



UTC Semi-Annual Progress Report (SAPR#9)



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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, through September 30, 2021. This SAPR covers work accomplished, collaborations with academic, government, and industry partners, and the center outputs, outcomes, and impacts for the period of April 1, 2021, through September 30, 2021.

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 launched, made progress on, and completed several research projects. Projects launched in previous years have been completed (27 projects) or are continuing into their subsequent phases (15 projects). Additionally, 5 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 (total of 47 projects). The status column indicates whether the project is accomplished or is still in progress. The new TOMNET projects are in the process of getting entered into the RiP dataset. Moreover, the completed project reports are getting ready to be entered into the TRID database. The TOMNET website [project page](#) has mostly been updated to present the research projects categorized by year and the lead university. The reports for the projects that have been

completed recently are under review and will be posted to TRID and the TOMNET Website within the next reporting period. Further details about progress made on a sample of active projects are provided below.

Table 1. TOMNET Research Projects

	Project Topic/Title	Institution (PI)	Active Period	Status
1.	How Do Perceptions and Adoption of Emerging Transportation Technologies Vary by Residential Location?	ASU (Khoeini)	Aug 2021- July 2022	
2.	The Influence of Mode Use on Level of Satisfaction with Daily Travel Routine: A Focus on Automobile Driving in the United States	ASU (Pendyala)	Aug 2021- July 2022	
3.	Assessing the Impact of Ridehailing Service Use on Bus Ridership: A Joint Modeling Framework Accounting for Endogeneity and Latent Attitude	ASU (Pendyala)	Aug 2021- July 2022	
4.	Accounting for the Influence of Attitudes in Modeling the Adoption and Usage of On-Demand Transportation and Electric Vehicles	ASU (Pendyala)	Aug 2021- July 2022	
5.	Development of an Integrated Model of Daily Activity-Travel Behavior and Well-Being	ASU (Pendyala)	Aug 2017- July 2018	
6.	To What Extent Are Millennials Really Different in Their Vehicle Miles of Travel Compared to Generation X?	ASU (Pendyala)	Aug 2018- July 2019	
7.	Do Attitudes Affect Behavioral Choices or Vice-Versa: Uncovering Latent Segments within a Heterogeneous Population	ASU (Pendyala)	Aug 2019- July 2020	
8.	Attitudes Towards Mobility Options/Technologies – A Multi-region Survey Design and Data Collection Effort	ASU (Khoeini)	Oct 2017- July 2020	
9.	Interaction of Transportation and Health, Wellbeing, and Safety – A National Survey Design and Data Collection	ASU (Khoeini)	Aug 2020 – Present	
10.	Transportation Policies, Pricing, and Priorities – A National Survey Design and Data Collection	ASU (Pendyala)	Aug 2020 – Present	
11.	Transportation Electrification – A National Survey Design and Data Collection	ASU (Pendyala)	Aug 2020 – Present	
12.	The Effect of Survey Methodology on The Collection of Attitudinal Data	ASU (Pendyala)	Aug 2020- July 2021	
13.	Investigating the Contributing Factors to Willingness to Share Automated Vehicles with Gender Focus	ASU (Khoeini)	Aug 2020- July 2021	
14.	Interaction of Familiarity, Safety Perceptions, and Willingness to Use Autonomous Vehicles in A Structural Equation Modeling Framework	ASU (Khoeini)	Aug 2020- July 2021	
15.	Effects of Attitudes Towards COVID On Travel Behavior During The Pandemic	ASU (Pendyala)	Aug 2020- July 2021	
16.	Expected Change in US Air Travel after the COVID-19 Pandemic	ASU (Khoeini)	Aug 2020- July 2021	
17.	Integrated Household Energy Analysis Tool (iHEAT)	ASU (Pendyala)	Aug 2020 – Present	
18.	Diversity, Equity, and Inclusion (DEI) Implications of Mobility-on-Demand Services	ASU (Khoeini)	Aug 2020 – Present	
19.	How Will Use of Autonomous Vehicles for Running Errands Affect Future Autonomous Vehicle Adoption and Ownership?	ASU (Pendyala)	Aug 2020- July 2021	
20.	Assembling Integrated Data Sets for Analyzing Connections between Travel Behavior, Attitudes, and the Built Environment	ASU (Salon)	Aug 2017- July 2018	
21.	Heterogeneity in the Relationship Between the Built Environment and Bicycling	ASU (Salon)	Aug 2018- July 2019	
22.	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	
23.	Comprehensive Review of Attitudes-Travel Behavior Literature	ASU (Salon)	Aug 2018- July 2019	
24.	The impact of non-transportation attitudes, preferences, and personality characteristics on residential location and travel choices	ASU (Salon)	Aug 2019- Present	
25.	Investigating Attitudinal and Behavioral Changes in U.S. Households Before, During, and After the COVID-19 pandemic	ASU (Salon)	Aug 2019- Present	

