



UTC Semi-Annual Progress Report (SAPR#8)



Submitted to:	Office of the Assistant Secretary for Research and Technology US Department of Transportation
Prime Federal Grant No:	69A3551747116
Center Title:	Center for Teaching Old Models New Tricks (TOMNET)
Center Director:	Ram M. Pendyala, Professor, Arizona State University ram.pendyala@asu.edu , 480-727-4587
Submission Date:	June 30, 2021
DUNS Number:	943360412
Employer Identification Number:	86-01-96696
Submitting Official:	Ram M. Pendyala, Director of TOMNET UTC Professor, Arizona State University 480-727-4587; ram.pendyala@asu.edu
Recipient Organization:	Arizona State University Office of Research and Sponsored Projects Administration PO Box 876011, Tempe, AZ 85287-6011
Grant Period:	December 1, 2016 – September 30, 2022
Reporting Period:	October 1, 2020 to March 31, 2021
Report Frequency:	Semi-Annual
Submitting Official:	 Ram M. Pendyala, PhD, Director

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 through March 31, 2021. 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, 2020 through March 31, 2021. It should be noted that due to the pandemic, the last TOMNET leadership meeting was held virtually on December 16th, 2021 to plan for the remaining funding cycles of TOMNET.

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 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, including third-party or external/secondary data sets, with disparate information – thus facilitating the development of comprehensive models of travel demand that reflect the effects of human attitudes.

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 education 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 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 worked on several research projects. Projects launched in previous years have been completed (16 projects) or are continuing into their subsequent phases (7 projects). Additionally, 17 new projects have been launched during the reporting period. The list of all active and accomplished TOMNET projects is provided in Table 1 with the active period for each project. The status column indicates whether the project is accomplished or is still in progress. TOMNET projects for the previous reporting periods have been entered into the [RiP database](#) with associated details. The new TOMNET projects are in the process of getting entered into the RiP database. Moreover, the

completed project reports are undergoing final formatting and will be entered into the TriD database during the next reporting period. The TOMNET website [project page](#) includes the research projects categorized by year and the lead university. The project reports that have been completed recently are under review and will be posted on the website soon. Further information about active projects and progress made during the reporting period can be found below.

Table 1. TOMNET Research Projects

	Project Topic/Title	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- July 2020	✓
4.	Attitudes Towards Mobility Options/Technologies – A Multi-region Survey Design and Data Collection Effort	ASU (Khoeini)	Oct 2017- July 2020	✓
5.	Interaction of Transportation and Health, Wellbeing, and Safety – A National Survey Design and Data Collection	ASU (Khoeini)	Aug 2020 - Present	⚙️
6.	Transportation Policies, Pricing, and Priorities – A National Survey Design and Data Collection	ASU (Pendyala)	Aug 2020 - Present	⚙️
7.	Transportation Electrification – A National Survey Design and Data Collection	ASU (Pendyala)	Aug 2020 - Present	⚙️
8.	The Effect of Survey Methodology on The Collection of Attitudinal Data	ASU (Pendyala)	Aug 2020 - Present	⚙️
9.	Investigating Factors Shaping Willingness to Share Automated Vehicles: A Focus on Gender	ASU (Khoeini)	Aug 2020 - Present	⚙️
10.	Interaction of Familiarity, Safety Perceptions, and Willingness to Use Autonomous Vehicles in A Structural Equation Modeling Framework	ASU (Khoeini)	Aug 2020 - Present	⚙️
11.	Effects of Attitudes Towards COVID On Travel Behavior During The Pandemic	ASU (Pendyala)	Aug 2020 - Present	⚙️
12.	Expected Change in US Air Travel after the COVID-19 Pandemic	ASU (Khoeini)	Aug 2020 - Present	⚙️
13.	Integrated Household Energy Analysis Tool (iHEAT)	ASU (Pendyala)	Aug 2020 - Present	⚙️
14.	Diversity, Equity, and Inclusion (DEI) Implications of Mobility-on-Demand Services	ASU (Khoeini)	Aug 2020 - Present	⚙️
15.	How Will Use of Autonomous Vehicles for Running Errands Affect Future Autonomous Vehicle Adoption and Ownership?	ASU (Pendyala)	Aug 2020 - Present	⚙️
16.	Assembling Integrated Data Sets for Analyzing Connections between Travel Behavior, Attitudes, and the Built Environment	ASU (Salon)	Aug 2017- July 2018	✓
17.	Heterogeneity in the Relationship Between the Built Environment and Bicycling	ASU (Salon)	Aug 2018- July 2019	✓
18.	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	✓
19.	Comprehensive Review of Attitudes-Travel Behavior Literature	ASU (Salon)	Aug 2018- July 2019	✓
20.	The impact of non-transportation attitudes, preferences, and personality characteristics on residential location and travel choices	ASU (Salon)	Aug 2019- Present	⚙️
21.	Investigating Attitudinal and Behavioral Changes in U.S. Households Before, During, and After the COVID-19 pandemic	ASU (Salon)	Aug 2019- Present	⚙️
22.	Consumer Attitudes and Behavioral Implications in the New Era of Shared Mobility	ASU (Zhang)	Aug 2019 - Present	⚙️
23.	Emerging Approaches to Autonomous Vehicles in Transportation Policy and Planning	ASU (Thad Miller)	Aug 2019 - Present	⚙️

24.	Teaching the travel demand flow estimation models: a new deep-learning approach using multi-source data	ASU (Zhou)	Aug 2019 - Present	⚙️
25.	Real-time Transportation Social Media Analytics using Pulse (Pulse-T)	ASU (Kandala)	Aug 2019 - Present	⚙️
26.	Latent variable models of Attitudes and Preferences, and their Prediction of Autonomous Vehicle Adoption Intent	ASU (Grimm)	Aug 2020 - Present	⚙️
27.	Attitudes Towards Mobility Options/Technologies – A Multi-region Survey Design and Data Collection Effort	GT (Circella)	Oct 2017- July 2020	✓
28.	An Investigation of the Contribution of Targeted Marketing Data to the Prediction of Attitudes	GT (Mokhtarian)	Oct 2017- - Present	⚙️
29.	Latent Vehicle Type Propensity Segments: Considering the Influence of Household Vehicle Fleet Structure	GT (Mokhtarian)	Aug 2018- July 2019	✓
30.	Combining Disparate Surveys across Time to Study Satisfaction with Life	GT (Mokhtarian)	Aug 2019- July 2020	✓
31.	Mode Substitutional Patterns of Ridehailing and Micro-mobility Services	GT (Circella)	Aug 2020 - Present	⚙️
32.	Response Willingness in Consecutive Travel Surveys	GT (Mokhtarian)	Aug 2020 - Present	⚙️
33.	Attitudes Towards Mobility Options/Technologies – A Multi-region Survey Design and Data Collection Effort	USF (Maness)	Oct 2017- July 2020	✓
34.	An exploration of contemporary issues in highway safety, evolving transportation alternatives, and activity and travel behavior modeling	USF (Maness)	Aug 2019- July 2020	✓
35.	Investigation of the Role of Attitudinal Factors on Adoption of Emerging Automated Vehicle and Vehicle Safety Technologies	USF (Mannering)	Aug 2017- July 2018	✓
36.	Emerging econometric and data collection methods for capturing attitudinal and social factors in activity and travel behavior modeling	USF (Mannering)	Aug 2018- July 2019	✓
37.	Exploration of the Relationships between Leisure Activity Participation Frequency and Social Capital	USF (Maness)	Aug 2020 - Present	⚙️
38.	Valuation of Free Electric Vehicle Charging Bundles	USF (Maness)	Aug 2020 - Present	⚙️
39.	Addressing potentially missing relevant information on attitudes and other behavioral elements as unobserved heterogeneity in highway safety studies	USF (Mannering)	Aug 2020 - Present	⚙️
40.	An empirical assessment of the role of attitudes and identification in safety research	USF (Mannering)	Aug 2020 - Present	⚙️
41.	Attitudes and Trust in Leveraging Integrated Sociotechnical Systems for Enhancing Community Adaptive Capacity	UW (Chen)	Oct 2017- July 2020	✓
42.	Meeting everyday needs in a disaster scenario: the potential for resource sharing through local networks	UW (Chen)	Aug 2020 - Present	⚙️

