2019 with a sample of approximately 1300 respondents. The team compiled the dataset and began a preliminary analysis of the impacts of social capital on leisure activity diversity. Preliminary results show that social capital (access to social resources) is correlated with greater leisure activity diversity. Additionally, access to instrumental social resources was found to impact leisure activity diversity more than expressive/emotional support resources. This shows that activity diversity may act more as an instrumental outcome thus supporting the team's hypothesized social capital theory of leisure activity behavior. Over the next quarter, the project team will produce a working paper to communicate these results as well as to conduct a sensitivity analysis of the effect size of social capital on leisure activity.

Project Title: Attitudes and Trust in Leveraging Integrated Sociotechnical Systems for Enhancing Community Adaptive Capacity
PI: Cynthia Chen, UW; Co-PI: Daniel B. Abramson, UW
The overarching goal of the project is to understand, model and develop ways in which communities can leverage unique – and interconnected – physical and social resources of place to enhance their own adaptive capacity. This current phase builds upon findings from previous project phases, including a pilot survey and follow-up full-community surveys, to implement a full-scale sample survey focused on issues of social connectivity, trust, place attachment, and disaster preparedness and response as relevant to different modes of transportation and communication services. Combining social network information with traditional survey data holds the potential to enrich and expand disaster preparedness planning research, and urban planning research more generally.

The pilot survey has been accomplished and the full community resilience sample survey is in its final stage. Full community resilience survey was administered in two communities: Seattle's Laurelhurst neighborhood (733 surveys administered) between October and December 2019; and, Westport, Grays Harbor County, WA (1243 surveys administered) between October and December 2019. The full-scale survey in South Park is underway as of March 2020 (1200 surveys administered). Although some data is

still coming in from the Laurelhurst and Westport surveys, that effort is nearly complete. Data is currently being collected from Seattle's South Park neighborhood. Together, these efforts contribute to a dataset that encompasses communities diverse in geography (urban/rural) and socioeconomic status. Due to the recent pandemic situation, we are also administering the COVID-19 follow-on survey to participants from the mentioned three communities who had indicated willingness to participate in additional community resilience research activities; the objective of this survey is to collect perishable longitudinal data about the attitudinal and behavioral response to the current public health crisis over the coming months.

What opportunities for training and professional development has the program provided?

In the *education* and *workforce development* domain, all of the TOMNET partners offered a number of undergraduate and graduate courses at their respective institutions during spring semester of 2020 (that spans the reporting period covered by this SAPR). Please note that the courses offered during fall 2019 have been reported in the previous SAPR. Table 2 offers a detailed summary of the courses offered by faculty members closely affiliated with the TOMNET center.

It should be noted that there are many additional transportation-related courses taught at each institution at both undergraduate and graduate levels; however, the scope of activities reported in this SAPR is limited to the activities of faculty members who comprise the core group of TOMNET and are deeply engaged in advancing the activities and mission of the center.

Table 2. Courses Offered by Mission-Critical Faculty Members of TOMNET (Fall 2019 and Winter 2020)

Semester	Course Level	Course No	Course Title	No	Instructor	Unit
ARIZONA STATE UNIVERSITY						
Spring20	Grad	CEE591	Interdisciplinary Transportation Seminar	2	Pendyala	SSEBE
Spring20	Grad	CEE598	Activity Travel Behavior Model	11	Pendyala	SSEBE
Spring20	Undergrad	PUP424	Planning Methods	24	Salon	SGSUP
Spring20	Undergrad/Grad	PUP430/550	Transportation/Environment	35	Salon	SGSUP
GEORGIA INSTITUTE OF TECHNOLOGY						
Spring20	Grad	CEE6601	Intro to Transportation Statistics	22	Mokhtarian	CEE
Spring20	Grad	CEE 6650	Discrete Choice Modeling	7	Mokhtarian	CEE
UNIVERSITY OF SOUTH FLORIDA						
Spring20	Grad	TTE6930	Graduate Transportation Seminar	11	Li	CEE
Spring20	Grad	TTE6651	Transportation and Land Use	12	Chen	MURP
Spring20	Undergrad	TTE4005	Transportation Engineering II	103	Chen	CEE
Spring20	Grad	TTE 5620	Air Transportation	8	Zhang	CEE
Spring20	Grad	TTE6315	Transportation Safety	14	Wang	CUTR
Spring20	Undergrad	TTE4004	Transportation Engineering I	20	Kourtellis	CEE
Spring20	Grad	CGN6933	Sustainable Transportation	16	Jackman	CEE
Spring20	Grad	CGN6933	Transportation and Infrastructure Network	9	Li	CEE
Spring20	Grad	TTE6501	Statistical and Econometric Methods II	8	Mannering	CEE
Spring20	Grad	CGN6833	Asphalt and Asphalt Mixes	20	Lu	CEE
UNIVERSITY OF WASHINGTON						
Winter20	Grad	URBDP 598H	History, Form, Theory and Ethics for Planning (HEFT) I: Premodern Roots	6	Abramson	Urban Pln
Winter20	Grad	CEE512	Transportation Data Collection	22	Chen	CEE

Notes: *Arizona State University:* SSEBE = School of Sustainable Engineering and the Built Environment; SGSUP = School of Geographical Sciences and Urban Planning; CIDSE = School of of Computing, Informatics, and Decision Systems Engineering; BS = Biological Sciences; SOS = School of Sustainability. *Georgia Institute of Technology:* CEE = School of Civil and Environmental Engineering; SCaRP = School of City and Regional Planning. *University of South Florida:* CEE = Department of Civil and Environmental Engineering; CUTR = Center for Urban Transportation Research. *University of Washington:* CEE = Department of Civil and Environmental Engineering; CEE/ST = Civil and Environmental Engineering/Sustainable Transportation Online Program; UrbPln = Department of Urban Design and Planning

In addition, TOMNET faculty supervised a number of students and post-doctoral scholars, providing them guidance and mentorship necessary to pursue independent research and discovery. Students engaged in TOMNET related research and education activities are listed in Table 3. Besides graduate students pursuing Master's and PhD degrees, the TOMNET consortium is involving nine undergraduate students in various research endeavors in an effort to provide research experiences for undergraduate students and inspire them to pursue advanced studies and a career in transportation systems engineering and planning. For instance, Madison Kerr is a senior civil and environmental engineering student who is involved in the project on Econometric Methods at USF. She began working in August 2019 and has an interest in environmental policy. She has designed an in-person interview to explore the attitudes and preferences of electric vehicle owners for public charging infrastructure.