26.	The Stability of Transport-Related Attitudes over Time: A Case Study During COVID-19	ASU (Salon)	Aug 2021- July 2022	⚙️
27.	Consumer Attitudes and Behavioral Implications in the New Era of Shared Mobility	ASU (Zhang)	Aug 2019 – Present	⚙️
28.	Emerging Approaches to Autonomous Vehicles in Transportation Policy and Planning	ASU (Thad Miller)	Aug 2019 – Present	⚙️
29.	Teaching the travel demand flow estimation models: a new deep-learning approach using multi-source data	ASU (Zhou)	Aug 2019 – Present	⚙️
30.	Real-time Transportation Social Media Analytics using Pulse (Pulse-T)	ASU (Kandala)	Aug 2019 – Present	⚙️
31.	Latent variable models of Attitudes and Preferences, and their Prediction of Autonomous Vehicle Adoption Intent	ASU (Grimm)	Aug 2020 – Present	⚙️
32.	Attitudes Towards Mobility Options/Technologies – A Multi-region Survey Design and Data Collection Effort	GT (Circella)	Oct 2017- July 2020	✓
33.	An Investigation of the Contribution of Targeted Marketing Data to the Prediction of Attitudes	GT (Mokhtarian)	Oct 2017- - Present	⚙️
34.	Latent Vehicle Type Propensity Segments: Considering the Influence of Household Vehicle Fleet Structure	GT (Mokhtarian)	Aug 2018- July 2019	✓
35.	Combining Disparate Surveys across Time to Study Satisfaction with Life	GT (Mokhtarian)	Aug 2019- July 2020	✓
36.	Mode Substitutional Patterns of Ridehailing and Micro-mobility Services	GT (Circella)	Aug 2020 – Present	⚙️
37.	Response Willingness in Consecutive Travel Surveys	GT (Mokhtarian)	Aug 2020- July 2021	✓
38.	Attitudes Towards Mobility Options/Technologies – A Multi-region Survey Design and Data Collection Effort	USF (Maness)	Oct 2017- July 2020	✓
39.	An exploration of contemporary issues in highway safety, evolving transportation alternatives, and activity and travel behavior modeling	USF (Maness)	Aug 2019- July 2020	✓
40.	Investigation of the Role of Attitudinal Factors on Adoption of Emerging Automated Vehicle and Vehicle Safety Technologies	USF (Mannering)	Aug 2017- July 2018	✓
41.	Emerging econometric and data collection methods for capturing attitudinal and social factors in activity and travel behavior modeling	USF (Mannering)	Aug 2018- July 2019	✓
42.	Exploration of the Relationships between Leisure Activity Participation Frequency and Social Capital	USF (Maness)	Aug 2020- July 2021	✓
43.	Valuation of Free Electric Vehicle Charging Bundles	USF (Maness)	Aug 2020- July 2021	✓
44.	Addressing potentially missing relevant information on attitudes and other behavioral elements as unobserved heterogeneity in highway safety studies	USF (Mannering)	Aug 2020- July 2021	✓
45.	An empirical assessment of the role of attitudes and identification in safety research	USF (Mannering)	Aug 2020 – Present	⚙️
46.	Attitudes and Trust in Leveraging Integrated Sociotechnical Systems for Enhancing Community Adaptive Capacity	UW (Chen)	Oct 2017- July 2020	✓
47.	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 (T4 Survey)
PI: Sara Khoeini (ASU), Giovanni Circella (GT), Michael Maness (USF)
Co-PI: Ram Pendyala (ASU), Deborah Salon (ASU), Patricia Mokhtarian (GT), Fred Mannering (USF)

Progress: Survey design, sample recruitment, data collection, data cleaning and weighting, and dissemination of initial results have all been completed during the 2017-2020 time period. During the reporting period, the research team worked on data analysis and behavioral choice modeling, presenting the results at various venues and writing scientific papers. In particular, T4 survey results have been

presented at [Automated Road Transport Symposium](#) during July 2021 through four presentations related to equity, perceptions of automation, older population mobility needs, and shared mobility systems. Sara Khoeini, Denise Baker, and Tassio Magassy were the presenters. Sara Khoeini also moderated the session related to AV perception. Showcasing the results of the T4 survey at such a high-caliber international event helped effectively disseminate the results of the T4 survey for a global audience. Additionally, Sara Khoeini presented a [summary](#) of T4 survey results at the meeting of the AASHTO Committee on Transportation System Operations (CTSO) which is comprised of government and DOT stakeholders from across the United States. This [webpage](#) reflects all of the activities and outputs related to the TOMNET Transformative Technologies in Transportation (T4) Survey products. Further analysis of T4 survey data is underway (projects #1, #2, #3, #12, #13, #14, #18, #19, #24, #31, and #36 in table 1); these efforts are in progress or have been completed during this reporting period and resulted in the preparation of papers for possible presentation at the 2022 Transportation Research Board Annual Meeting and publication in the Transportation Research Record: Journal of the Transportation Research Board.

Project Title: How Do Perceptions and Adoption of Emerging Transportation Technologies Vary by Residential Location?

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

Progress: When it comes to the future of emerging transportation modes such as ride-hailing services and autonomous vehicles (AVs), various survey-based studies have explored the role of socioeconomic and attitudes in shaping people’s perceptions and adoption of these innovative mobility options. However, the role of residential location and other spatial/geographical attributes has not been explored as much, possibly due to the difficulty in collecting detailed spatial information in surveys. A better understanding of such relationships would help in the design of land use patterns and residential developments of the future that are conducive to the adoption and use of transportation innovations (while minimizing unintended consequences). The proposed study utilizes T4 survey data (Project #8) to clarify the spatial variability in perceptions and choices related to emerging transport technologies, the transferability of data across different locations, and the geographic factors that merit enhanced attention in the future. This project has been launched in this reporting period and the results will be presented at [ASCE International Conference on Transportation & Development](#) during Summer 2022 in Seattle, WA.

Project Title: The Influence of Mode Use on Level of Satisfaction with Daily Travel Routine: A Focus on Automobile Driving in the United States

PI: Ram Pendyala (ASU), **Co-PI:** Sara Khoeini (ASU) (collaboration with D-STOP, Univ of Texas at Austin)

Progress: How does the extent of automobile use affect the level of satisfaction that people derive from their daily travel routine? This is the research question addressed by this study. The proposed study utilizes data collected through the T4 Survey. This research effort recognizes the presence of endogeneity when modeling multiple behavioral phenomena of interest and the role that latent attitudinal constructs reflecting lifestyle preferences play in shaping the association between behavioral mobility choices and degree of satisfaction. Results show that latent attitudinal factors representing an environmentally friendly lifestyle, a proclivity towards car ownership and driving, and a desire to live close to transit and in diverse land use patterns affect the relative frequency of auto-driving mode use for non-commute trips and level of satisfaction with daily travel routine. Additionally, the amount of driving positively impacts satisfaction with daily travel routine, implying that bringing about mode shifts towards more sustainable alternatives remains a formidable challenge – particularly in automobile-centric contexts. A paper based on this study has been accepted for presentation at the 2022 TRB annual meeting and is under review for publication in the Transportation Research Record: Journal of the Transportation Research Board.

Project Title: Assessing the Impact of Ridehailing Service Use on Bus Ridership: A Joint Modeling Framework Accounting for Endogeneity and Latent Attitudes

PI: Ram Pendyala (ASU), **Co-PI:** Sara Khoeini (ASU) (collaboration with D-STOP, Univ of Texas at Austin)

Progress: Transit ridership has been on the decline for several years. One key contributing factor is the rise of ridehailing service usage and its impact on transit use. This study provides a comprehensive and holistic assessment of the impacts of ridehailing service use on transit ridership while controlling for a host of socio-economic, demographic, and attitudinal factors. The study utilizes the T4 Survey data set. Study results indicate that ridehailing use frequency is significantly associated with a decrease in bus use, suggesting that ridehailing serves as a substitute for bus use (more than it serves as a compliment). The findings suggest that transit agencies need to explore pathways towards leveraging ridehailing services to better complement transit usage. Preliminary study results have been presented at [Environmental Health Matters Initiative](#) during July 2021. A paper is also accepted for presentation at the 2022 TRB annual meeting and under review for publication.