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

Progress on Active Research Projects

Project Title: Attitudes Towards Emerging Mobility Options and Technologies
PI: Sara Khoeini (ASU), Giovanni Circella (GT), Michael Maness (USF) **Co-PI:** Ram Pendyala (ASU), Patricia Mokhtarian (GT), Fred Mannering (USF)

Description of Progress: Survey design, recruitment, data collection, data cleaning and weighting, and dissemination of initial results have all been completed during 2017-2020 time period. During the reporting period, the research team worked on data analysis, presenting the results at various venues, and writing scientific papers to explore users' attitudes, behaviors, and choices toward new transportation technologies and services. This [webpage](#) reflects all of the activities and outputs related to the TOMNET Transformative Technologies in Transportation (T4) Survey. It includes survey summary description, team members, survey instruments, project scope, reports, and compilation of all presentations and papers out of this project. Particularly, Sara Khoeini (PI at ASU) presented the summary results of T4 Survey at four key committee meetings during TRB 2021 including Automation Committee (ACP30), Traveler Behaviour

and Values Committee (AEP30), Critical Issues Subcommittee (AEP10-1), Behavioral Processes: Quantitative and Qualitative Subcommittee (AEP30-4). The presentation slides are available on the T4 survey webpage. Further analysis of T4 survey data is leading to eight research projects (items #8, #9, #10, #14, #15, #20, #26, #31 in Table 1; these have been launched during this reporting period and will be explained in the forthcoming project descriptions. It is envisioned that several of these projects will be presented at TRB Annual Meeting 2022. Additionally, multiple presentations have already been planned to be presented at [Automated Road Transportation Symposium](#) in July 2021.

Project Title: Interaction of Transportation and Health, Wellbeing, and Safety; Transportation Policies, Pricing, and Priorities; Transportation Electrification – A National Survey Design and Data Collection
PI: Ram Pendyala (ASU) **Co-PI:** Sara Khoeini (ASU)

Description of Progress: ASU research team has started to design a national survey to tackle the most important and timely transport issues in the US including the next generation of transport pricing and taxation, electrification, transport infrastructure condition, and investment priorities, health implications of transportation, and safety. The TOMNET research team working on this project is fully leveraging the services of TOMNET Research Professor, Peter R. Stopher, who is a world pioneer in survey design. The initial survey draft has been documented and the team is working on fine-tuning the questions. It is envisioned that the pilot phase of data collection to be conducted during Summer 2021 and the full deployment is planned for fall 2021 (hopefully after the pandemic). Considering the team experience with conducting two surveys (T4 survey and COVIDFuture) in previous years, we are expecting to conduct this survey very smoothly using Qualtrics online panel over the next reporting period. The rich data collected throughout these surveys could help policy and planning decisions significantly, considering the infrastructure and environment focus of the new administration.

Project Title: The Effect of Survey Methodology on The Collection of Attitudinal Data
PI: Ram Pendyala (ASU) **Co-PI:** Sara Khoeini (ASU)

Description of Progress: Attitudes play an important role in determining people’s perceptions, behaviors, and choices concerning transportation. However, measuring one’s attitudes in a comprehensive manner remains a challenging task. The most common tools to collect attitudinal data are surveys, which can take many forms. This research compares the effect of different survey instruments, namely online and paper, and different sampling frames on the measurement of attitudes while controlling for socioeconomic attributes. This survey methodology study will use data from two survey deployments, namely the pilot deployment of the TOMNET Transformative Technologies in Transportation (T4), and the first wave of the [COVID Future](#) Panel Data Study. This research aims to shed light on the extent to which population attitudes can be effectively captured through different survey and sampling strategies. The analysis has already been completed as part of Denise da Silva Baker’s (PhD Candidate at ASU) dissertation. It is expected that at least one conference paper and one journal publication will be produced out of this study during the next reporting period.

Project Title: Investigating Factors Shaping Willingness to Share Automated Vehicles: A Focus on Gender
PI: Sara Khoeini (ASU) **Co-PI:** Ram Pendyala (ASU)

Description of Progress: Much attention is paid to the three revolutions in transportation (Sperling, 2018): the future will be electric, autonomous, and shared. However, it is known that willingness to adopt shared transportation goes beyond advancing technology; attitudes and preferences play an important role in the decision to share a ride (Lavieri, et al., 2017). Women’s issues in transportation are of much interest due to challenges faced daily by women, who exhibit complex activity-travel patterns. This study uses T4 Survey data to understand the attitudinal factors shaping men’s and women’s willingness to share rides

when using ridehailing services that adopt automated vehicles for their fleets. A Structural Equations Model is estimated to measure the effects of gender upon the willingness to share rides in autonomous vehicles, controlling for respondents' attitudes (latent constructs), current use of mobility-on-demand services, and socioeconomic characteristics. Understanding women's willingness to engage in autonomous shared rides will enable the process of including them in the automated, shared, and electric future. The analysis has already been completed as part of Denise da Silva Baker's (PhD Candidate at ASU) dissertation. It is expected that at least one conference paper and one journal publication will be produced out of this study during the next reporting period.

Project Title: Interaction of Familiarity, Safety Perceptions, and Willingness to Use Autonomous Vehicles in a Structural Equations Modeling Framework

PI: Sara Khoeini (ASU) **Co-PI:** Ram Pendyala (ASU)

Description of Progress: Autonomous vehicles are the most challenging and exciting emerging technology on the horizon for transportation systems. It is very important to understand the degree to which people are familiar with the technology, how they feel about it, and the expected level of adoption when AVs become available for widespread use. This understanding will substantially help the private and public sectors better plan for the successful and safe launching of AV technology in the real world. This project aims to deepen the understanding of the multivariate relations between AV perceptions and willingness to use AVs in many forms. To accomplish that, a structural equations model was estimated using the T4 Survey data. The results of this study will help policymakers better understand the effects of familiarity and safety perceptions on willingness to use autonomous vehicles, enabling more informed decisions regarding strategies to ensure a smooth adaptation to the new technology. The analysis has already been completed as part of Denise da Silva Baker's (PhD Candidate at ASU) dissertation. It is expected that at least one conference paper and one journal publication will be produced out of this study during the next reporting period.

Project Title: Effects of Attitudes Towards COVID on Travel Behavior During the Pandemic

PI: Ram Pendyala (ASU) **Co-PI:** Deborah Salon (ASU), Sara Khoeini (ASU)

Description of Progress: This project uses data from the first wave of the COVID Future Panel study to evaluate attitudes towards COVID-19 and their influence on travel behavior. An exploratory factor analysis identified two underlying constructs based on the measured attitudes, namely "Concern about COVID Response" and "COVID Health Concern." A cluster analysis based on the factor scores yielded four groups with distinct attitudes. The finding of this study highlights the significance of COVID-related attitudes in shaping the travel behavior of respondents during the pandemic, and once again highlights the importance of including attitudes in transport demand modeling and forecasting. The main work of this project has been conducted in the reporting period and will be included as a dissertation chapter of Denise da Silva Baker; a short paper on this work has already been published in Transport Findings.