Table 3. Students and Research Staff Engaged in TOMNET-Related Research and Education Activities

Name of Scholar	Level	Major/ Unit	Supervisor/ Advisor
ARIZONA STATE UNIVERSITY			
Xin Ye	Research Professor	SSEBE	Pendyala
Jie Ma	PhD Student Visiting Scholar	SSEBE	Pendyala/Ye
Irfan Batur	PhD Student	SSEBE	Pendyala
Matthew Conway	PhD Student	SGSUP	Salon
Amanda Minutello	Undergrad	SSEBE	Pendyala
Tae Hooie Kim	PhD Student	SSEBE	Pendyala
Tassio Bezerra Magassy	PhD Student	SSEBE	Pendyala
Shivam Sharda	PhD Student	SSEBE	Pendyala
Denise Capasso da Silva	PhD Student	SSEBE	Pendyala/Khoeini
Laura Mirtich	Undergrad	BS	Salon
Shuyao Hong	PhD Student	SGSUP	Salon
Nathan Harness	Undergrad	SEEBE	Salon
Alexis Ross	Undergrad	Economics	Salon
Kelly Baker	Undergrad	SOS	Salon
GEORGIA INSTITUTE OF TECHNOLOGY			
Gwen Kash	Postdoc	CEE	Mokhtarian
Yongsung Lee	Postdoc	CEE	Circella
Sungtaek Choi	Postdoc	CEE	Circella
Ali Etezady	PhD Student	CEE	Circella/Mokhtarian
Alyas Widita	PhD Student	SCaRP	Circella
Xinyi Wang	PhD Student	CEE	Mokhtarian
Faaiqa (Atiyya) Shaw	PhD Student	CEE	Mokhtarian
Sung Hoo Kim	PhD Student	CEE	Mokhtarian
Yun-Hsuan (Grace) Chen	MS Student	SCaRP/CEE	Circella
UNIVERSITY OF SOUTH FLORIDA			
Asim Alogaili	Grad Student	CEE	Mannering
Suryaprasanna Balusu	Grad Student	CEE	Pinjari/Mannering
Natalia Barbour	Grad Student	CEE	Zhang/Mannering
Nawaf Alnawmasi	Grad Student	CEE	Mannering
Trang Luong	Grad Student	CEE	Maness
Divyamita Mishra	Grad Student	CEE	Maness
Nameetha Ramachandra	Grad Student	BAIS	Maness
Lori Palaio	Grad Student	CEE	Bertini/Maness
Madisen Kerr	Undergrad	CEE	Maness
Tung Vo	Grad Student	CEE	Maness
Dr. Nikhil Menon	Postdoc Associate	CEE	Maness/Bertini
UNIVERSITY OF WASHINGTON			
Andres Arjona	Masters Student	UrbPln	Abramson
Asela Chavez Basurto	Masters Student	UrbPln	Abramson
Matt Bloch	Undergrad	Civil	Chen

Xiangyang Guan	Postdoc fellow	CEE	Chen
Katherine Idziorek	PhD Student	UrbPln	Chen/Abramson
Yuanjie Tu	PhD Student	CEE	Chen
Feilong Wang	PhD Student	CEE	Chen
Xi Zhu	PhD Student	CEE	Chen

In the *technology transfer* domain, Arizona State University continued the weekly **TOMNET webinar/seminar series** that is presented to a worldwide audience. Table 4 presents a list of TOMNET-sponsored seminars for the period covered by this SAPR. Speakers met with TOMNET faculty and students, thus enabling the development of collaborative ties. It should be noted that other TOMNET partner institutions have transportation seminar series that are open to the public and professionals in the community. These seminars are generally held on a weekly basis at each of the institutions and include a mix of attendees comprising of students, professionals, academics, scholars, and members of the public. As those institutions are a part of other UTCs, their seminars are not listed here to avoid double-counting across SAPRs of multiple UTCs. TOMNET faculty members are heavily engaged in existing transportation seminar series at each institution and helping to organize specific seminars that are badged as TOMNET-sponsored seminars. These seminars, delivered by renowned speakers, specifically address topic areas of relevance to TOMNET and are of broad interest to the professional community.

Table 4. Key TOMNET-Sponsored Technology Transfer Events

Institution	Title of Seminar/ Webinar	Speaker Name and Affiliation	Date
ASU	Autonomous Vehicles: Industry and Technology Overview	**Karl Theisen** Arizona State University	October 9, 2019
USF	Personalized Incentive-Based Peak Avoidance and Driving Time-Savings	**Peng Chen** University of South Florida	October 18, 2019
ASU	Growing Electric Vehicle Markets	**Ken Kurani** University of California at Davis	October 23, 2019
USF	Statistical Inference of Probabilistic Origin-Destination Demand Using Day-to-Day Traffic	**Sean Qian** Carnegie Mellon University	October 25, 2019
USF	Aviation and the Environment: A Focused Look at Wildlife Hazards at Airports	**Sarah Brammell** Blue Wing Environmental	November 1, 2019
USF	Improve Air Traffic Management with Trajectory Based Operations	**Dave Knorr** Federal Aviation Administration	November 8, 2019
USF	Quantity-Contingent Auctions and Allocation of Airport Slots	**Michael O. Ball** University of Maryland	November 15, 2019
ASU	Energy Efficient Mobility Systems: The Transforming Transportation Ecosystem	**Prasad Gupte** Department of Energy	December 4, 2019
USF	Walk Your Way	**Danya Shi** BCC Engineering	January 17, 2020
USF	Trajectory Planning for Connected Autonomous Modular Vehicles: Theory, Modeling and Experiments	**Xiaopeng Li** University of South Florida	January 24, 2020
ASU	Cyber-Physical Systems for Vehicle-In-The-Flow Traffic Control	**Jonathan Sprinkle** University of Arizona	January 30, 2020
USF	Intelligent Transportation Systems Field Applications: Advanced Mobility Readiness	**Tolga Ercan** TransCore	January 31, 2020
USF	Operational Design for Modular Autonomous Vehicles-based Transportation Systems	**Zhiwei Chen** University of South Florida	February 07, 2020
ASU	Three Transportation Revolutions: Steering Automated, Shared, and Electric Vehicles to a Better Future	**Daniel Sperling** University of California at Davis	February 12, 2020
USF	Beyond ITS: Major Trends in TSMO and CAV	**Steve Lockwood** University of South Florida	February 14, 2020

USF	Analysis of Leisure Activity Variety using Social Capital Measures	**Trang Luong** University of South Florida	February 21, 2020
USF	An Inferential Study of the Potential Consumer Value of Free Charging for Users of Public EV Charging Systems	**Divyamitra Mishra** University of South Florida	February 21, 2020
USF	Crucial Factors in Roadway Design	**Michael O. Ojo** Florida Dept of Transportation	February 28, 2020
ASU	A Once in a Lifetime Project Every 10 Years	**W. Charles Greer, Jr.** University of Illinois	March 5, 2020
UW	Transportation Big Data: Promises, Issues and Solutions	**Cynthia Chen** University of Washington	March 18, 2020

TOMNET offered a five-day workshop (equivalent to a graduate-level course) that provides in-depth coverage of activity-travel behavior analysis methods with an emphasis on the specification, estimation, and application of activity-based travel behavior models for policy-making. The course covered a variety of statistical and econometric methods that are used in research and practice for modeling, understanding, explaining, and forecasting activity-travel demand. Participants were taught how to deploy statistical and econometric choice models in a microsimulation environment. The course covered emerging techniques for simulating traveler choices and forecasting travel demand under a wide variety of socio-economic, demographic, built environment, modal, and network scenarios. Attendees undertook hands-on exercises in the estimation of activity-travel behavior models, population synthesis, model application in a forecasting mode, and interpretation and use of the model outputs for transportation planning and policy analyses. More information about this workshop and other planned workshops for the remainder of the year can be found on the TOMNET website.