Project Title: Accounting for the Influence of Attitudes in Modeling the Adoption and Usage of On-Demand Transportation and Electric Vehicles

PI: Ram Pendyala (ASU) (in collaboration with D-STOP, University of Texas at Austin)

Progress: This project is concerned with identifying factors that contribute to the adoption of on-demand transportation services and electric vehicle (EV) ownership in the Indian context. While there is an extensive and growing body of research related to these transportation innovations in the developed world, evidence-based research on these topics remains sparse in the Indian context. Using a unique survey data set collected in 2018 from a sample of 43,000 respondents spread across 20 cities in India, this project develops a holistic integrated modeling framework to shed light on the factors that affect the adoption of on-demand transportation services and electric vehicles in India. In particular, not only does this project consider socio-economic and demographic variables that affect these behavioral choices, but the study places a special emphasis on understanding the important role played by attitudes, values, and perceptions in determining the adoption of on-demand transportation services and EVs. A paper based on this study has been accepted for presentation at the 2022 TRB Annual Meeting and is under consideration for publication in Transportation Research Record.

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), Steve Polzin (ASU) + Many TOMNET Team Members

Progress: TOMNET has started to design a national survey to gather data on attitudes, perceptions, and values on the most important and timely transport issues in the US, including the next generation of transportation pricing and revenue generation mechanisms, electrification, transport infrastructure condition and investment priorities, health implications of transportation, and safety. Due to the complexity and widespread interest in the survey topics, the survey design team has not yet been able to finish the survey design phase. The core team members have decided to expand their literature review efforts to make sure the new surveys result in behaviorally robust data sets that can be used to guide future policymaking in various transportation-related priority topics. It is envisioned that the pilot phase of data collection will be conducted during Summer 2022 and the full deployment will happen in fall 2022 and spring 2023 (hopefully after the pandemic).

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

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

Progress: This project uses data from the first wave of the COVIDFuture 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 Economic Consequences of COVID Response” and “Concern about Health Impacts of COVID.” A cluster analysis based on the factor scores yielded four groups with distinct attitudinal profiles. The findings of this study highlight the significance of COVID-related attitudes in shaping the travel behavior of respondents during the pandemic, and once again reinforce the importance of including attitudes in transport demand modeling and forecasting. The analysis has been completed as part of Denise Baker’s (PhD Candidate at ASU) dissertation and presented at the [International Road Federation](#) World Meeting in Dubai, UAE. The results of this study have also 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)

Progress: The impact of COVID on air travel has been very substantial. Although it is expected that air travel will recover to a certain degree (especially when the pandemic is over), there is considerable uncertainty about the extent to which the reduction in air travel for personal and business purposes (witnessed during the pandemic) is going to persist. It is of interest to understand the reasons for the long-term shifts in air travel behavior, and how air travel recovery will differ among subgroups of the population defined by socioeconomics and attitudes (once the pandemic fades). 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, a structural equations model system with latent attitudinal variables is developed. The results highlight and capture the significant role of attitudes in shaping future mobility choices. The results of this study have been presented at the International Choice Modeling Conference, 2021 during this reporting period, and a paper has been accepted for presentation at the 2022 TRB annual meeting and is under consideration for publication in the Transportation Research Record.

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)

Progress: This project aims to collect survey data at multiple time points and present detailed insights on the extent to which American society will “go back” to pre-COVID-19 way of life after the threat of contagion is gone. This project is an online longitudinal national survey that is co-sponsored by NSF and TOMNET, and involves a collaboration between ASU and University of Illinois Chicago (UIC). The project [website](#) has more information about the project in addition to the link to the [released wave 1 dataset](#). In this period, the project team delivered multiple virtual webinars and conference presentations based on wave 1 results; published five papers; submitted six papers for presentation at the TRB annual meeting; and, finished designing a “wave 3” follow up survey to capture trends over time, which will be deployed in October and November 2021. The plan is to conduct additional data analysis and publish results in multiple journal articles, present findings at both virtual and in-person conferences, continue to update the project website with new findings as they come in, and publicize study results in the popular press as opportunities arise. In addition to data analysis and reporting, it is envisioned that wave 2 and wave 3 data sets will be cleaned, weighted, and released during the next reporting period.

Project Title: The Stability of Transport-Related Attitudes over Time: A Case Study During COVID-19

PI: Deborah Salon (ASU)

Progress: The most important goal of the TOMNET UTC is to study and document the role of attitudes in travel behavior modeling and demand forecasting. Although attitudes can be useful predictors in travel

models, their utility is dependent on the ability to forecast attitudes into the future. If attitudes are stable over time, then the forecasting of attitudes for a future horizon year may be easier to accomplish. This project investigates the stability of attitudes using two waves of the COVIDFuture survey, which include responses from the same respondents between 3.5 and 11 months apart. The project found that attitudes have fairly high stability, particularly when factors are analyzed. Demographic groups that are generally found to have more changeable attitudes, such as young people, still display moderately to highly correlated attitudes across waves of the survey. The study concludes that attitudes, while not perfectly constant, display enough stability to be useful for prediction. The results of this study have been accepted to be presented at the 2022 TRB annual meeting and have also been published in [Transport Findings](#).

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

PI: Giovanni Circella (GT)

Progress: Using the data collected in the T4 survey, a study regarding the impacts of the use of ridehailing services (such as those provided by Uber and Lyft) on the use of other travel modes in the three regions of Atlanta, GA, Phoenix, AZ and Austin, TX is being conducted. The purpose of this study is to explore the heterogeneous impacts of ridehailing: in so doing, we apply a latent-class cluster analysis on indicators of changes in the use of various travel modes as a result of ridehailing adoption, including socioeconomics, demographics, a land-use attribute, and individual attitudes as covariates. We find four distinctive classes of behavioral changes in response to ridehailing. This study makes an important contribution to the transportation research and planning community, as it reveals substantial heterogeneity in ridehailing impacts, which were masked in previous studies that focused on average impacts. It also helps identify and suggest policy responses that could be customized to users' socioeconomics and residential neighborhoods where their trips happen to increase the efficiency of their desired transportation impacts. A paper derived from this research is currently under review for publication in a scientific journal. Grace Chen completed her master thesis during this semester based on this work. Also, a paper was prepared by the research team in collaboration with Calvin Thigpen, the Director of Policy Research at the e-scooter company *Lime*, and this paper was submitted and accepted for publication in the forthcoming annual meeting of the Transportation Research Board in January 2022.