Project Title: Expected Change in US Air Travel after the COVID-19 Pandemic

PI: Sara Khoeini (ASU) **Co-PI:** Ram Pendyala (ASU), Deborah Salon (ASU)

Description of Progress: Among all of the multi-modal impacts of COVID-19 on the transportation system, its impact on air travel has been the most substantial (besides public transit). Although it is expected that air travel will eventually recover, especially when the pandemic is over, the question remains as to the extent to which the pandemic routine of making fewer trips by air for personal and/or business purposes is going to stick. This research addresses this question, the reasons for the expected change in air travel, and how the air travel recovery may differ across groups of the population defined by socioeconomics and attitudes. This study uses data from the first wave of the COVIDFUTURE Panel Survey. To better

understand the comprehensive role of people's attitudes, attributes, and behaviors in shaping respondents' expectations of change in their air travel after the pandemic, this study aims to develop an econometric model system with latent attitudinal variables. The output of this study will help highlight and capture the important and significant role of attitudes in choice modeling practices. This research will also help planning and policy practice as well as the airline industry to have a better understanding of the expected change in air travel demand for personal and business travel after the pandemic. The results of this study will be presented at the International Choice Modeling Conference during the next reporting period and will be published as a journal paper.

Project Title: Integrated Household Energy Analysis Tool (iHEAT)

PI: Ram Pendyala (ASU)

Description of Progress: Integrated Household Energy Analysis Tool (iHEAT) is an online calculator to estimate the combination of household and transportation energy consumption based on the home and travel attributes of the users. 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. This integrated model system provides a methodology to estimate total household and transportation energy expenditure and can be used for planning and policymaking in the context of reducing household energy consumption. This tool is particularly timely and useful, given the emphasis that the new administration is placing on global climate change and moving towards sustainability, reduction in energy consumption, and the use of clean forms of energy.

Project Title: Diversity, Equity, and Inclusion (DEI) Implications of Mobility-on-Demand Services

PI: Sara Khoeini (ASU) **Co-PI:** Ram Pendyala (ASU)

Description of Progress: Emerging transportation technologies including autonomous vehicles and shared mobility services are bringing transformative changes to the transportation landscape. These technologies exhibit the potential to enhance safety, mobility, accessibility, and convenience for users. In exploring technology adoption pathways, it is very critical to think about broader equity considerations of these services by including all segments of the population, particularly disadvantaged groups. This project offers a detailed investigation of the extent to which familiarity and awareness, willingness to use and pay, and general perceptions of emerging transportation technologies vary among different groups of the population (defined by income, race, and disability). This study utilizes the T4 survey data to examine diversity, equity, and inclusion (DEI) implications of new and emerging mobility technologies and services. The preliminary data analysis has been conducted. It is expected that at least one conference paper and one journal publication will be produced out of this study during the next reporting period.

Project Title: How Will Use of Autonomous Vehicles for Running Errands Affect Future Autonomous Vehicle Adoption and Ownership?

PI: Ram Pendyala (ASU) **Co-PI:** Sara Khoeini (ASU)

Description of Progress: New transformative technologies are bringing disruptive changes to the transportation landscape. However, there is much uncertainty about how AVs will be used and how the potential use of AVs may impact future household ownership of such vehicles. Not only do users not have to worry about the driving task, but they can send AVs (with no occupant) for pick-ups, deliveries, and running errands. To what extent will the potential use of AVs for running such errands impact people's willingness to adopt and purchase an AV? This is the main research question of this study. The analysis is based on T4 Survey data and using structural equations modeling, this study will unveil how the level of interest in using AVs to run errands (without an occupant) will potentially affect the choice of purchasing/owning an AV. The study will identify policy and pricing pathways that will help shape future

AV adoption to be sustainable and equitable. The analysis for this project is nearly completed and the related abstract has been accepted for presentation at International Road Federation World Meeting in Dubai in November 2021. It is envisioned that a paper will also be produced out of this study.

Project Title: Latent Variable Models of Attitudes and Preferences: Predicting Autonomous Vehicle Adoption Intent

PI: Kevin Grimm (ASU) **Co-PI:** Ram Pendyala (ASU)

Description of Progress: The overall goal of this project is to use latent variable models to examine the factor structure of participant attitudes toward the adoption of new transportation technologies. The exploratory factor analysis has been conducted and the project team is in the middle of analytical model estimation. It is envisioned that the outputs of this project will produce multiple conference and journal papers that identify the latent factors contributing to the adoption of new transportation technologies.

Project Title: Investigating Attitudinal and Behavioral Changes in U.S. Households Before, During, and After the COVID-19 Pandemic (a.k.a. COVID Future Survey)

PI: Deborah Salon (ASU) **Co-PI:** Ram Pendyala (ASU), Sara Khoeini (ASU)

Description of Progress: In this project, we are interested to know, after the threat of contagion is gone, to what extent will American society “go back” to our 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?

In this period, we:

- 1) Gave multiple virtual webinars and conference presentations based on our wave 1 results
- 2) Submitted five papers for publication based on results from our Wave 1 data
- 3) Posted two papers on arXiv based on results from our Wave 1 data
- 4) Published our dataset itself on the ASU Dataverse so that others can also analyze it
- 5) Added content to our project website at covidfuture.org
- 6) Implemented a “wave 2” follow up survey to capture trends over time, deployed between November 2020 and March 2021 (approximately 4 months from when respondents took our initial survey), which collected approximately 3,000 responses
- 7) Designed a “wave 3” follow up survey to capture trends over time, which we will be deploying between May and September 2021 (approximately 4 months from when respondents took our wave 2 survey)

Continuing this project, we will be conducting additional data analysis and will aim to publish our results in multiple journal articles, present our work at multiple webinars and virtual conferences, continue to update our website with new findings as they come in, and publicize our efforts in the popular press as opportunities arise. In the next reporting period, we also plan to clean, weight, and publish the Wave 2 data that we have collected, and collect the Wave 3 data. We will also seek additional funding to support undergraduate researchers in summer and fall of 2021, as well as a larger grant that we hope will allow us to continue this survey effort with at least two more survey waves.

Project Title: Investigating the Contribution of Targeted Marketing Data to the Prediction of Attitudes

PI: Patricia Mokhtarian (GT) **Co-PI:** Giovanni Circella (GT), Kari Watkins (GT)

Description of Progress: 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”, $N \sim 8,000$), and the attitudinally-rich survey designed by the project team and funded by the Georgia Department of Transportation (the “GDOT survey” or dataset, $N \sim 3,500$, before cleaning). The goal of

the 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 distinctive feature of the current study is the addition of targeted marketing (TM) variables to the common variable (CV) set that previously contained only socioeconomic/demographic (SED) and land use (LU) characteristics. TM variables can be purchased economically from third-party providers (such as Experian), and include a host of indicators of lifestyle and various behaviors. The premise of the current study is that such 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. At the end of the previous reporting period, we had completed initial versions of most of the analyses involved in this ambitious and complex project and were in the process of fine-tuning the analyses to gain the maximum benefit possible. During the present reporting period, the PI presented the project to an international audience of urban modelers – a key opportunity to disseminate this ground-breaking approach to in-practice model improvement. The primary PhD student on this project, Atiyya Shaw, completed her dissertation on this subject and passed her dissertation defense on January 27, 2021. We expect three papers to result from this research: one was submitted previously and revised/resubmitted during the present reporting period – this paper offers a tutorial on targeted marketing (TM) data and its potential transportation applications, as well as some empirical details on our own application of such data to help transfer attitudinal information into travel behavior-oriented datasets. We expect the remaining two papers to be submitted during the next reporting period. One will detail our attitude imputation methodology and internal validation results, and the other will describe the external validation results.

Project Title: Mode Substitution Patterns of Ridehailing and Micro-mobility Services

PI: Giovanni Circella (GT) **Co-PI:** Patricia Mokhtarian (GT)

Description of Progress: Using the pooled T4 survey data, a study regarding the impacts of the use of ridehailing services and micromobility services on the use of alternative travel modes in the three regions of Atlanta, GA, Phoenix, AZ, and Austin, TX is proposed. A latent-class cluster analysis is conducted to model the changes in the use of various travel modes as a result of ridehailing adoption, while controlling for socioeconomics, demographics, land-use attributes, and individual attitudes. Grace Chen, a graduate student researcher working on this project, gave a presentation on the topic of this paper at the annual meeting of the Transportation Research Board in January 2021, and a revised version is about to be submitted for publication in a scientific journal. The micromobility piece of the work is under preparation for an August 1 submission of a paper to be considered for presentation at the 2022 TRB Annual Meeting. This study makes an important contribution to the field, as it reveals substantial heterogeneity in ridehailing and micromobility sustainability impacts across the population.