Table 5. Short Courses/Workshops Hosted or Conducted by TOMNET Core Faculty

Organizing Institution	Title of Workshop or Short Course	Workshop Instructors	Date of Event	Location of Event	Number of Attendees
ASU	Transportation Big Data: Promises, Issues and Solutions	**Ram M. Pendyala, PhD** Arizona State University **Shivam Sharda** Arizona State University **Taehooie Kim** Arizona State University **Vladimir Livshits** Maricopa Association of Governments	March 9-13, 2020	Arizona State University	15
ASU	Attitudes and Travel Behavior Literature Review Course	**Matthew Conway** Arizona State University **Deborah Salon** Arizona State University	Fall semester 2019	ASU	7

What do you plan to do during the next reporting period to accomplish the goals?
TOMNET has a number of activities planned for the next reporting period to ensure rapid growth in the portfolio of accomplishments of the center. In the research domain, TOMNET faculty members will continue making progress on research projects and the results will be disseminated widely through various channels. Moreover, TOMNET team members are planning to meet virtually during the next reporting period to talk about various TOMNET plans including the selected projects for the upcoming year. The TOMNET leadership team had a short virtual meeting on April 13 to keep the whole TOMNET enterprise moving forward at full speed.

In the education and workforce development domain, TOMNET faculty members will continue to

teach undergraduate and graduate courses at their respective institutions while enhancing the content to reflect new discoveries and trends in the profession. In particular, TOMNET faculty members are introducing concepts related to traveler behavior and values, attitudes and perceptions, and data fusion and machine learning technologies in their courses. TOMNET faculty members will continue to mentor students and guide them to the completion of their studies and appropriate career pathways.

In the technology transfer domain, TOMNET will continue to organize webinars/seminars/short courses such as those listed previously in the report (in VIRTUAL mode). These webinars will be recorded and archived at the TOMNET website for the benefit of those who cannot attend the webinars live and in-person. The seminars and webinars will be publicized via various distribution lists and e-mail listservs. Due to the current pandemic situation, we are planning all of our short courses and seminar events to be conducted fully online for safety considerations.

Discussions are underway to organize a symposium, called the A4 Symposium. This symposium will focus on Attitudes, Automation, Autonomy, and Access (hence, A4) and bring together the many key themes addressed by TOMNET. TOMNET will be launching a data science challenge, inviting students from around the world to participate in a data challenge and student paper competition. Students will be required to submit entries that aim to enhance the profession's understanding of the relationships between traveler attitudes, behaviors, perceptions, and preferences, while clearly explaining how their submissions can be translated into real-world tools and models that can be implemented in planning agencies to advance the state-of-the-practice. This data challenge and student paper competition are planned to be launched in Fall 2020/Spring 2021, potentially in conjunction with A4 symposium. These initiatives have been postponed to the next year due to the current Pandemic situation. TOMNET scholars will continue to engage in considerable K-12 outreach activities.

The multi-city TOMNET survey is completed and the compiled, clean, weighted data is ready for analysis with 3740 completed responses across four southern metro areas. The first outreach event for this project is a planned for June 12, 2020 with a series of webinars delivered by project researchers from all four involved universities. Additionally, it is envisioned that during the next reporting period, the results of the survey will be disseminated widely through different channels such as presentations at local agencies, national and international conferences, research briefs, project reports, and academic journal papers. Moreover, advanced modeling and analysis of the cleaned/weighted data will commence during the next reporting period, thus leading to the production of numerous impactful products during and beyond the life of TOMNET.

TOMNET will heavily engage in analyzing the impacts of COVID-19 on human activities and travel behavior, attitudes towards work and online shopping, and other remote activity engagement. One of the existing TOMNET projects (No. 22 in Table 1) and one new project (No. 10 in Table 1) are exploring the impacts of COVID-19 on community responsiveness and travel behavior and lifestyle attitudes. Results from these efforts will be disseminated in the next reporting period.

2. PARTICIPANTS & COLLABORATING ORGANIZATIONS

TOMNET researchers have been actively collaborating with a number of organizations and partners in academia and industry. These partnerships have created many opportunities for the impact of TOMNET to be felt on a broad scale. TOMNET has actively pursued partnerships and engaged with a number of other entities so that the research projects and products are of value to a broad set of stakeholders and constituents. TOMNET researchers work very closely with Atlanta Regional Commission, Maricopa Association of Governments, and Georgia Department of Transportation. The full list is below.

What organizations have been involved as partners?
- Maricopa Association of Governments, Phoenix, Arizona: In-kind support, data sets, research
- Atlanta Regional Commission, Atlanta, Georgia: Data sharing and personnel exchange

- Arizona Department of Transportation, Phoenix, Arizona: Exploring statewide travel patterns
- Georgia Department of Transportation, Atlanta, Georgia: In-kind and cash support, data sets, collaborative research, funding of matching-project research
- Oak Ridge National Laboratory – National Transportation Research Center, Knoxville, TN: Exploratory analysis of the impacts of providing free public charging infrastructure on plug-in electric vehicle ownership and usage, including attitudes towards EV ownership.
- The University of Leeds, Leeds, United Kingdom, and the University of Warsaw, Warsaw, Poland: Aid in the design of a survey exploring electric vehicle charging behavior.
- Laurelhurst Earthquake Action Preparedness, Seattle, WA: Collaborative research
- City of Westport, Westport, WA: Collaborative research, supplied facilities
- Westport Tsunami Safety Committee, Westport, WA: Collaborative research
- City of Seattle Office of Emergency Management: Collaborative research
- Arizona State University Decision Theater: In-kind support, data sets, collaborative research

Have other collaborators or contacts been involved?