Project Title: Response Willingness in Consecutive Travel Surveys

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

Progress: This project addresses the following questions: (1) Who is more likely to respond to a follow-up survey? (2) How does recruiting respondents based on their willingness expressed in a preceding travel survey bias the follow-up survey sample? (3) What survey sample could we expect if we recruited respondents from the 2017 NHTS respondents in different geographic regions in the U.S.? We used two datasets: the National Household Travel Survey (NHTS) and a Georgia DOT (GDOT)-sponsored follow-up survey. We focused on the Georgia subset of the NHTS for the model estimation process. The final working dataset contained about 8,400 Georgia respondents to the NHTS, nearly 5,000 of whom indicated a willingness to participate in a follow-up survey ("WTP"). That willingness was put to the test with the GDOT survey. We mailed the GDOT survey to the Georgia NHTS respondents in September 2017. Ultimately, about 1,400 of the 5,000 "willing" NHTS respondents replied to the GDOT survey. We note that for the purpose of this study, the GDOT survey was used only to determine respondents' actual completion (or not) of the follow-up survey; all other respondent data was obtained from the NHTS. We separated the final working dataset into a training set (60%) and a test set (40%). Findings suggest that the requirements of the preceding survey influenced respondents' WTP. Specifically, for NHTS, respondents from survey-burdened households (e.g., large households) were less likely to report WTP. Respondents' attitudes towards privacy and travel liking were also influential to their WTP. Respondents

from specific groups (e.g., travel-restricted people, frequent transit users) were more likely to report WTP. By participating in travel surveys, these groups may be seeking to improve the quality of their travel. A master's thesis based on this study was completed and filed in Spring 2021, and a paper summarizing the study was submitted to the journal *Transportation* in July 2021. This paper was presented at a STEPS seminar at the University of California, Davis, in May 2021. During the next reporting period, we should receive peer-review comments on the paper and will revise and resubmit.

Project Title: Exploration of the Relationships between Leisure Activity Participation Frequency and Social Capital, **PI:** Michael Maness (USF)

Progress: This research theorizes that an individual's expressive social support has a strong correlation with the increasing frequency of activities that are performed to maintain and strengthen social connections. These activities would have higher affiliation scores. This affiliation scale ranged from "gratification of the need to be with and relate to others in a cooperative, enjoyable way [(high score)] vs. the need to do things alone [(low score)]." The twenty most popular activities encompass a full spectrum of affiliation scores from the highest score of 72 for visiting family and friends to the lowest score of 30 for reading non-fiction. Independent zero-inflated ordered probit models were estimated for each of the 20 leisure activities. The six out of ten activities with higher affiliation scores – visiting family and friends, playing video games, dining out, playing board games, taking a nature walk, and watching football – have significant and positively stronger effect of expressive social support in increasing the participation frequency. Expressive social support positively and significantly enhances church-attending frequency, but its effect is smaller and less significant than instrumental social capital. Although playing cards, going to the movie theater, as well as baking and cooking for leisure only have moderately significant and positive effects of expressive social support, these effects are still stronger (if not opposite with the instrumental social capital) thus supporting our hypothesis. The working paper has been refined and corrections were made to the results to more accurately differentiate expressive social capital from instrumental social capital.

Project Title: Valuation of Free Electric Vehicle Charging Bundles
PI: Michael Maness (USF)

Progress: The project team completed an additional analysis that included accounting for correlation in the alternatives due to shared labels in the stated choice experiment. Results were shown to be comparable to previous results with all population segments expressing some willingness-to-pay (WTP) for free charging at the two- and three-year time frames. An abstract was accepted for presentation at the 2021 Behavior, Energy, and Climate Change conference entitled: A National Estimate of the Value of a Free EV Charging Event in the US. The project team began preparation for the presentation by developing slides and completing research analyses. The team expects to present their results at the conference over the next reporting period and to develop a journal article for submission to a peer-reviewed journal. The research team also attempted to account for sociodemographic differences in preferences, but the results were inconclusive. The team attempted to separate the population into classes based on sociodemographics and regional differences. This result was unexpected and further explorations of patterns in the sample are underway.

Project Title: Addressing Potentially Missing Relevant Information on Attitudes and Other Behavioral Elements as Unobserved Heterogeneity in Highway Safety Studies
PI: Fred Mannering (USF)

Progress: The project team continues to address several critical issues in the fields of highway safety, alternative transportation modes, and activity and travel behavior modeling. Regarding highway safety,

the project team completed work and submitted four papers for journal review in the study period:

- Alnawmasi, N., Mannering, F., The impact of higher speed limits on the frequency and severity of freeway crashes: Accounting for temporal instability and unobserved heterogeneity.
- Hou, Q., Hou, X., Leng, J., Mannering, F., A note on the analysis of crash-injury severities and out-of-sample prediction with random parameters logit models.
- Alogaili, A., Mannering, F., Differences between day and night pedestrian-injury severities: Accounting for temporal and unobserved effects in prediction.
- Islam, M., Mannering, F., The temporal evolution of driver injury severities in crashes involving fatigued/drowsy driving.

Project Title: An Empirical Assessment of the Role of Attitudes and Identification in Safety Research

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

Progress: The research team has developed a questionnaire to collect individuals' retrospective driving behavior data before and during the pandemic. The team developed questions on: (1) driving status and tenure, (2) vehicle miles traveled (VMT), (3) VMT changes due to pandemic, (4) incidents, (5) moving violation volume, and (6) attitudes towards safety. Additionally, the survey acquires information on people's attitudes and concerns with the pandemic. The research team performed a test of the survey during the reporting period where it was found that respondents could reliably answer the questions given. The research team seeks to perform full-scale data collection during the next reporting period to coincide with the timing of the annual Leisure Activity and Social Resources Survey.

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 adaptive capacity. This current phase builds upon findings from previous project phases, including a pilot survey, follow-up full-community surveys, and a full-scale sample survey, to implement multiple interviews and focus group meetings across the three communities on issues of social connectivity, trust, place attachment, and disaster preparedness and response as relevant to different modes of transportation and communication services. Understanding the interactions among these three aspects of the community will provide us with data to inform strategies for enhancing community adaptive capacity. During the reporting period, descriptive data analysis from the full-scale community resilience survey in Laurelhurst, Westport, and South Park have been completed. Analysis of the Interviews with community partners and community stakeholders have been completed. To gain deeper insight into the quantitative survey findings, in the last phase, we held semi-structured interviews with two categories of stakeholders in roles relevant to facilitating disaster preparedness and local resource matching in each of the three communities: 1) community leaders from grassroots disaster preparedness organizations and community service/mutual aid providers; and 2) hazard planners working for municipalities or regional agencies. The research team is in the process of convening a series of focus groups to further elaborate upon the willingness to share data gathered from the community resilience sample survey. Through the focus groups, we hope to learn more about individuals' motivations for being willing – or not willing – to share resources in a disaster scenario. Although the focus groups were originally planned to take place in person, we moved to an online format due to the circumstances of the COVID-19 pandemic. Focus group members were recruited from among survey respondents who had indicated they would be willing to be contacted for a follow-up interview and who provided an email address. In the last phase, one of the four planned group meetings were completed. In this phase, we completed the remaining three group meetings and also finished the analysis.