Project Title: Exploration of the Relationships between Leisure Activity Participation Frequency and Social Capital; **PI:** Michael Maness (USF) **Co-PI:** Fred Mannering (USF)

Description of Progress: The USF team has continued to analyze data from the leisure activity and social capital survey. The team found that expressive social capital/social support (access to expressive social resources) is correlated with greater leisure frequency for activities associated with higher social affiliation. Additionally, access to expressive social resources was found to impact leisure activity frequency while instrumental social capital had no effect. To the authors’ knowledge, this refined and specially designed survey is the first in the transportation literature to use both position generator and resource generator to measure social capital. In this area of social capital and leisure activity, the team

presented results at the 2021 Transportation Research Board Annual Meeting. The team also performed a second wave of data collection during November/December 2020 (one year after the initial data collection). A third wave is planned for April/May 2021. These web-based surveys will be used to compare pre-COVID activity behavior to COVID-era activity behavior.

Project Title: Valuation of Free Electric Vehicle Charging Bundles

PI: Michael Maness (USF) **Co-PI:** Fred Mannering (USF)

Description of Progress: The team continued a data collection and analysis effort to understand the zero-price effect on preferences for free electric vehicle charging. Results showed that attribute non-attendance existed in the experiment with about 14% to 18% of respondents being non-attendant to free prices (i.e., having no zero-price effect). Additionally, the size of the zero-price effect was generally positively correlated with value of time – suggesting that the zero-price effect could have some equity implications if such a policy was instituted. Over the next half-year, the research team will continue to analyze the charger choice experiment data to explore respondent characteristics corresponding to differing zero-price effect sizes. Additionally, the vehicle choice experiment will be analyzed to establish willingness-to-pay estimates for free public charging bundles. All population segments exhibited some willingness-to-pay (WTP) for free charging at the two- and three-year time frames. Over the next reporting period, the models will be refined to account for the correlation between the two EV alternatives and to examine sociodemographic differences in charging and vehicle choice behavior.

Project Title: Meeting Everyday Needs in a Disaster Scenario: The Potential for Resource Sharing Through Local Networks

PI: Cynthia Chen (UW) **Co-PI:** Daniel B. Abramson (UW)

Description of Progress: 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 project is built on data collected in a related project “Attitudes and Trust in Leveraging Integrated Sociotechnical Systems for Enhancing Community Adaptive Capacity” funded by TOMNET and ended before the reporting period. While the accomplished project focus was more on data collection, this current active project is more focused on analysis and in-depth understanding of the previously collected data. Accomplishments during the reporting period and future plans are as follows:

1. *Data analysis from full-scale community resilience survey in Laurelhurst, Westport, and South Park.*
Analysis of the survey data is ongoing.
2. *Interviews with community partners and community stakeholders.*
3. *Focus groups with survey participants.*

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 2021. Please note that the courses offered during fall 2020 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 faculty and are *deeply engaged* in advancing the activities and mission of the center.

Table 2. Courses Offered by Core Faculty Members of TOMNET (Spring 2021)

Semester	Course Level	Course No	Course Title	No	Instructor	Unit
Arizona State University						
Spring 21	Undergrad	PUP424	Planning Methods	23	Salon	SGSUP
Spring 21	Graduate	CEE506	Life Cycle Assessment of Transportation	15	Chester	CEE
Spring 21	Graduate	CEE576	Highway Geometric Design	46	Mamlouk	CEE
Spring 21	Graduate	CEE598	Transportation Network Modeling	10	Lou	CEE
Spring 21	Graduate	CEE598	Smart City Sustainability and Environ	18	Coseo	SGSUP
Spring 21	Graduate	CEE591	Transportation Seminar	20	Pendyala	CEE
Georgia Institute of Technology						
Spring 21	Grad	CEE6601	Statistics in Transportation	16	Mokhtarian	CEE
University of South Florida						
Spring 21	Graduate	TTE6930	Graduate Transportation Seminar	8	Li/Zhang	CEE
Spring 21	Graduate	TTE6655	Transportation and Land Use	20	Chen	MURP
Spring 21	Undergrad	TTE4005	Transportation Engineering II	75	Zhang	CEE
Spring 21	Graduate	TTE 5620	Air Transportation	16	Zhang	CEE
Spring 21	Undergrad	TTE4004	Transportation Engineering I	12	Maness	CEE
Spring 21	Graduate	TTE6501	Statistical and Econometric Methods II	2	Mannering	CEE
Spring 21	Undergrad/ Graduate	CGN4933/TTE6 933	Autonomous and Connected Transportation	8	Li	CEE
Spring 21	Graduate	CGN 6311	Introduction to Data Science	21	Qing Lu	CEE
University of Washington						
Winter 21	Graduate	CET512	Transportation Data Collection	18	Chen	CEE
Winter 21	Graduate & Undergrad	BE 405/505	Built Environments Studio	19	Abramson	CBE

Notes: *Arizona State University*: SSEBE = School of Sustainable Engineering and the Built Environment; SGSUP = School of Geographical Sciences and Urban Planning. *Georgia Institute of Technology*: CEE = School of Civil and Environmental Engineering. *University of South Florida*: CEE = Department of Civil and Environmental Engineering; *University of Washington*: CEE = Civil & Environmental Engineering; Urban Pln = Urban 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 engages three 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.

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			
Irfan Batur	PhD Student	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
Matthew Wigginton Conway	PhD Student	SGSUP	Salon
Harsha Vamsi Kalluri	MS Student	CIDSE	Pendyala
Laura Mirtich	Undergrad	SOLS	Salon
Holden Weisman	Undergrad	SGSUP	Salon
GEORGIA INSTITUTE OF TECHNOLOGY			
Gwen Kash	Postdoc	CEE	Mokhtarian
Sungtaek Choi	Postdoc	CEE	Circella
Ali Etezady	PhD Student	CEE	Circella/Mokhtarian
Xinyi Wang	PhD Student	CEE	Mokhtarian

Faaiga (Atiyya) Shaw	PhD Student	CEE	Mokhtarian
Sung Hoo Kim	PhD Student	CEE	Mokhtarian
Yun-Hsuan (Grace) Chen	MS Student	SCaRP/CEE	Circella
Kara Todd	MS Student	CEE	Circella
UNIVERSITY OF SOUTH FLORIDA			
Asim Alogaili	Graduate Student	CEE	Mannering
Suryaprasanna Balusu	Graduate Student	CEE	Mannering/Pinjari
Natalia Barbour	Postdoctoral Associate	CEE	Maness
Nawaf Alnawmasi	Graduate Student	CEE	Mannering
Qianwen Li	Graduate Student	CEE	Li/Mannering
Trang Luong	Graduate Student	CEE	Maness
Divyamita Mishra	Graduate Student	CEE	Maness
Lori Palaio	Graduate Student	CEE	Bertini/Maness
Tung Vo	Graduate Student	CEE	Maness
Dr. Nikhil Menon	Research Associate	CUTR	Maness/Bertini
UNIVERSITY OF WASHINGTON			
Cristina Cano-Calhoun	MUP Student	URBDP	Abramson/Chen
Katherine Idziorek	PhD Student	Urban Planning	Chen/Abramson

Related to K-12 activities, Dr. Sara Khomeini and Dr. Ram Pendyala, with the assistance of TOMNET PhD student Irfan Batur, have designed a series of online outreach modules for high school students. These modules have interesting field activities such as completing and analyzing a household travel survey, traffic count and signal timing analysis, and global transportation research topics such as implications of transportation on climate change and automated vehicles. The goal is to inspire high school students to pursue a career in transportation. These modules were provided to a group of 100 Arizona high school students in collaboration with an educational initiative at ASU during the Spring 2021 semester (namely, the National Summer Transportation Institute, which was held in Spring 2021 due to COVID). As part of this activity, Sara Khomeini (TOMNET Assistant Director) organized and moderated an online career event for participating high school students as well as ASU students around careers in transportation. After successful implementation and potential revisions, the modules will be posted on the TOMNET website so that other universities and stakeholders can take advantage of them during and after the COVID-19 pandemic. Dr. Khomeini invited an academic (Elham Fini, Associate Professor, ASU), industry (Ellie Volosin, AECOM; Sanjay Paul, RICK Engineering), and government (Baloka Belezamo, Arizona DOT) to discuss career opportunities in transportation ([link](#) to the recorded webinar).