- Professor Chandra Bhat, the University of Texas at Austin, TX
- Professor Laurie Garrow, Georgia Tech, Atlanta, GA
- Professor Brian German Georgia Tech, Atlanta, GA
- Prof. Joseph Saleh, Georgia Tech, Atlanta, GA
- Prof. Patrick Singleton, Utah State University, Logan, UT
- Jia Tang, a PhD student from Nanjing University
- Prof. Rolf Moeckel, Technical University of Munich, Germany
- South Park Information and Resource Center
- Washington Emergency Management Division
- Washington State Parks
- Shoalwater Bay Tribe
- Westport Police Department
- Grays Harbor County Emergency Management
- South Beach Regional Fire Authority
- Ocosta Public School District
- Northwest Healthcare Response Network
- University of Washington School of Public Health
- Seattle Emergency Hubs

TOMNET works closely with members of the D-STOP University Transportation Center led by the Center for Transportation Research at the University of Texas at Austin. A key element of the strategic partnership between the two centers is the participation of D-STOP in the multicity survey on attitudes towards and adoption of transformative transportation technologies. TOMNET team members are engaged in collaborative endeavors with other University Transportation Centers, including the Regional UTC in the Pacific Northwest, the National UTC led by the University of California at Davis, and the Regional UTC in Region 9 led by the University of Southern California.

3. OUTPUTS

The following is a list of **publications, conference papers, and presentations** produced by TOMNET core faculty members during the reporting period covered by this SAPR. To the extent possible, papers and presentations likely to be listed in other UTC SAPR documents have been omitted.

Arizona State University

__Papers Published Within Reporting Period__

1. Dias, F., Lavieri, P.S., Sharda, S., Khoeini, S., Bhat, C.R., Pendyala, R.M., Pinjari, A.R., Ramadurai, G., and Srinivasan, K.K (2020). A Comparison of Online and In-Person Activity Engagement: The Case of Shopping and Eating Meals. *Transportation Research Part C: Emerging Technologies* 114, 643-656.
2. Mondal, A., Bhat, C.R., Costey, M.C., Bhat, A.C., Webb, T., Magassy, T.B., Pendyala, R.M., & Lam, W.H.K. (2020). How do people feel while walking? A multivariate analysis of emotional well-being for utilitarian and recreational walking episodes. *International Journal of Sustainable Transportation,* 1-16.
3. Devaraj, A., Ambi Ramakrishnan, G., Nair, G.S., Srinivasan, K.K., Bhat, C.R., Pinjari, A.R., Ramadurai, G., & Pendyala, R.M. (2020). Joint model of application-based ride hailing adoption, intensity of use, and intermediate public transport consideration among workers in Chennai City. *Transportation Research Record*, 0361198120912237.
4. Astroza, S., Garikapati, V.M., Pendyala, R.M., Bhat, C.R. & Mokhtarian, P.L. (2019). Representing heterogeneity in structural relationships among multiple choice variables using a latent segmentation approach. *Transportation 46*, 1755–1784. https://doi.org/10.1007/s11116-018-9882-7

__Presentations Within Reporting Period__

1. Capasso da Silva, D. (2020, January). *The effect of attitudes on women's willingness to share autonomous vehicles.* Poster presented at the 10th Annual SSEBE Graduate Research Symposium, Tempe, AZ.
2. Magassy, T.B. (2020, January). *Preliminary Survey Results with Participants on the Valley Metro-Waymo Demonstration Project.* Poster presented at the 10th Annual SSEBE Graduate Research Symposium, Tempe, AZ.
3. Batur, I., Sharda, S., Kim, T., Khoeini, S., Pendyala, R.M., & Bhat, C. (2020, January). *Mobility, time poverty, and well-being: How are they connected and how much does mobility matter?* Presented at the 99th Annual Meeting of the Transportation Research Board, Washington, D.C.
4. Capasso da Silva, D., Astroza, S., Batur, I., Koeini, S., Magassy, T.B., Pendyala, R., & Bhat, C. (2020, January). *Are millennials really all that different than generation X? An analysis of factors contributing to differences in vehicle miles of travel.* Presented at the 99th Annual Meeting of the Transportation Research Board, Washington, D.C.
5. Devaraj, A., Ramakrishnan, G.A., Nair, G.S., Srinivasan, K., Bhat, C.R., Pinjari, A., Ramadurai, G., & Pendyala, R.M. (2020, January). *Joint model of app-based ridehailing adoption, intensity of use, and intermediate public transport consideration among workers in Chennai City.* Presented at the 99th Annual Meeting of the Transportation Research Board, Washington.
6. Dias, F., Kim, T., Bhat, C.R., Pendyala, R.M., Lam, W.H.K., Pinjari, A., Srinivasan, K., & Ramadurai, G. (2020, January). *Modeling the Evolution of Ridehailing Adoption and Usage: A Case Study of the Puget Sound Region*. Presented at the 99th Annual Meeting of the Transportation Research Board, Washington, D.C.
7. Dias, F., Lavieri, P., Sharda, S., Khoeini, S., Bhat, C.R., Pendyala, R.M., Pinjari, A., Ramadurai, G., & Srinivasan, K. (2020, January). *A comparison of online and in-person activity engagement: The case of shopping and eating meals*. Presented at the 99th Annual Meeting of the Transportation Research Board, Washington, D.C.
8. Garcia, C., Armoogum, J., & Batur, I. (2020, January). *Immobility and activity levels: A comparison of the United States and France. Presented* at the 99th Annual Meeting of the Transportation Research Board, Washington, D.C.
9. King, D., & Capasso da Silva, D. (2020, January). *Accessibility in Practice: A case study of twenty-minute Tempe.* Presented at the 99th Annual Meeting of the Transportation Research Board, Washington, D.C.
10. Khoeini, S., Capasso da Silva, D., Sharda, S., Magassy, T.B., & Pendyala, R.M. (2020, January) *An integrated model of activity-travel behavior and subjective well-being.* Presented at the 99th Annual Meeting of the Transportation Research Board.
11. Mondal, A., Bhat, C.R., Costey, M., Bhat, A., Webb, T., Magassy, T.B., Pendyala, R.M., & Lam, W.H.K. (2020, January). *How do people feel while walking?: A multi-variate analysis of emotional well-being for utilitarian and recreational walking episodes.* Presented at the 99th Annual Meeting of the Transportation Research Board, Washington, D.C.
12. Nair, G.S., Bhat, C.R., Batur, I., Pendyala, R.M., & Lam, W.H.K. (2020, January). *A model of deadheading trips and pickup locations for ridehailing service vehicles*. Presented at the 99th Annual Meeting of the Transportation Research Board, Washington, D.C.
13. Sharda, S., Kim, T., Khoeini, S., Batur, I., & Pendyala, R.M. (2020, January). *Development of an integrated model system of transport and residential energy consumption.* Presented at the 99th Annual Meeting of the Transportation Research Board.
14. Conway, M.W., Harness, N., Mirtich, L., Ross, A., Hong, S., & Salon, D. (2020, January). *How important are attitudes in travel behavior models?* Presented at the Bridging Transport Researchers Conference, Online.
15. Sharda, S. (2019, December). *Joint model of risky driving behavior, device use and secondary task engagement using naturalistic driving study (nds) data.* Presented at Conference of Transportation Research Group of India (CTRG), India.
16. Capasso da Silva, D. (2019, November). *User perceptions and potential adoption of autonomous vehicles - An in-depth attitudinal survey based study.*
    a. Poster presented at the ASU Pavements and Materials Conference, Tempe, AZ.
    b. Poster presented at the Chandler Autonomous Vehicles Symposium, Chandler, AZ.
    c. Poster presented at the Smart Cities Workshop, Tempe, AZ.