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 Fall 2021. Please note that the courses offered during Spring 2021 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 2021)

Semester	Course Level	Course No	Course Title	No	Instructor	Unit
Arizona State University						
Fall 21	Undergrad	CEE372	Transportation Engineering	60	Pendyala	SSEBE
Fall 21	Undergrad	PUP430	Transport Planning/Environment	67	Salon	SGSUP
Fall 21	Graduate	PUP550	Transportation/Environment	7	Salon	SGSUP
Fall 21	Graduate	PUP642	Urban & Regional Economic Analysis	36	Salon	SGSUP
Fall 21	Graduate	PUP710	Planning Theory	8	Salon	SGSUP
Georgia Institute of Technology						
Fall 21	Grad	CEE 6623	Transportation Survey Methods	20	Mokhtarian	CEE
University of South Florida						
Fall 21	Undergrad	TTE4004	Transportation Engineering I	68	Maness	CEE
Fall 21	Graduate	TTE6507	Travel Demand Modeling	4	Maness	CEE
Fall 21	Graduate	TTE6307	Statistical and Econometric Methods I	19	Mannering	CEE
Fall 21	Graduate	TTE5205	Traffic Systems Engineering	19	Lin	CUTR
Fall 21	Undergrad	TTE4006	Pavement Design	6	Lu	CUTR
Fall 21	Graduate	TTE6930	Graduate Transportation Seminar	8	Zhang	CEE
Fall 21	Undergrad	CGN4933	Sustainable Transportation	26	Zhang	CEE
Fall 21	Graduate	TTE6657	Sustainable Transportation	7	Zhang	CEE
Fall 21	Graduate	TTE6267	Traffic Flow Theory	11	Li	CEE
University of Washington						
Fall 21	Graduate	CET581	Travel Demand Forecasting	10	Chen	CEE
Fall 21	Graduate/ Undergrad	URBDP 423/523	Introduction to Urban Design	17	Abramson	URBDP
Fall 21	Graduate/ Undergrad	URBDP 424	Site Planning	13	Abramson	URBDP

Notes: 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	Comp Science	Pendyala
Laura Mirtich	Undergrad	SOLS	Salon
Holden Weisman	Undergrad	SGSUP	Salon
Nicole Corcoran	PhD Student	SGSUP	Salon
Adam Costello	Undergraduate	SOS/SGSUP	Salon
GEORGIA INSTITUTE OF TECHNOLOGY			
Gwen Kash	Postdoc	CEE	Mokhtarian
Ali Etezady	PhD student/postdoc	CEE	Circella/Mokhtarian
Xinyi Wang	MS & PhD student	CEE	Mokhtarian
Sung Hoo Kim	PhD student/postdoc	CEE	Mokhtarian
Yun-Hsuan (Grace) Chen	MS student	SCaRP/CEE	Circella
Ilsu Kim	PhD student	CEE	Circella/Mokhtarian
Regan Buchanan	MS student	SCaRP	Mokhtarian
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
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
Grace Jia	PhD Student	CEE	Chen

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 available archives 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. Further, Dr. Sara Khoeini presented findings of the T4 survey at various conferences and Dr. Deborah Salon presented results of the COVID Future survey in different venues. These presentations are listed later in the report.

Table 4. Key TOMNET-Sponsored Technology Transfer Events

Inst.	Title of Seminar/ Webinar	Speaker Name and Affiliation	Date
USF	Planning Towards Shared, Electric, Modular Automated Mobility	Joseph Chow, New York University	04/02/2021
USF	The Multi Modal Intelligent Traffic Signal System – Using V2X Data for Priority-Based Traffic Control	Larry Head, University of Arizona	04/09/2021
ASU	On the Behavioral of Adaptive Cruise Control Vehicles: An Empirical Study	Danjue Chen, University of Massachusetts, Lowell	04/16/2021
ASU	The Impact of COVID-19 Travel Restrictions on Phoenix Air Quality	Matt Fraser, Arizona State University	04/23/2021
USF	Testing Autonomous Vehicles with Naturalistic and Adversarial Driving Environment	Henry Liu, University of Michigan Ann Arbor	04/23/2021

ASU	Ending the Energy-Poverty Nexus: An Ethical Imperative for the Low-Carbon Energy Transition	Clark Miller, Arizona State University	04/30/2021
ASU	Valley Metro – Waymo AV Mobility-on-Demand (MOD) Project: Experience from a Real-World Pilot Demonstration	Angie DeVore, Joseph Gregory, Valley Metro; Ram M. Pendyala, ASU; Thaddeus Miller, University of Massachusetts-Amherst; Discussant: Kaity Fischer, Waymo	05/07/2021
ASU	Smart Planning Rising Up with Digital Twin: Transforming the Interconnection Between Open Data and City Planners	Xuesong (Simon) Zhou, PhD, Arizona State University Dustin Carlino, A/B Street	06/07/2021
USF	Opportunities for Interactions between Individual Drivers and Traffic Control in the AI World	Wei-Hua Lin, University of California Berkeley	09/03/2021
USF	Is Sharing Caring? Understanding Shared Mobility Impacts	Susan Shaheen, UC Berkeley	09/10/2021
USF	Transforming Tampa’s Tomorrow through Innovation and Resilience	Jean Duncan, City of Tampa	09/17/2021
USF	Paradigm Shift Towards Smart and Healthy Cities— Systems Innovation at the Nexus of Transportation, Environment, and Public Health	H. Oliver Gao, Cornell University	09/24/2021

Note: ASU = Arizona State University; GT = Georgia Institute of Technology; USF = University of South Florida; UW = University of Washington

What do you plan to do during the next reporting period to accomplish the goals?

TOMNET has several 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 contributed to, 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 additional 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 see the production of tangible research outputs that can significantly benefit policy and decision making of the transport sector, particularly in the wake of recent natural and technological disruptions. Dissemination of these research products will further contribute to the TOMNET education and workforce development goals as well as technology transfer domain.

TOMNET core 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 in-person seminars 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 also 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 for the Summer of 2022.