In the *technology transfer* domain, Arizona State University continued the [TOMNET webinar series](#) that is presented to a worldwide audience. Due to the pandemic, the webinars were provided in a completely online format with archived recordings available on the TOMNET website. In addition to ASU, USF was also very active in organizing transportation webinars. These events are advertised widely and very well attended. Table 4 presents a list of ASU and USF TOMNET-sponsored seminars for the period covered by this SAPR. Two of these very well-attended webinars were related to COVID-19 impacts on Human Activity-Mobility Patterns. The first one was a [two-hour webinar](#) on November 19, 2020 consisting of a series of short presentations based on the [COVIDFuture](#) Survey. The second one was a [Zephyr Foundation panel discussion](#) organized and moderated by TOMNET director Ram Pendyala on behavioral dynamics and the future of travel demand, especially in a post-pandemic era. Dr. Chen (TOMNET associate director at UW) served as one of the panelists in this discussion.

Further, Dr. Patricia Mokhtarian, Dr. Deborah Salon, and Dr. Giovanni Circella have given multiple presentations on the impacts of the pandemic on travel behavior and the adoption of teleworking in a variety of meetings, including a workshop organized as part of the annual meeting of the Transportation Research Board in January 2021 (attended by 1040 participants) and a conference organized by the World Conference for Transport Research Society. Dr. Circella and Dr. Salon were also featured as experts on

these topics in various newspaper articles, including articles that were published in the New York Times, Wall Street Journal, the San Francisco Chronicle, the Washington Post, and the Sacramento Bee.

Table 4. Key TOMNET-Sponsored Technology Transfer Events

Inst.	Title of Seminar/ Webinar	Speaker Name and Affiliation	Date	No.
ASU	Development of an Operational Safety Assessment Methodology for Automated Vehicles	Jeffrey Wishart, Exponent	10-1-2020	20
ASU	Updated Vehicle Operating Cost Models Function of Roadway Characteristics for an Array of Vehicle Classes and Technologies	Elie Hajj, University of Nevada	10-14-2020	29
ASU	Cement-Bitumen Treated Materials for Cold Recycling of Asphalt Pavements in Italy and Europe	Andrea Graziani, Università Politecnica delle Marche, Ancona	10-21-2020	18
ASU	Transportation and Fulfillment Optimization at Amazon	Andrea Qualizza, Amazon	10-28-2020	17
ASU	Security and Resilience of Transportation Cyber-Physical-Social Systems	Mashrur Chowdhury, Clemson University	11-5-2020	27
ASU	Implications of COVID-19 on Human Activity-Mobility Patterns During and After the Pandemic: Initial Results from the COVIDFUTURE Longitudinal Survey Study	Deborah Salon, Matthew Wigginton Conway, Denise Capasso da Silva, Sara Khoeini, Ehsan Rahimi, Ali Shamshiripour, Ram Pendyala, Sybil Derrible, Abolfazl Mohammadian, Team of Presenters: ASU and UIC	11-19-2020	154
ASU	Panel on Behavior Dynamics – The Future...Accelerated (Zephyr Foundation), Organizer and Moderator: Ram M. Pendyala, Arizona State University	Steve Polzin, USDOT Jiangbo (Gabe) Yu, AECOM Michael F. Hyland, UC Irvine Mark Bradley, RSG, Inc. Nancy McGuckin, TravelBehavior.US Cynthia Chen, Univ of Washington	12-15-2020	200
ASU	Managing Reusable Packages in Modern Supply Chain Systems: A Lagrangian Decomposition Approach for the Standard Vehicle Routing Problem with Backhauls	Monireh Mahmoudi, Michigan State University	3-12-2021	19
ASU	When Machines Don't Learn: Common Reasons for Failed Integrations Between Machine Learning and Discrete Choice	Timothy Brathwaite, Ph.D., Stitch Fix Inc.	3-19-2021	141
ASU	Assessing and Communicating About AV Safety	Marjory Blumenthal, RAND Corporation	3-26-2021	36
USF	Current Status of Policies and Regulations of UAS	Jay Merkle, Federal Aviation Administration	10-2-2020	~20
USF	Innovations for Advancing Transit Services	Carolyn House Stewart, Hillsborough Area Regional Transit Authority	10-9-2020	~20
USF	Fieldnotes on Online Optimization of Shared Mobility Systems	Kenneth Kuhn, Scoop Technologies Inc.	10-16-2020	~20
USF	Understand 'human' Aspects of Sustainable Mobility Systems	Amanda Irimi Blomberg Stathopoulos, Northwestern University	10-23-2020	~20
USF	M-CORES, COVID 19, and Planning of State Transportation Agency	Huiwei Shen, Florida Department of Transportation	10-30-2020	~20
USF	Research on Urban Air Mobility	Hualong Tang, USF	11-6-2020	~20
USF	An Overview of NASA's Advanced Air Mobility Activities	Michael Patterson, NASA Langley Research Center	11-13-2020	~20
USF	Sustainable Transportation	Panagiotis Ch. Anastasopoulos, University at Buffalo	11-20-2020	~20
USF	Updates on Traffic Safety Research	Mouyid Islam, USF	12-4-2020	~20

USF	Automated Modular Vehicles: Some Future Applications	Monica Menendez, New York University in Abu Dhabi	1-27-2021	~20
USF	UAS Delivery Services are Coming to a Home Near You (I think.)	Daniel Friedenzohn, Embry-Riddle Aeronautical University	2-19-2021	~20
USF	The Airport Master Planning Process – A Review in Times of COVID	Fin Bonset, VHB, Inc.	2-26-2021	~20
USF	Florida Department of Transportation District 7 Program, Management and Specialty Engineering	Kelli Bradley and Megan Miller, Florida Department of Transportation	3-5-2021	~20
USF	Impact of COVID-19 on Travel Behavior and Implications for Telecommuting: Results from a Nationwide Survey	Nikhil Menon, USF	3-12-2021	~20
USF	Investigating Autonomous Vehicle Impacts on Individual Activity-Travel Behavior	Chandra R. Bhat, University of Texas at Austin	3-19-2021	~20
USF	Bikeshare Destination Choices and Accessibility Among Disadvantaged Communities	Xiaodong Qian, University of California Davis	3-26-2021	~20

ASU = Arizona State University; GT = Georgia Institute of Technology; USF = University of South Florida; UW = University of Washington; UT = University of Texas at Austin.

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. Particularly, TOMNET has so far partially or fully funded four surveys on new transportation technologies, community resilience and disaster-response, leisure and social-capital activity engagement, and COVID-19 travel implications. Moreover, TOMNET is in the process of collecting more national survey data on transport pricing and priorities, health and transportation interaction, and electrification. Considering the availability of diverse and rich datasets, it is expected that the next two reporting periods will yield tangible and fruitful research outputs that can significantly benefit policy and decision making in the transport sector, particularly in the wake of recent natural and technological disruptions. Dissemination of these valuable research products will also contribute to TOMNET education and workforce development goals as well as technology transfer activities.

Additionally, TOMNET faculty members will continue to teach undergraduate and graduate courses at their respective institutions while enhancing the content to reflect discoveries and trends in the profession. 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 and online short courses such as those listed previously in the report.

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 were planned to be launched in Spring 2021, potentially in conjunction with A⁴ symposium. These initiatives have been postponed to the next reporting period due to the current pandemic.