Georgia Tech

Papers Published Within Reporting Period

1. Kim, S.H., Circella, G., & Mokhtarian, P.L. (2019). Identifying latent mode-use propensity segments in an all-AV era. *Transportation Research Part A: Policy and Practice 130*, 192-207.
2. Lee, Y., Circella, G., Mokhtarian, P. L., & Guhathakurta, S. (2019). Heterogeneous residential preferences among millennials and members of generation x in California: A latent-class approach. *Transportation Research Part D: Transport and Environment*. https://doi.org/10.1016/j.trd.2019.08.001
3. van Herick, D. & Mokhtarian, P.L. (2020). How much does the method matter? An empirical comparison of ways to quantify the influence of residential self-selection. *Travel Behaviour and Society 18*, 68-82.

Presentations Within Reporting Period

1. Shaw, F.A. (2020, February). *Transportation data integration and utilization in an era of transport disruption.* Presented at a Research Seminar, Department of Civil, Structural and Environmental Engineering and Stephen Still Institute for Sustainable Transportation and Logistics, University at Buffalo, Buffalo, NY.
2. Shaw, F.A., Wang, X., & Mokhtarian, P.L. (2020, February). *Pursuing the "impossible" dream: Incorporating attitudes into regional transportation models*. Presented at the University of Florida, Gainesville, FL.
3. Choi, S. & Mokhtarian, P. L. (2020, January). *How attractive is it to use the internet while commuting? A work-attitude based segmentation of Northern California commuters*. Presented at the Atlanta Regional Commission (ARC) meeting, Atlanta, GA.
4. Etezady, A., Mokhtarian, P. L., Circella, G. & Malokin, A. (2020, January). *Not all minutes are created equal: How does the impact of travel time on commute mode choice differ by demographics and propensity to multitask?* Presented at the Atlanta Regional Commission Meeting, Atlanta, GA.
5. Shaw, F.A., Wang, X., & Mokhtarian, P.L. (2020, January). *Using machine learning to impute attitudes into a household travel survey: How well does it work?* Presented at the Atlanta Regional Commission Meeting, Atlanta, GA.
6. Kim, S.H., Mokhtarian, P.L., & Circella, G. (2020, January). *Do people expect autonomous vehicles to change their residential location and vehicle ownership? Early glimpses from the state of Georgia.* Presented at the 99th Annual Meeting of the Transportation Research Board, Washington, DC.
7. Choi, S. & Mokhtarian, P. L. (2020, January). *How attractive is it to use the internet while commuting? A work-attitude based segmentation of Northern California commuters*. Presented at the 99th Annual Meeting of the Transportation Research Board, Washington, DC.
8. Kash, G. & Mokhtarian, P.L. (2020, January). *How much and what for? The interrelated effects of gender and age on mobility and trip purpose.* Presented at the 99th Annual Meeting of the Transportation Research Board, Washington, DC.
9. Kash, G. & Mokhtarian, P.L. (2020, January). *What counts as commute travel? Identification and resolution of key issues around measuring complex commutes in the national household travel survey.* Presented at the 99th Annual Meeting of the Transportation Research Board, Washington, DC.
10. Mokhtarian, P.L. (2020, January). *Biggest steps to decarbonization: Is telecommuting an answer?* Presented at the 99th Annual Meeting of the Transportation Research Board, Washington, DC.
11. Shaw, F. A., Wang, X., Mokhtarian, P.L., & Watkins, K.E. (2020, January). *Targeted marketing data as a transportation data source: Applications, integration, and validation*. Presented at the 99th Annual Meeting of the Transportation Research Board, Washington, DC.
12. Wang, X., Shaw, F.A., & Mokhtarian, P.L. (2020, January). *Latent vehicle type propensity segments: Considering the influence of household vehicle fleet structure.* Presented at the 99th Annual Meeting of the Transportation Research Board, Washington, DC.
13. Wang, X., Shaw, F.A., Mokhtarian, P.L., Circella, G., & Watkins, K. (2019, November). *The pursuit of happiness: Combining disparate travel surveys across time to investigate satisfaction with life.* Quantitative Brown Bag Seminar, Psychology Department, Georgia Institute of Technology, Atlanta, GA.
14. Lee, Y., & Circella, G. (2019, October). *How, to what extent, and why do travel behaviors of ridehailing users differ from those of non users? Mobility patterns in the 2017 national household transportation survey.* Paper presented at the 2019 Annual Meeting of the Association of Collegiate Schools of Planning, Greenville, SC.
15. Kash, G. & Mokhtarian, P.L. (2019, September). *How much and what for? The interrelated effects of gender and age on mobility and trip purpose.* Presented at the Women's Issues in Transportation Conference, Irvine, CA.
16. Wang, X., Shaw, F.A., & Mokhtarian, P.L. (2019, September). *Why did you choose an suv? Identifying gender differences in latent vehicle-type propensity segments*. Presented at the Women's Issues in Transportation Conference, Irvine, CA.

University of South Florida

Textbooks Published Within Reporting Period

1. Mannering, F. & Washburn, S. (2020). *Principles of highway engineering and traffic analysis (7th edition)*. John Wiley and Sons, New York, NY. (Original work published December 2019).
2. Washington, S., Karlaftis, M., Mannering, F., & Anastasopoulos, P. (2020). *Statistical and econometric methods for transportation data analysis* (3rd edition). CRC Press, Taylor and Francis Group, New York, NY.