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 online platforms have been

used to continue K-12 outreach programs. In the next reporting period, TOMNET will continue taking advantage of successful online modules to disseminate information about careers in transportation. Sara Khoeini delivered a webinar entitled “Narrative of Transportation” to approximately 150+ high school students as part of the AZ Transportation YOU program organized by the WTS Phoenix Chapter to explain how the transportation industry has evolved through the years.

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 researchers work very closely with Atlanta Regional Commission, Maricopa Association of Governments, and the Georgia Department of Transportation.

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, impacted by pandemic.*
- *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): Writing of a chapter, larger international collaboration.*
- *Asian Development Bank Institute (ADBI): Collaborative research*
- *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 researchers across the world to produce cutting-edge research products and advance the discipline of traveler behavior and attitudes. The list of researchers that work closely with TOMNET researchers include:

Have other collaborators or contacts been involved?

- *Professor Chandra Bhat, 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 Konstadinos 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*
- *Dr. Shin-Hyung Cho, Visiting scholar, Seoul National University, S. Korea*

- Bert van Wee, TU Delft, the Netherlands
- Baiba Pudane, TU Delft, the Netherlands
- Calvin Thigpen, e-scooter Lime
- 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

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. Javadinasr, M., Magassy, T.B., Rahimi, E., Davatgari, A., Salon, D., Bhagat-Conway, M.W., Chauhan, R.S., Pendyala, R.M., Derrible, S. and Khoeini, S. (2021). The enduring effects of COVID-19 on travel behavior in the United States: A panel study on observed and expected changes in telecommuting, mode choice, online shopping and air travel. arXiv preprint arXiv:2109.07988.
2. Stopher, P., Magassy, T.B., Pendyala, R.M., McAslan, D., Arevalo, F.N. and Miller, T. (2021). An Evaluation of the Valley Metro–Waymo Automated Vehicle RideChoice Mobility on Demand Demonstration, Final Report (No. FTA Report No. 0198). United States. Department of Transportation. Federal Transit Administration.
3. Mahmoudi, M., Tong, L., Garikapati, V.M., Pendyala, R.M., Zhou, X. (2021). How many trip requests could we support? An activity-travel based vehicle scheduling approach. *Transportation Research, Part C: Emerging Technologies*, 128. <https://doi.org/10.1016/j.trc.2021.103222>.
4. Parker, N., Breetz, H., Salon, D., Conway, M., Williams, J., and Petersen, M. (2021). Who saves money buying electric vehicles? Heterogeneity in total cost of ownership. *Transportation Research, Part D: Transport and Environment*, 96. <https://doi.org/10.1016/j.trd.2021.102893>.
5. Salon, D., Conway, M.W., da Silva, D.C., Chauhan, R.S., Derrible, S., Mohammadian, A.K., Khoeini, S., Parker, N., Mirtich, L., Shamshiripour, A. and Rahimi, E. (2021). The potential stickiness of pandemic-induced behavior changes in the United States. *Proceedings of the National Academy of Sciences*, 118(27).
6. Mirtich, L., Conway, M.W., Salon, D., Kedron, P., Chauhan, R.S., Derrible, S., Khoeini, S., Mohammadian, A.K., Rahimi, E. and Pendyala, R. (2021). How stable are transport-related attitudes over time?. *Findings*, <https://doi.org/10.32866/001c.24556>.
7. Chauhan, R.S., da Silva, D.C., Salon, D., Shamshiripour, A., Rahimi, E., Sutradhar, U., Khoeini, S., Mohammadian, A.K., Derrible, S. and Pendyala, R. (2021). COVID-19 related attitudes and risk perceptions across urban, rural, and suburban areas in the United States. *Findings*, <https://doi.org/10.32866/001c.23714>.
8. Baker, D.C., Khoeini, S., Salon, D., Conway, M.W., Chauhan, R.S., Pendyala, R.M., Shamshiripour, A., Rahimi, E., Magassy, T., Mohammadian, A., and Derrible, S. (2021). How do attitudes toward COVID-19 affect travel behavior during the pandemic? *Transport Findings*, <https://doi.org/10.32866/001c.24389>.

Presentations Within Reporting Period

1. Salon, D. (2021). Investigating attitudinal and behavior changes in US household during and after the COVID-19 pandemic. Presented at the COVID Information Commons Webinar, Online
2. Salon, D. (2021). “How will the COVID-19 pandemic affect the future of transport? Presented at the AECOM Webinar, Online.
3. Salon, D. (2021, April). How will the COVID-19 pandemic affect the future of transport? Presented at the Mobility 21, National Mobility Summit, Online.
4. Batur, I., Khoeini, S., & Pendyala, R.M. (2021, July). Ridehailing services: Mode changing patterns and sustainability implications. Presented at the Environment Health Matter Initiative.
5. Khoeini, S. & Pendyala, R.M. (2021, July). Diversity, equity, and inclusion (DEI) implications of transport automation: TOMNET

- transformative technologies in transportation (T4) survey. Presented at the Automated Road Transportation Symposium.
6. Khomeini, S. & Pendyala, R.M. (2021, July). Autonomous vehicles: Familiarity, concerns, and perceptions, results from TOMNET transformative technologies in transportation (T4) survey. Presented at the Automated Road Transportation Symposium.
 7. D. Baker, Khomeini, S. & Pendyala, R.M. (2021, July). Stated and actual sharing preferences for ridehailing services and autonomous vehicles: Insights from TOMNET T4 survey. Presented at the Automated Road Transportation Symposium.
 8. Magassy, T., Khomeini, S. & Pendyala, R.M. (2021, July). AV perceptions among older people: Exploring results from TOMNET T4 survey. Presented at the Automated Road Transportation Symposium.
 9. Khomeini, S. (2021, May). Expected change in US air travel after the COVID-19 pandemic: An integrated choice and latent variable (ICLV) model framework. Presented at the International Choice Modeling Conference.
 10. Magassy, T., Batur, I., Khomeini, S. & Pendyala, R.M. (2021, June). Use of ride-hailing services by the elderly: An attitudinal analysis. Presented at the ASCE Transportation and Development Conference.