TOMNET scholars will continue to engage in considerable K-12 outreach activities. Due to the pandemic, TOMNET in-person summer outreach activities were canceled but the center is fully leveraging online platforms to continue K-12 outreach programs. For the next reporting period, we will continue taking advantage of our successful online modules to disseminate information about careers in

transportation and we will make these modules available via the TOMNET website for other UTCs and organizations to use. We will certainly explore if we could also conduct our usual in-person activities.

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 the Georgia Department of Transportation. The full list is below.

What organizations have been involved as partners?

- *Oak Ridge National Laboratory – National Transportation Research Center: Collaborative research*
- *Northwestern University: Collaborative research*
- *Atlanta Regional Commission, Atlanta, Georgia: Collaborative research and personnel exchange*
- *Georgia Department of Transportation, Atlanta, Georgia: In-kind support, data sets, collaborative research, funding of matching-project research.*
- *Universidad de Chile and Universidad de Concepcion (Chile), University of Leeds (UK) and German Aerospace Institute – DLR (Germany): Collaborative research*
- *World Conference for Transport Research Society (WCTRS): Large international collaboration.*
- *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*
- *Maricopa Association of Governments, Phoenix, Arizona: In-kind support, data sets, collaborative research*

TOMNET core research members are actively collaborating with other researchers across the world to produce cutting-edge research products and advance the discipline of travel behavior. The list of researchers that have been in close collaboration with TOMNET researchers is furnished below:

Have other collaborators or contacts been involved?

- *Professor Chandra Bhat, the University of Texas at Austin, TX*
- *Professor Abolfazl Mohammadian, University of Illinois-Chicago, IL*
- *Professor Sybil Derrible, University of Illinois-Chicago, IL*
- *Professor Laurie Garrow, Georgia Tech, Atlanta, GA*
- *Professor Brian German, Georgia Tech, Atlanta, GA*
- *Professor Joseph Saleh, Georgia Tech, Atlanta, GA*
- *Professor Patrick Singleton, Utah State University, Logan, UT*
- *Professor Lauren Steimle, Georgia Tech, Atlanta, GA*
- *Professor Dima Nazzal, Georgia Tech, Atlanta, GA*
- *Professor Timor Besedes, Georgia Tech, Atlanta, GA*
- *Jia Tang, PhD student from Nanjing University*
- *Professor Rolf Moeckel, Technical University of Munich, Germany*
- *Professor Alejandro Tirachini, University of Chile, Chile*
- *Professor Constantinos Antoniou, Technical University of Munich, Germany*
- *Professor Barbara Lenz, German Aerospace Institute*
- *Professor Dick Ettema, Utrecht University, Utrecht, Netherlands*
- *Professor Clark Miller, Arizona State University, Tempe, AZ*
- *Researchers at two universities in Chile, one university in the UK, and one research institution in Germany*
- *Executive Board of the International Association for Travel Behaviour Research*
- *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*

One major collaboration that was initiated more than a year ago and is ongoing during the last reporting period is between ASU and the University of Illinois at Chicago (UIC), specifically involving Dr. Deborah Salon, Dr. Ram Pendyala, and Dr. Sara Khoeini from ASU and Dr. Abolfazl Mohammadian and Dr. Sybil Derrible from UIC. This collaboration, aimed at understanding the impact of COVID-19 on people's lives, activities, attitudes, and future behaviors, has resulted in the administration of a nationwide survey and the release of survey data to understand what a post-pandemic future might look like. The research team members meet every Monday to discuss the research plan and progress, with a view to explore insights and solutions that can mitigate the negative impacts of the pandemic for various segments of the population and help agencies plan for an uncertain future. The [COVIDFuture survey](#) has already collected two waves of national data and is in the planning phase for the third wave of data collection. The research team is looking for additional sources of funding to support the continuation of this project.

Prof. Dick Ettema, an internationally-respected travel behavior scholar at Utrecht University in the Netherlands, had read and appreciated Georgia Tech's previous TOMNET-funded analysis of the behavioral impacts of automated vehicles, based on data collected from a prior project funded by the Georgia Department of Transportation. He was getting ready to conduct a related project, building on and expanding the questions asked in our survey, and asked if we would be interested in collaborating. Dr. Patricia Mokhtarian and PhD candidate Sung Hoo Kim are accordingly participating in this valuable project that will involve data collection on three continents (The Netherlands, Australia, and Canada). Another key collaboration involves TOMNET Senior Researcher, Dr. Giovanni Circella, working with a group of researchers to write a chapter reviewing COVID-19 transportation research to date, under the auspices of the World Conference for Transport Research Society (WCTRS).

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. Conway, M., Salon, D., Capasso da Silva, D., & Mirtich L. (2020). How will the COVID-19 pandemic affect the future of urban life? Early evidence from highly-educated respondents in the United States. *Urban Science*, 4(4). DOI: 10.3390/urbansci4040050.
2. Kim, T. and Jerath, K. (2021). Congestion-aware cooperative adaptive cruise control for mitigation of self-organized traffic jams. *IEEE Transactions on Intelligent Transportation Systems*. <https://ieeexplore.ieee.org/abstract/document/9363017>
3. Dias, F.F., Kim, T., Bhat, C.R., Pendyala, R.M., Lam, W.H.K., Pinjari, A.R., Srinivasan, K.K., & Ramadurai, G. (2021). Modeling the evolution of ride-hailing adoption and usage: A case study of the puget sound region. *Transportation Research Record* 2675, 81-97.
4. Guensler, R., Ko, J., Kim, D., Khoeini, S., Sheikh, A., & Xu, Y. (2020). Factors affecting Atlanta commuters' high occupancy toll lane and carpool choices. *International Journal of Sustainable Transportation*, 14, 12, 932-943.
5. Kim, T., Sharda, S., Zhou, X., & Pendyala, R.M. (2020). A stepwise interpretable machine learning framework using linear

regression (LR) and long short-term memory (LSTM): City-wide demand-side prediction of yellow taxi and for-hire vehicle (FHV) service. *Transportation Research Part C: Emerging Technologies*, 120, 102786.

Presentations Within Reporting Period

1. Salon, D., and Pendyala, R. (2021, January). Forecasting the "stickiness" of pandemic-era travel behavior changes. The future of travel in a post-covid-19 world. The Future of Travel in a Post-COVID-19 World. Presented at the Transportation Research Board Annual Meeting, Online.

Georgia Tech

Papers Published Within Reporting Period

1. Malokin, A., Circella, G., & Mokhtarian, P.L. (2021). Do millennials value travel time differently because of productive multitasking? A revealed preference study of northern California commuters. *Transportation*, <http://link.springer.com/article/10.1007/s11116-020-10148-2>.
2. Clark, C., Mokhtarian, P.L., Circella, G., & Watkins, K. (2021). The role of attitudes in perceptions of bicycle facilities: A Latent-Class Regression Approach. *Transportation Research, Part F* 77, 129-148.