Papers Published Within Reporting Period

1. Mannering, F., Bhat, C.R., Shankar, V., & Abdel-Aty, M. (2020). Big data, traditional data and the tradeoffs between prediction and causality in highway-safety analysis. *Analytic Methods in Accident Research 25*, 100113, 1-9.
2. Barbour, N., Zhang, Y., & Mannering, F. (2020). An exploratory analysis of the role of socio-demographic and health-related factors in ride sourcing behavior. *Journal of Transport and Health 16*, 100832, 1-9.
3. Menon, N., Zhang, Y., Pinjari, A., & Mannering, F. (2020). A statistical analysis of consumers' perceptions towards automated vehicles and their intended adoption. *Transportation Planning and Technology*, *43(3),* 253-278.
4. Islam, M. & Mannering, F. (2020). A temporal analysis of driver-injury severities in crashes involving aggressive and non-aggressive driving. *Analytic Methods in Accident Research*, *27*, 100128, 1-16.
5. Sheela, P. & Mannering, F. (2020). The effect of information on changing opinions toward autonomous vehicle adoption: An exploratory analysis. *International Journal of Sustainable Transportation*, *14(6),* 475-487.
6. Maness, M. (2020). Choice Modeling Perspectives on the Use of Interpersonal Social Networks and Social Interactions in Activity and Travel Behavior. Book chapter in *Mapping the Travel Behavior Genome: The Role of Disruptive Technologies, Automation, and Experimentation*.
7. Tahlyan, D., Balasu, S., Sheela, P.V., Maness, M., & Pinjari, A. (2020). Improving the spatial transferability of travel demand forecasting models: An empirical assessment of the impact of incorporating attitudes on model transferability. Book chapter in *Mapping the Travel Behavior Genome: The Role of Disruptive Technologies, Automation, and Experimentation*.

Presentations Within Reporting Period

1. M. Maness. (2019). *An inferential study of the potential consumer value of free charging*. Presented at the 2019 Behavior, Energy, and Climate Change Conference, Sacramento, CA.

University of Washington
Presentations Within Reporting Period

1. Idziorek, K., C. Chen & Abramson, D.B. (2020, January). *Integrating social factors into transportation-focused disaster preparedness research*. Presented at the 99th annual meeting of the Transportation Research Board, Washington DC.
2. Wang, F., Guan, X. & Chen, C. (2020, January). *A framework for leveraging emerging data to understand impacts of abnormal events on collective and individual travel patterns*. Presented at the 99th annual meeting of the Transportation Research Board, Washington DC.
3. Zhu, X., Feng, J., Huang, S. & Chen, C. (2020, January). *An online updating method for preference learning*. Presented at the 99th annual meeting of the Transportation Research Board, Washington DC.

In summary, TOMNET core faculty generated 14 journal publications and two textbooks within the reporting period covered by this SAPR. These journal publications are directly attributable to funding provided by the TOMNET UTC. During the reporting period of this SAPR, TOMNET researchers presented 40 conference presentations at the various venues; and 21 of the presentations took place at the 99th Annual Meeting of the Transportation Research Board in Washington, DC during January 2020. Moreover, two of the poster presentations out of TOMNET projects delivered by Denise Capasso da Silva (TOMNET graduate student at ASU working on T4 Survey) received the best student poster awards at ASU Research Symposium (Tempe, AZ, 2019) and Pavement/Materials Conference (Tempe, AZ, 2019).

Website(s) or other Internet site(s)

One major product of the center is the TOMNET website that is being continuously enhanced to support the mission of the center. The website is a portal with comprehensive information about the activities of the Center. No new websites were developed during this reporting period; however, the websites listed in the prior progress report were enhanced and updated with additional content during the reporting period. More importantly, the link to the TOMNET COVID-19 survey is embedded on the front page of the website in addition to two Medium articles from the TOMNET director (Ram Pendyala) on his insights on potential shifts in travel behavior after the pandemic.

Software Programs, Codes, and Products

During the reporting period covered by this SAPR, the TOMNET team has worked diligently towards developing a few key products that would be of value to the transportation planning community.

Over the past year, TOMNET has collected a super-large dataset on attitudes and perceptions toward new transportation technologies with rich sets of questions covering respondents' socioeconomic, attitudes, and travel characteristics. After a comprehensive analysis of the data, data sets will be released for public use as well. In the meantime, the findings from the survey will be disseminated to the community through a series of webinars and research papers.

The University of Washington team has developed a standardized survey instrument and started collecting data on how communities access information and respond to disaster situations and crises. They have also added a follow-up survey to ask about community resilience during COVID-19 pandemic. This survey and protocols for engaging with community groups is a product that the TOMNET team envisions making available to any community that may wish to collect such data.

As noted in prior progress reports, the TOMNET team at ASU has been heavily involved in the development and application of open source tools including the synthetic population generator called PopGen, and R and Python codes for transportation model estimation and implementation. These codes are being documented and will be posted to the TOMNET website shortly. In particular, the programs will enable the estimation of advanced econometric choice models (such as integrated choice latent variable or ICLV models) that are most suited to jointly modeling attitudes and behaviors in a simultaneous equations framework. Moreover, an integrated Household Energy Analysis Tool (iHEAT) is under development. The alpha version of this calculator is already implemented online and the researchers are working to improve the modeling method as well as the application and visualization features of the tool.

In addition, TOMNET is developing the Wellbeing Estimator for Activities and Travel (WBEAT). This special model is intended to serve as an add-on module for any activity-based travel demand model system. The methodology embedded in the module calculates a wellbeing index for each person in the simulation based on the activities (predicted to be) undertaken by that individual (including "travel" episodes) over the course of a day. Given the critical role that transportation plays in shaping the wellbeing of communities, this tool will prove valuable in assessing and comparing the potential impacts of alternative transportation investments, policies, and mobility options on societal wellbeing. The model system has been developed and the results have been presented at TRB2020. The journal paper based on this study is also under review for possible publication in *Transportation Letters* and the TOMNET researchers are working on addressing the reviewer comments and making revisions.

Lastly, all TOMNET seminars and webinars have been recorded, streamed live, and archived on the TOMNET website for the general public. The seminar recordings can be accessed here.

Databases and Research Materials

In a number of TOMNET projects, integrated datasets have been developed (or are under development) using data fusion techniques with a view to studying the impact of attitudes on different transportation-related choices such as residential location choice, mode choice, vehicle ownership, and adoption of emerging mobility services and automated vehicle technologies. Some of the data sets are based on native survey data collection efforts undertaken by the TOMNET team. Other data sets have been assembled by integrating and fusing data that is already available in the public domain. A number of these efforts are described in Section 2 of this report. All data sets assembled by TOMNET will be made available (without personally identifiable information) via the TOMNET website for the broader community.

The rich set of data collected in the transportation technology survey (3740+ responses) is cleaned, weighted, geocoded, and documented with a data dictionary. The TOMNET team is analyzing the data extensively. This dataset includes a comprehensive set of variables on socioeconomics, general attitudes, residential and vehicle ownership information, and perceptions, attitudes, and potential use of new transportation options such as ridehailing services and autonomous vehicles. It is a unique database considering its comprehensiveness as well as multi-region coverage.