University of Washington

Papers Published Within Reporting Period

1. Guan, X. & Chen, C. (2021). A behaviorally-integrated individual-level state-transition model that can predict rapid changes in evacuation demand days earlier. *Transportation Research, Part E*, 152, 102381.
<https://doi.org/10.1016/j.tre.2021.102381>

Georgia Tech

Papers Published Within Reporting Period

1. Shaw, F.A., Wang, X., Mokhtarian, P.L., & Watkins, K.E. (2021). Supplementing transportation data sources with targeted marketing data: Applications, integration, and internal validation. *Transportation Research Part A*, 149, 150-169.
2. Wang, X., Shaw, F.A., & Mokhtarian, P.L. (2021). Latent vehicle type propensity segments: Considering the influence of household vehicle fleet structure. *Travel Behaviour and Society*, 26, 41-56.
3. Kim, S.H. & Mokhtarian, P.L. (2021). Who (never) makes long-distance leisure trips? Disentangling structurally zero trips from usual trip generation processes. *Travel Behaviour and Society*, 25, 78-91.
4. Malik, J., Bunch, D., Handy, S.L., & Circella, G. (2021). Understanding the role of the built environment in the use of ridehailing for non-work travel after accounting for residential self-selection. *Journal of Transport Geography*, 91, 102952.
5. Malik, J., Alemi, F., & Circella, G. (2021). Who wants to share? Exploring the factors that affect the frequency of use of ridehailing and the adoption of shared ridehailing in California. *Transportation Research Record, Journal of the Transportation Research Board*, 0361198120985151.

Presentations Within Reporting Period

1. Mokhtarian, P. (2021, April 8). How, and for whom, will activity patterns be modified by self-driving cars? Expectations from the state of Georgia. Presented at #SMARTer Together Webinar, Institute for People and Technology (IPAT), Georgia Tech.
2. Mokhtarian, P & Wang, X. (2021, May). Respondent profiles of willingness to respond in consecutive travel surveys: An investigation based on the U.S. national household travel survey. Presented at the STEPS program Webinar, University of California, Davis.
3. Circella, G. (2021, April 29). Investigating the temporary vs. longer-term impacts of the COVID-19 pandemic on mobility. Presented at the Executive Board Meeting of the California Department of Transportation (Caltrans).
4. Circella, G. (2021, May 12). Investigating the temporary vs. longer-term impacts of the COVID-19 pandemic on mobility. Presented at the Online Pre-Summit Research Day, International Transport Forum.
5. Circella, G. (2021, May 27). Investigating the temporary vs. longer-term impacts of the COVID-19 pandemic on mobility. Just sustainabilities in a post-pandemic world. Presented at an online conference, University of Washington.
6. Circella, G. (2021, June 3). Investigating the impacts of the COVID-19 pandemic on mobility in the greater Los Angeles region. Presented at the Southern California Association of Governments (SCAG) Transportation Policy Committee Meeting.
7. Circella, G. (2021, September 2). Analysis of heterogeneity in travel behavior changes during the COVID-19 pandemic in the greater Los Angeles region. Presented at the Research Seminar, ETH Zurich - Swiss Federal Institute of Technology, Switzerland.
8. Circella, G. (2021, September 22). Investigating the temporary vs. longer-term impacts of the COVID-19 pandemic on mobility. Presented at the Online Smart City Research Symposium, University of Stavanger (Norway).

University of South Florida

Papers Published Within Reporting Period

1. Li, Q., Li, X., & Mannering, F. (2021). An assessment of discretionary lane changing decisions using a random parameters approach with heterogeneity in means and variances. *Transportation Research Record*, 2675(6), 330-338.
2. Barbour, N., Menon, N., & Mannering, F. (2021). A statistical assessment of work-from-home participation during different stages of the COVID-19 pandemic. *Transportation Research Interdisciplinary Perspectives* 11, 100441.

3. Palaio, L., Vo, T., Maness, M., Bertini, R., & Menon, N. (2021). A multi-city investigation of the effect of special calendar days on bike-share system ridership. *Transportation Research Record*, 2675(7), 404-423.

In summary, TOMNET core faculty generated 17 publications within the reporting period covered by this SAPR. These publications are directly attributable to funding provided by the TOMNET UTC. During the reporting period of this SAPR, the TOMNET researchers delivered 18 presentations at various venues.

Website(s) or other Internet site(s)

One major product of the center is the [TOMNET website](#) that has been updated during the reporting period. A separate webpage has been dedicated to the [TOMNET T4 Survey](#) to organize all of the project documentation and outputs in one place. All of the presentations and final project reports are available on this webpage. Additionally, the link to the TOMNET COVID-19 survey and the released data (wave 1) is embedded on the first page of the TOMNET website, enabling visitors to download the first wave of the COVID Future National Survey data (No. 25 in Table 1). The research page of the TOMNET website has also been updated to reflect project scopes and reports, with additional updates scheduled to be made in the next reporting period.

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 beta 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. Updated versions of these tools are being developed in open-source format and will be posted on the TOMNET website. Moreover, R and Python codes associated with other TOMNET transportation model estimation and implementation efforts as well as data fusion procedures are being documented in various publications. The software codes 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.

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. All data sets assembled by TOMNET will be made available (without personally identifiable information) via the TOMNET website for the broader community. In the meantime, findings from the surveys will be disseminated to the community through a series of webinars and research papers. So far, the COVID Future wave 1 dataset has been made available to the public via this [link](#) on the ASU data repository called Dataverse.

It should be noted that the majority of TOMNET core team publications include applicable model specifications that can be used by practitioners easily to better model the recent transformations in traveler behavior and values due to new transport technologies as well as the pandemic. These model specifications showcase robust and statistically viable solutions to integrate attitudes in travel behavior analysis. A 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 to individuals’ transportation decisions. The insights gained in this project (#1 by GT team) are improving the ability of

regional travel demand forecasting models to incorporate attitudes, thereby improving their predictions of behavioral trends and responses to policy. Due to the significance of this research and the broad spectrum of Targeted Marketing Data available to provide useful variables related to personal attitudes and lifestyle choices, this study is counted as a research product/material as it highlights the opportunities and challenges of using Targeted Marketing Data in travel demand forecasting in practice.

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	16	17	33	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, help provide critical information that agencies need to minimize the potential negative impacts and maximize the potential positive impacts of new transportation technologies. Four studies out of the T4 survey were presented at the Automated Road Transportation Symposium during Summer 2021. This symposium brings together high-caliber decision-makers of the automated transportation industry from around the world to share their perspectives and progress. Presenting the results of the T4 survey at this venue counts as a significant outcome of TOMNET research. As a result of this series of presentations, European [WISE-ACT](#) researchers approached Sara Khoeni (T4 Survey Project Lead) for further collaboration to study the behavioral implications of AV adoption in the future.

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 using social and transportation networks to accomplish essential activities, both on an everyday basis and during times of disruptions wrought by disasters.