Presentations Within Reporting Period

1. Mokhtarian, P. (2020, November). Transport 2050: Remote work and the future of transportation. Presented at Translink, Vancouver, BC.
2. Mokhtarian, P. (2020, November). Teleworking and travel behavior. Presented at the FHWA/TRB Joint Expert Meeting on Emerging Trends: Future Travel Demand.
3. Mokhtarian, P. (2020, November). The extent and prospects of work from home. Presented at the Fall 2020 Housing Statistics User Group Meeting.
4. Mokhtarian, P. (2020, November). Enriching transportation survey datasets using big data and machine learning. Presented at Applied Urban Modelling 2020: Modelling the New Urban World, Online.
5. Circella, G. (2021, January). The Future of automation policy: From California to DC. Presented for the 3 Revolutions Policy Webinar Series, University of California Davis.
6. Circella, G. (2021, January). Investigating the Temporary vs. longer-term impacts of the COVID-19 pandemic on mobility. Presented at the Hearing of the Transportation Finance and Policy Committee of the Minnesota House of Representatives.
7. Circella, G. (2021, January). The Future of travel in a post-COVID-19 pandemic world. Session #1018. Presented at the 100th Annual Meeting of the Transportation Research Board, Online.
8. Mokhtarian, P. (2021, January). Travel behavior research: We've come a long way, and have a long way to go! Session #1087. Presented at the 100th Annual Meeting of the Transportation Research Board, Online.
9. Mokhtarian, P. (2021, January). The future of travel in a post-COVID-19 pandemic world. Session #1018. Presented at the 100th Annual Meeting of the Transportation Research Board, Online.
10. Circella, G. (2021, February). Telework, adoption of ICT and equity issues: What are the longer-term implications of the COVID-19 pandemic. Presented at the California Capitol Corridor Joint Power Authority (CCJPA).
11. Circella, G. (2021, February). Studying the temporary vs. longer-term impacts of the COVID-19 pandemic on mobility. Presented at the World Conference on Transport Research Society (WCTRS) SIG F1/AUM Webinar, Online.
12. Circella, G. (2021, March). Investigating the temporary vs. longer-term impacts of the COVID-19 pandemic on mobility. Presented at the 3 Revolutions Policy Conference, University of California, Davis.

University of South Florida

Papers Published Within Reporting Period

1. Balusu, S., Mannering, F., & Pinjari, A. (2020). Hazard-based duration analysis of the time between motorcyclists' initial training and their first crash. *Analytic Methods in Accident Research*, 28, 100143.
2. Zheng, L., Sayed, T., & Mannering, F. (2021). Modeling traffic conflicts for use in road safety analysis: a review of analytic methods and future directions. *Analytic Methods in Accident Research*, 29, 100142.
3. Islam, M. and Mannering, F. (2021). The role of gender and temporal instability in driver-injury severities in crashes caused by speeds too fast for conditions. *Accident Analysis and Prevention*, 153, 106039.

Presentations Within Reporting Period

1. Li, Q. (2021, January). Assessment of discretionary lane-changing decisions using a random parameters approach with heterogeneity in means and variances. Presented at the Transportation Research Board Annual Meeting, Online.
2. Tahlyan, D., Stathopoulos, A., & Maness, M. (2021, January). Disentangling social capital – understanding the effect of social support and social network resources on social activity participation. Presented at the Transportation Research Board Annual Meeting, Online.

3. Luong, T. and Maness, M. (2021, January). Comprehensive analysis of leisure activity variety as an instrumental outcome of social capital. Presented at the Transportation Research Board Annual Meeting, Online.
4. Palaio, L., Vo, T., Maness, M., Bertini, R., & Menon, N. (2021, January). A multi-city investigation of the effect of special calendar days on bike-share system ridership. Presented at the Transportation Research Board Annual Meeting, Online.

University of Washington

Papers Published Within Reporting Period

1. Yan, P., Lee, C., Chu, C., Chen, C., & Luo, Z. (2020). Matching and pricing in ride-sharing: optimality, stability, and financial sustainability. *OMEGA International Journal of Management Science*. <https://doi.org/10.1016/j.omega.2020.102351>
2. Feng, J., Huang, S., & Chen, C. (2020). Modeling user interaction with app-based reward system: a graphical model approach integrated with max-margin learning. *Transportation Research Part C*. <https://doi.org/10.1016/j.trc.2020.102814>
3. Zhu, X., Feng, J., Huang, S., & Chen, C. (2020). An online updating method for time-varying preference learning. *Transportation Research Part C Emerging Technology*. <https://doi.org/10.1016/j.trc.2020.102849>
4. Feng, J., Zhu, X., Huang, S., & Chen, C. (2020). A learning framework for personalized random utility maximization (RUM) modeling of user behavior. *IEEE Transactions on Automaton Science*. DOI: 10.1109/TASE.2020.3041411
5. Abramson, D. (2020). Environmentalism in China's Chengdu Plain. In *Greening East Asia: The Rise of the Eco-Developmental State*, edited by Ashley Esarey, Mary Alice Haddad, Joanna Lewis, and Stevan Harrell, University of Washington Press, Chapter 10.
6. Olshansky, R., Xiao, Y., & Abramson, D. (2020). Guest editorial to the special issue: Lessons learned from post-2008 Wenchuan earthquake community recovery. *Natural Hazards* 104, 1–3.

Presentations Within Reporting Period

1. Chen, C. (2020, October). Machine learning in transportation: Learning mobility patterns from big data. Presented at the Responsible Machine Learning Summit, UCSB Center for Responsible Machine Learning, Online.
2. Idziorek, K. (2020, November). Meeting everyday needs in a disaster scenario: Resource matching through local networks. Presented at the Association of Collegiate Schools of Planning Annual Conference, Online.
3. Wu, S. and Abramson, D. (2020, November). Towards the future preservation of the Linpan landscape: Assessing socio-ecological resilience through ICT-enabled governance in rural Chengdu. Presented at the Association of Collegiate Schools of Planning Annual Conference, Online.
4. Chen, C. (2020, December) Panel on behavioral dynamics – the future... accelerated. Zephyr foundation, <https://zephyrtransport.org/events/2020-12-15-panel-behavior-dynamics/>.
5. Wu, S. and Abramson, D. (2020, December). Towards the future preservation of the Linpan landscape: Assessing socio-ecological resilience through ICT-enabled governance in rural Chengdu. Presented at the 4th Association of Pacific Rim Universities Sustainable Cities and Landscapes Conference, Online.
6. Wu, S. and Abramson, D. (2020, December). Socio-ecological resilience as a basis for cultural landscape preservation. Presented at the 14th Annual Conference of the International Association for China Planning.
7. Chen, C. and Ban, J. (2021, January). Using mobile sensor data for evaluating mobility pattern changes from before to after an event: lessons learned from the Seattle Alaskan viaduct replacement project. Presented at the 100th Annual Meeting of the Transportation Research Board, Washington DC.
8. Chen, C. and Huang, S. (2021, January). Correcting self-selection biases in mobile sensor data for OD estimation: a likelihood-based method leveraging multiple biased data sources. Presented at the 100th Annual Meeting of the Transportation Research Board, Washington DC, Online.
9. Wang, J.; Zhang, Y.; Chen, C. & Ban, J. (2021, January). Travelers' adaptive behaviors in response to Seattle's Alaskan way viaduct replacement project. Presented at the 100th Annual Meeting of the Transportation Research Board, Washington DC, Online.
10. Idziorek, K. (2021, January). Anticipated willingness to share resources in a disaster scenario: The role of attitudinal variables. Presented at the Transportation Research Board Annual Meeting, Online.
11. Abramson, D. and Nguyen, L. (2021, March). Integrating multiple sea level rise hazard scenarios in coastal community adaptive planning. Presented at the Earthquake Engineering Research Institute 2021 Annual Meeting.

In summary, TOMNET **core** faculty generated 16 journal publications 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, the TOMNET researchers presented 34 presentations at various venues. The highlight of this period's outputs is the considerable number of presentations and publications related to the COVID-19 pandemic and its impact on travel behavior.

Website(s) or other Internet site(s)

One major product of the center is the [TOMNET website](#), which has had a round of updates during the reporting period, and is scheduled for another round of updates in the next reporting period. A separate webpage has been developed solely for [TOMNET T4 Survey](#) to organize all of the project documentation, presentations, and output in one place. All of the presentation files, including those presented at TRB 2021, and final project reports are available at this webpage.

Additionally, the link to the NSF and TOMNET-funded COVIDFuture survey is embedded on the first page of the TOMNET website, enabling visitors to participate in the ongoing COVID-19 study (No. 21 in Table 1). Moreover, links to the two recent/major TOMNET webinars are available on the home page as well. It is worth mentioning that the [COVID-19 website](#) was created during this reporting period, serving as a home for all information about the COVID-19 project. The website features periodic blog posts that provide insights and results from the survey on a continuous basis.