Moreover, data is being collected by the University of Washington team about community access to information and disaster response mechanisms which includes responses to the COVID-19 pandemic situation. The third dataset which is in the collection phase is about measuring and understanding the short- and long-term impacts of COVID-19 on the transportation systems. It is envisioned that this research will end up with a large dataset from various population cohorts across the US to understand how COVID-19 might temporarily or permanently change people's travel, shopping, working, studying, and leisure lifestyles.

At this time, the TOMNET team does not have any other products to report under the following categories: *Technologies or techniques; Inventions, patent applications, and/or licenses; Other products (Physical collections, Software or NetWare, Instruments or equipment).*

TOMNET is tracking metrics in an effort to see how the center is doing relative to targets specified in the Technology Transfer Plan. Table 6 provides a summary of performance for two metrics.

Table 6. TOMNET Metrics on Products

Metric	Annual Target	Previous Reporting Period	This Reporting Period	Annual Total	Assessment
Number of software products, data sets, or model specifications released	2	1	1	2	Still in beta-version testing. Need to release deployment ready versions.
Number of publications in refereed journals	15	20	14	34	Greatly exceeded annual target.

4. OUTCOMES

Increases in the body of knowledge:
Better information is critically needed on the transformative impacts that emerging transportation technologies and new mobility services will have on cities. This need is particularly urgent at a time of rapid socio-economic, demographic, and technological change. The **TOMNET Transformative Technologies in Transportation (T4) Survey** is creating the much-needed knowledge base to understand the potential evolution of travel choices of residents in several major cities in the sunbelt (where transit is generally not very mature) in the wake of changes brought about by the advent of new mobility services, e.g., shared mobility and ridehailing, as well as automated vehicles and micromobility. TOMNET research has also shed deep insights on the traveler behaviors and choices of millennials, with a focus on generational differences. TOMNET research is resulting in increases in the body of knowledge related to residential location choice, driver behavior and risk-taking, and the connection between activity-travel and time use patterns on the one hand and wellbeing on the other. TOMNET research is increasing body of knowledge on the presence of market segments that follow different causal structures in terms of relationships that govern their travel choices. This body of knowledge is critical to advancing more realistic and accurate travel demand forecasting models. Moreover, TOMNET researchers are studying the potential impacts of COVID-19 on people's travel behavior, time use, and activity styles before, during and after the pandemic to help decision-makers plan and adapt transportation systems to the crisis.

Improved techniques in addressing transportation issues:
The analysis of the data collected in **T4 Survey** is already contributing to improved planning processes and informing policymakers on very important trends that are quickly reshaping mobility patterns. The TOMNET team is developing new techniques for crafting future automated vehicle and shared mobility scenarios for analysis in travel demand forecasting exercises. *These scenarios are informed by the data collected in the survey, thus providing forecasts of scenarios that are more likely to play out.* Techniques for developing scenarios and analyzing the scenarios are being developed for potential implementation in real-world travel demand forecasting models. Currently, travel demand models are not equipped to

generate meaningful and empirically driven scenarios, and the techniques developed by TOMNET will help fill this gap. In addition, TOMNET developed an integrated household energy analysis tool and an integrated wellbeing analysis tool, both of which incorporate techniques and algorithms that can be implemented in conjunction with existing travel demand forecasting models and planning processes. The team has also developed novel methods for fusing data from targeted marketing firms with data from traditional household travel surveys; this results in highly enriched data that can be used to advance more accurate travel forecasts.

Enlargement of the pool of trained transportation professionals:

TOMNET has been very successful and productive in engaging undergraduate, and graduate students besides post-doctoral researchers. TOMNET trainees include minorities and women, and the number of students engaged in TOMNET activities has grown considerably. These students are unlikely to have been involved in transportation research and education in the absence of TOMNET. Additionally, TOMNET is actively disseminating research outputs through various channels and conducting short courses, thus enlarging the pool of "trained" transportation professionals. TOMNET has been tracking progress in achieving outcomes relative to targets established in the Technology Transfer Plan. A summary of progress is shown in Table 7 for two metrics.

The TOMNET team is re-evaluating the metrics for outcomes. It would appear that these metrics are not quite ideal for tracking purposes, given that the number of workshops does not necessarily constitute an outcome and determining improvement in forecast accuracy is extremely challenging to do within the lifetime of a UTC (because of the time it takes for MPO models to be significantly updated with new data and methods). Discussions are underway to potentially change the metrics to consider number of individuals participating in TOMNET research, education, and technology transfer activities, and the number of instances that TOMNET researchers and research results have been cited and quoted in the press or other similar public outlets.

Table 7. TOMNET Metrics on Products

Metric	Annual Target	Previous Reporting Period	This Reporting Period	Annual Total	Assessment
Number of workshops, short courses, and tutorials	2	1	2	3	Need to focus on more full-scale workshops and tutorials in 2020. TOMNET is holding many seminars/webinars.
Improvement in accuracy of travel forecasts due to TOMNET research methods	10%	0%	5%	5%	Initial efforts exhibit considerable promise in improving travel forecasts. Need to do more testing in the agency environment.

5. IMPACTS

What is the impact on the effectiveness of the transportation system?

ASU/GT/USF: Charting a sustainable pathway for smart cities of the future requires detailed data about people's movements, transportation preferences, and attitudes and perceptions towards new mobility options and technologies. The data and tools being developed under the auspices of TOMNET are making it possible for agencies to more accurately forecast the potential impacts of transformative transportation technologies, resulting in a more effective transportation system and informed decision-making on transportation investments and improvements that will advance mobility for all.

ASU: Virtually overnight, a large fraction of U.S. households has transitioned from a reality of long commutes to telecommuting, from in-person to online classes and business meetings, and from in-store to online shopping – even for groceries. Many of these changes were happening already, but COVID-19 has pressed the fast-forward button. It is very important that the transportation sector be responsive to this situation during and after the pandemic. This needs rich data sources to monitor people's perceptions and behaviors during and after the pandemic. ASU is collecting a national survey on people's behavior and

lifestyles before, during, and after the pandemic. Initial survey results suggest that respondents do expect substantial changes in telecommuting, business air travel, and online shopping that will persist after the pandemic. This will directly impact future transportation planning efforts and agencies from around the country have requested access to the data to aid in their planning efforts.

UW: The data gathered from the community resilience surveys by UW and community outreach activities will help to inform both transportation and emergency planners about what actions people anticipate they will take in the event of a large earthquake (and, for the coastal areas, accompanying tsunami). Where will they seek health care and medications? What resources are located within communities that could serve alternative purposes in a time of need? How can different kinds of transportation and communications sources be enhanced or better leveraged through social relationships and local knowledge? In addition to the earthquake and tsunami scenarios upon which we focused in earlier phases of the study, we now add understanding transportation behavior changes during a pandemic.

What is the impact on the adoption of new practices, or instances where research outcomes have led to the initiation of a start-up company?