Finally, 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 the pandemic and new normal. The COVID-19 wave 1 dataset has been released to the public and it is envisioned that the data will help in planning a strong recovery as well as retaining positive behaviors (e.g., more walking and bicycling) that occurred during the pandemic. The data paper which accompanies the released data has been published in [Nature Scientific Data](#). It is worth highlighting that the summary of the collected data during Wave 1 has been published in [PNAS Policy Report](#) on July 6, 2021, by a team led by TOMNET Associate Director Deborah Salon.

Improved techniques in addressing transportation issues

Previous SAPRs discussed the significance of TOMNET research to understand the role of attitudes in the adoption of new transport technologies, response to disasters and pandemics, and safety research. Other ongoing TOMNET research efforts shed light on best practices for travel survey data collection and

analysis. The project titled “The Effect of Survey Methodology on the Collection of Attitudinal Data” suggests that the weighting of survey data based on socioeconomic attributes cannot completely remove the potential bias of the respondent sample when it comes to analyzing attitudes and lifestyle preferences. This project illustrates the importance of studying attitudes through multivariate econometric and statistical model estimation. Similarly, the project titled “Response Willingness in Consecutive Travel Surveys” is highlighting the advantages and disadvantages of recruiting survey respondents from among those responding to previous surveys. TOMNET research shows that it can be very cost-effective to do so, which is welcome news for budget-limited planning agencies and researchers. However, new respondents should also be recruited, with an eye to counteracting the demographic biases that tend to be amplified at successive stages of the repeated recruitment. The results of this study can be used to estimate specifically the magnitude of the biases, and accordingly determine how best to counteract them. Considering the TOMNET study to evaluate the usefulness of targeted marketing data in attitudinal travel behavior research as well, these research outcomes have collectively enhanced knowledge regarding data collection and utilization, and advance the profession’s ability to make maximum use of available data in accurately modeling behavioral processes.

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. During this reporting period, MS degrees were awarded to Xinyi Wang & Grace Chen (Georgia Tech); PhDs were awarded to Ali Etezady, Atiyya Shaw, and Sung Hoo Kim (Georgia Tech). Grace Chen and Ali Etezady are working for prominent transportation consulting firms, Atiyya Shaw is a postdoctoral scholar at UC Berkeley, and Sung Hoo Kim will be taking a faculty position in S. Korea next year. Matt Conway (from ASU) got his PhD and joined the University of North Carolina at Chapel Hill as an Assistant Professor in fall 2021. Katie Idziorek (from UW) got her PhD and joined the University of North Carolina at Charlotte as an Assistant Professor in fall 2021. Nikhil Menon who was a Postdoc scholar at USF also joined Pennsylvania State University in fall 2021 as an Assistant Professor. 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 Outcomes

Metric	Annual Target	Previous Reporting Period	This Reporting Period	Annual Total	Assessment/notes
Number of unique individuals that downloaded/used TOMNET data/codes	100	150	150	300	The main published data source in this reporting period is COVIDFuture Survey (wave 1) and T4 Survey Results
Number of students/scholars participating in TOMNET research	50	42	Additional 3	45	Some students are the same across the periods; so, the total number reflects the unique cases.

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 that is characterized by data-driven informed decision-making about transportation investments and improvements that will advance mobility for all. The overall impacts of multiple surveys funded by TOMNET, in understanding the interactions between travelers and new disruptive technologies including mobility-on-demand services, automation, electrification, health and wellbeing, pricing and taxation, safety, COVID-19 pandemic, leisure activities, and community resilience is very significant and difficult to be quantified. So far, wave 1 of COVID Future dataset which is partially funded by TOMNET has been released to the public and more than 300 unique individuals have downloaded the data. The other TOMNET surveys will also be released to the public after initial assessment and data analysis have been completed. It is envisioned that the findings, analytical models, and raw datasets can significantly reveal people's behaviors, perceptions, and choices and therefore substantially enlighten the future of 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 difficult to determine the exact number because some agencies use published findings and data sources without notifying TOMNET team. However, this table presents the number of agencies that have adopted TOMNET data sources and/or modeling tools, to the best of the team's knowledge and awareness.

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 drive 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. A number of agencies have adopted the latest version of the synthetic population generator called PopGen, which is currently supported and enhanced continuously through the support of TOMNET funding. The Travel Forecasting Resource (tfresource.org) was enabled through funding provided by TOMNET; this resource is used by practitioners, students, scholars, and researchers worldwide (including thousands of individuals in the United States) to learn about best practices in transportation demand forecasting, planning, and network modeling. 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) using PopGen. Lastly, COVIDFuture survey data and findings are very informative in shaping the vision for a new normal, and how the profession can maximize the positive aspects and minimize the negative impacts of the pandemic.

UW: The data gathered from our surveys 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/flooding). In addition to the earthquake and tsunami scenarios upon which we focused in earlier phases of the study, we have now added understanding transportation and social network behavior changes during a pandemic.

What is the impact on the body of scientific knowledge?

Table 7 illustrates the number of citations for research papers that were produced during 2018, 2019, 2020, and 2021 thus far by the core TOMNET team. During these four complete years, the TOMNET core research was sponsored by TOMNET and so the citations are credited to TOMNET that provided the financial resources for these studies and products. The two distinguished TOMNET faculty that have a

huge contribution to these highly cited works are Fred Mannering and Patricia Mokhtarian. During the reporting period, **Professor Fred Mannering** received the **2021 HNTB-CUTC lifetime achievement award in transportation research and education**. This award has been presented since 2015 to honor individuals who have had a long history of significant and outstanding contributions to university transportation education and research resulting in a lasting contribution to transportation. **Professor Patricia Mokhtarian** has been named the **2021 recipient of the Lifetime Achievement Award from the International Association for Travel Behaviour Research** for her significant contributions to the field. Mokhtarian is the first woman to receive this prestigious honor, which has only been awarded to nine others since its creation in 2003.

What is the impact on transportation workforce development?

To date, various TOMNET project activities have engaged undergraduate, graduate, and PhD students in research about transportation in various domains including emerging transportation technologies, impacts of the pandemic, resilience issues in rural and remote areas, survey data collection, advanced statistical modeling, and data fusion. In most of these studies, researchers studied the role of attitudes in shaping travel behavior and choices. In the outreach activities to date, TOMNET provided opportunities for professionals and academics to learn about findings of the research undertaken by the center through various webinars, conference presentations, reports, and publications.

Table 7. TOMNET Metrics on Impacts

Metric	2018	2019	2020	2021	Total
Number of agencies adopting TOMNET data/tools	2	1	1	1	5
Citations of TOMNET Publications	970	587	3,867	6,863 (+)	12,287

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.