Software Programs, Codes, and Products

As noted in prior progress reports, the TOMNET team at ASU has been heavily involved in the development and application of open source tools that reflect model outputs of the TOMNET projects. So far, the fully functional version of the synthetic population generator called PopGen, the alpha version of the integrated Household Energy Analysis Tool (iHEAT), and the final models of the Wellbeing Estimator for Activities and Travel (WBEAT) have been created. These tools have been explained in previous reports in detail. Final versions of these tools will be developed in open-source format and will be posted on the TOMNET website. The development of these software tools has been delayed due to transitions in personnel, with computer science students helping to develop the software code graduating and TOMNET having to bring on new computer science students who need to become familiar with the systems from scratch. TOMNET has developed R and Python codes for transportation model estimation and implementation efforts as well as data fusion procedures for targeted marketing data. These codes enable the estimation of advanced econometric choice models (such as integrated choice latent variable or ICLV models) that are most suited when dealing with attitudinal data.

Databases and Research Materials

In a number of TOMNET projects, integrated datasets have been developed (or are under development) using data fusion techniques so that the impacts 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 may be studied in detail. 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. All data sets assembled by TOMNET are in the process of being documented, stripped of personally identifiable information, and checked for compliance with IRB protocols that must be followed in the context of research involving human subjects. In the meantime, findings from the surveys are being disseminated to the community through a series of webinars and research papers.

The COVIDFuture Survey project, which is being jointly undertaken by Arizona State University and the University of Illinois-Chicago with support from the National Science Foundation and TOMNET, will produce a longitudinal database documenting various impacts of COVID-19 on people's lives across the United States. These impacts include current and future trends on telecommuting, e-shopping, mode choice, air travel, and income and employment. The dataset and analytical products are key outputs that TOMNET and collaborating researchers are producing to help address the transportation planning and modeling challenges brought on by the pandemic. The COVIDFuture Wave 1 dataset has been made available to the public in this reporting period at this [link](#) on the ASU data repository called Dataverse.

TOMNET is tracking metrics to see how the center is doing relative to targets specified in the Technology Transfer Plan. Table 5 provides a summary of performance for two metrics.

Table 5. 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	Datasets are being cleaned, weighted, and documented. The codes are in beta versions.
Number of publications in refereed journals	15	13	16	29	Greatly exceeded the annual target.

4. OUTCOMES

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. Data and insights from the T⁴ survey, and subsequent publications documenting survey results, will help provide critical information that agencies need to minimize the potential negative impacts and maximize the potential positive impacts of new transportation technologies.

The community resilience survey that the TOMNET team at the University of Washington has implemented is also very beneficial in understanding the mental and physical elements that impact community disaster preparedness and resilience, and the survey is particularly relevant to the current pandemic situation. The findings from this research can inform strategies for enhancing community adaptive capacity in facing disasters, wherein social and transportation networks can be leveraged to accomplish essential activities and access essential goods and services, both on an everyday basis and during times of disruption.

TOMNET researchers are studying the potential impacts of COVID-19 on people's travel behavior, time use, and activities before, during, and after the pandemic to help decision-makers plan and adapt transportation systems to a new normal. The COVID-19 Wave 1 dataset has been released to the public during this reporting period and it is envisioned that the data will help in planning a strong recovery as well as retaining desirable behaviors (e.g., more walking and bicycling) that occurred during the pandemic. Another key TOMNET research project “An Investigation of the Contribution of Targeted Marketing Data to the Prediction of Attitudes” has increased awareness of the importance of attitudes in shaping individual mobility choices. Once completed, this project will enable the inclusion of attitudinal variables in travel forecasting models and enhance predictive capabilities and accuracy.

Improved techniques in addressing transportation issues

The analysis of the data collected in the T⁴ Survey is already contributing to improved planning processes and informing policymakers about very important trends that are rapidly evolving in the mobility space. The TOMNET team is developing 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 modeling 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. The updated [TOMNET website](#) now includes the name, affiliation, degree, and profile pictures of all 64 students and scholars that have been deeply engaged in TOMNET research during their education. 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 6 for two metrics.

Table 6. TOMNET Metrics on Products

Metric	Annual Target	Previous Reporting Period	This Reporting Period	Annual Total	Assessment/notes
Number of unique downloads of TOMNET data/codes	100	0	150	150	Primarily COVID Survey (Wave 1) and T ⁴ Survey Results/Reports/Presentations
Number of students/scholars participating in TOMNET research	50	38	Additional 4	42	Numbers represent unique cases/students.

5. IMPACTS

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

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 and **equitable** transportation system as well as informed decision-making on transportation investments and improvements that will advance mobility for all. The overall impacts of multiple surveys funded by TOMNET in understanding the interactions between transport system usage and new disruptive changes including mobility-on-demand services, automation, electrification, health and wellbeing, pricing and taxation, safety, COVID-19 pandemic, leisure activities, and community resilience is undoubtedly substantial, and yet difficult to quantify. So far Wave 1 of COVIDFuture dataset which is partially funded by TOMNET has been released to the public and around 150 unique individuals have downloaded the data. More than 1,000 unique individuals have accessed TOMNET reports, webinar recordings, and T⁴ Survey results, reports, and presentations.

It is envisioned that the findings, analytical models, and raw datasets can provide significant insights regarding people's behaviors, perceptions, and choices and therefore substantially inform transport system planning and policymaking. Table 7 illustrates the number of agencies that have used TOMNET products annually as a quantitative metric to measure TOMNET impact. However, it is substantially difficult to obtain the exact number as some agencies use published findings and data sources without necessarily notifying the TOMNET team. The TOMNET team is also reluctant to require a sign-up process as that often creates a barrier to open access, and many individuals do not wish to sign up and disclose their contact information for fear of being added to e-mail lists in which they do not wish to be added. As such, the table offers a very conservative estimate of TOMNET impacts.

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 that can inform travel models and resulting 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 the National Household Travel Survey (NHTS). Lastly, COVIDFuture survey data and findings are providing critical information about what the new normal after the pandemic may look like, and how the profession should plan to maximize the positive impacts and minimize the negative impacts of the pandemic experience.

UW: The work at University of Washington 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?

During the latest TOMNET leadership meeting, which was held virtually on December 16, 2020, the TOMNET core team discussed the best metric to measure TOMNET impact on the body of scientific knowledge. There was unanimous agreement that citations to TOMNET research products, including papers, books, data sources, and modeling tools, could serve as a strong quantitative metric regarding impact on the body of scientific knowledge. As such, Table 7 shows the number of Google Scholar citations for research papers that were produced during 2018, 2019, and 2020 by the core TOMNET team. During these three complete years, the work of the TOMNET core team was sponsored by TOMNET and citations are counted for only those products and papers that can be attributed to TOMNET funding.

Table 7. TOMNET Metrics on Impacts

Metric	2018	2019	2020	Total
Number of agencies adopting TOMNET data/tools	2	1	1	4
Citations of TOMNET Publications	970	587	3867	5424

What is the impact on transportation workforce development?

To date, TOMNET activities have engaged high school, undergraduate, graduate, and post-graduate students in timely transformative transportation issues, data collection methods, and advanced analytical techniques. In the outreach, webinar, and workshop activities to date, TOMNET provided opportunities for the general transport community to learn from TOMNET researchers and external speakers.

It is very rewarding to see that TOMNET-sponsored graduate students are graduating with Master’s and PhD degrees and are joining academia or professional organizations. Yongsung Lee (from GT) is an Assistant Professor at the University of Hong Kong since fall 2020. Matt Conway (from ASU) will join the University of North Carolina at Chapel Hill as an Assistant Professor in fall 2021. Katie Idziorek (from UW) will join the University of North Carolina at Charlotte as an Assistant Professor in fall 2021. Atiyya Shaw (from GT) has started as a post-doc at UC Berkeley in spring 2021. Denise da Silva Baker will join Y2K Engineering consulting firm in Arizona in summer 2021.

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.