ASU/GT/USF: Results from the **T4 Survey** are helping to craft realistic future scenarios and travel forecasts. Several agencies have expressed interest in adopting and implementing the integrated household energy analysis tool (iHEAT) and well-being estimation and analysis tool (WBEAT). TOMNET research has also led to improved specification of transportation forecasting models in agencies by demonstrating the presence of market segments that follow different causal structures in decision-making and have different proclivities towards multitasking. TOMNET research is helping to craft new and improved transportation safety campaigns, with explicit recognition that different messaging is required for different market segments (due to heterogeneity in safety behaviors). TOMNET has also provided guidance to ADOT for weighting the Arizona sample of National Household Travel Survey (NHTS).

UW: The community resilience project is building upon earlier work to test and promote an appreciative inquiry approach to disaster mitigation planning that highlights community strengths over vulnerabilities. Such an approach to hazard planning has the potential to help communities develop mitigation strategies that will benefit them on an everyday basis as well as in the case of a disaster.

What is the impact on the body of scientific knowledge?

ASU/GT/USF: The **T4 Survey** has provided agencies and researchers around the world a comprehensive data collection instrument and strategy for collecting reliable data on how people might adopt and adapt to transformative technologies in transportation. The insights from the survey are greatly expanding the body of scientific knowledge on the Future of Mobility.

UW: The community-engaged workshops and survey instruments that are being developed through the community resilience project will help to inform future research and action regarding region-wide resilience strategies. By engaging both urban and rural communities, we will be able to understand better what the differences are in the needs of communities representing a range of demographic and socioeconomic profiles. Within the fields of urban and hazard mitigation planning, for example, the further development of appreciative inquiry-based approaches for hazard mitigation planning is an area of growth that holds much promise for informing future hazard planning approaches that can better take local needs, resources, knowledge, and strengths into account. Furthermore, the collection of ephemeral data during the COVID-19 epidemic will help to build an understanding of household- and community-level preparedness actions and attitudes regarding pandemic scenarios.

GT: As a part of TOMNET-supporting research activities, researchers at Georgia Tech investigated whether the use of ridehailing services affects the use of other travel modes (e.g., public transit, walking, and biking) and if so, how much and in which directions. While existing studies looked at *trip-level* substitution or complementarity patterns, a focus on medium-term travel patterns (those in a typical month) allows us to see the net effects (i.e., a sum of direct and indirect effects) of emerging mobility services on the

transportation system. With the 2017 National Household Travel Survey (NHTS), the first nation-wide transportation survey that recorded use of ridehailing services, our preliminary results show that on net, ridehailing users tend to take transit, walk, and bike *more frequently* while driving *fewer* miles and owning *fewer* household cars, compared to otherwise comparable non-users. However, as individuals' ridehailing frequency increases, the differences in travel outcomes between users and equivalent non-users become smaller, suggesting that substitution effects may be larger than complementary effects as the adoption increases. With much richer information in the TOMNET future mobility survey than the 2017 NHTS, researchers are developing complex behavioral models, which incorporate attitudes and perceptions and thus, generate more realistic estimates for the impacts of shared mobility services. We expect these models to shed light on the way these impacts are distributed (i.e., heterogeneously) across individuals, neighborhoods, and regions. Researchers will be able to identify population groups and neighborhoods, for which planners and policymakers can develop targeted approaches and reduce the environmental impacts of shared mobility services, while promoting enhanced mobility options.

GT: Another TOMNET-related study analyzed the responses to a novel set of questions about how individuals' activity patterns are likely to change in an automated-vehicle era. The study identified four dimensions of change: distance of travel (e.g. for shopping, eating, socializing), frequency of travel, time flexibility, and leisure/long-distance travel. Scores were developed for each individual in the sample, indicating the likelihood of change on each dimension. Then, individuals were clustered on their scores, identifying six clusters of people with distinctive profiles with respect to likely changes. The study provides a helpful early glimpse of the way automated vehicles may influence our behavior.

What is the impact on transportation workforce development?

ASU: TOMNET has enabled multiple undergraduate students, including Barrett Honors College students, to participate in transportation research. These students have graduated and are now in industry as transportation engineering professionals; thus TOMNET has directly impacted the workforce.

GT: TOMNET Ph.D. student **Atiyya Shaw** is nearing the completion of her dissertation and is accordingly on the job market. During this reporting period, she was invited to three on-campus faculty interviews, at the University of Buffalo, UC Berkeley, and the University of North Carolina. TOMNET Ph.D. student Sung Hoo Kim was accepted into the competitive Future Faculty Fellows program offered by the School of Civil and Environmental Engineering at Georgia Tech. This rigorous program involves training in best pedagogical practices, interviews of faculty mentors, and preparation and delivery of guest lectures. Sung Hoo delivered an outstanding guest lecture on cluster analysis to Dr. Mokhtarian's Transportation Survey Methods class on October 17, 2019.

UW: The community resilience project activities have engaged undergraduate, graduate, and Ph.D. students in community-engaged research about transportation issues in rural and remote areas, particularly as related to emergency planning and hazard mitigation. In previous phases of the project, students were trained to use WeTable participatory GIS equipment to engage collaboratively with experts in urban planning, transportation planning, and hazard mitigation planning on potential planning interventions for remote coastal communities. In the community workshop activities to date, we provided opportunities for the public to learn about disaster planning best practices and to share local knowledge with planners and hazard mitigation specialists. We have also engaged multiple NSF REU students in this project who have learned technical skills relevant to data collection and analysis.

TOMNET has been tracking progress in achieving impacts as outlined in the Technology Transfer Plan. A summary of progress is shown in table 8 for two metrics. Again, the TOMNET team is re-visiting these metrics to ensure that they are appropriate for tracking the performance of the UTC. While the first metric is appropriate, the second metric tends to be harder to measure and assess. The TOMNET team is considering a change in the second metric to reflect the number of individuals educated and trained in the use of new tools developed by TOMNET (impact on workforce), or the number of instances where

TOMNET research results have contributed to a change in design or policy (again, rather difficult to measure, but could be an easier metric than the existing one).

Table 8. TOMNET Metrics on Impacts

Metric	Annual Target	Previous Reporting Period	This Reporting Period	Annual Total	Assessment
Number of agencies adopting TOMNET tools	2	1	1	2	TOMNET is working with multiple agencies to enhance product adoption.
Improve mobility for transportation disadvantaged populations	5%	0%	0%	0%	Difficult metric to quantify and assess. Need to consider replacing this metric with one that is more measurable.

6. CHANGES/PROBLEMS

There are no changes to or problems with the scope, mission, budget, or operations of TOMNET.

7. SPECIAL REPORTING REQUIREMENTS

The institution has submitted all required financial and progress reports to date.