




UTC Semi-Annual Progress Report (SAPR#13)



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Center Director:	Ram M. Pendyala, Professor, Arizona State University ram.pendyala@asu.edu , 480-965-5649
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Submitting Official:	Ram M. Pendyala, Director of TOMNET UTC Professor, Arizona State University 480-965-3589; ram.pendyala@asu.edu
Recipient Organization:	Arizona State University Office of Research and Sponsored Projects Administration PO Box 876011, Tempe, AZ 85287-6011
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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 since. This SAPR, the 13th produced under this grant, covers work accomplished, collaborations with academic, government, and industry partners, and the center outputs, outcomes, and impacts for the period of April 1, 2023, through September 30, 2023.

During this reporting period, it is worth noting that TOMNET has been granted a one-year, no-cost time extension (NCE), extending TOMNET's grant validity through September 30, 2024. The prolonged duration of the COVID-19 pandemic significantly affected the pace of progress on several projects. This has partly stemmed from challenges associated with the administration of surveys, the ability of staff to conduct meetings and execute project tasks and technology transfer activities in person, disruptions in the availability of national-level data sets that supported the Center's research and delays due to slower than expected COVID recovery that affected the ability to gather data necessary to understand post-COVID conditions. Thus, this one-year grant extension provides the necessary time for the completion of several research projects and initiatives as well as key technology transfer activities that will facilitate the dissemination of research results for recently completed and in-progress projects.

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 the recent and expected transformative changes in transportation systems. Additionally, the center leverages a number of analysis methods and tools to advance its mission, including the application of data fusion and machine learning algorithms to integrate datasets (e.g., third-party or external/secondary datasets) 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. 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 outreach activities that would attract students from diverse backgrounds to the profession. 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 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 knowledge gained not only helps move advanced data fusion approaches and modeling

methods into practice but also builds a richer understanding of travel behavior which supports the public and private sector stakeholders making policy and investment decisions about transportation.

What was accomplished under these goals?

Within this reporting period, TOMNET researchers launched, made progress on, and completed several research projects. Projects launched in either previous years or the current year have been completed (48 projects) or are continuing into their subsequent phases (12 projects). The list of all active and completed TOMNET projects is provided in Table 1 with the active period for each project (total of 60 projects). Additionally, all project entries into the RiP and/or TRiD databases have been completed. The TOMNET website [project page](#) is regularly updated to provide information and deliverables for the research projects, categorized by year and lead university. Several reports for projects completed recently are under review and will be posted to TRID and the TOMNET website within the next reporting period.

Table 1. TOMNET Research Projects

Project Topic/Title	Institution (PI)	Active Period	Status
1* The Induced Demand Implications of Alternative Adoption Modalities of Automated Vehicles	ASU (Batur)	2023 - Present	⚙️
2* Understanding the Impacts of Extreme Heat on Human Activity-Mobility and Time Use Patterns	ASU (Batur)	2023 - Present	⚙️
3* Does Ridehailing Use Affect Vehicle Ownership or Vice Versa? An Exploratory Investigation of the Relationship Using a Latent Market Segmentation Approach	ASU (Batur)	2022 - 2023	✓
4* An Analysis of Changes in Time Use and Activity Participation in Response to the COVID-2019 Pandemic in the United States: Implications for Well-being	ASU (Polzin)	2022 - 2023	✓
5* Access to Food in a Severe Prolonged Disruption: The Case of Grocery and Meal Shopping During the COVID-19 Pandemic	ASU (Pendyala)	2022 - 2023	✓
6* A Multidimensional Analysis of Willingness to Share Rides in a Future of Autonomous Vehicles	ASU (Batur)	2022 - 2023	⚙️
7* Evolution of Mode Use Due to COVID-19 Pandemic in the United States: Implications for the Future of Transit	ASU (Pendyala)	2022 - 2023	✓
8* Assessing the Impact of Ridehailing Service Use on Bus Ridership: A Joint Modeling Framework Accounting for Endogeneity and Latent Attitudes	ASU (Pendyala)	2021 - Present	⚙️
9 The Influence of Mode Use on Level of Satisfaction with Daily Travel Routine: A Focus on Automobile Driving in the United States	ASU (Pendyala)	2021 - 2022	✓
10 The Stability of Transport-Related Attitudes over Time: A Case Study During COVID-19	ASU (Salon)	2021 - 2022	✓
11 Expected Change in US Air Travel After the COVID-19 Pandemic	ASU (Khoeini)	2020 - 2022	✓
12 Investigating Attitudinal and Behavioral Changes in U.S. Households Before, During, and After the COVID-19 Pandemic	ASU (Salon)	2020 - 2022	✓
13 Latent Variable Models of Attitudes and Preferences, and Their Prediction of Autonomous Vehicle Adoption Intent	ASU (Grimm)	2020 - Present	⚙️
14 How Will Use of Autonomous Vehicles for Running Errands Affect Future Autonomous Vehicle Adoption and Ownership?	ASU (Batur)	2020 - 2022	✓
15 Interaction of Familiarity, Safety Perceptions, and Willingness to Use Autonomous Vehicles in A Structural Equation Modeling Framework	ASU (Khoeini)	2020 - 2022	✓
16 Investigating the Contributing Factors to Willingness to Share Automated Vehicles with Gender Focus	ASU (Khoeini)	2020 - 2022	✓
17 The Effect of Survey Methodology on The Collection of Attitudinal Data	ASU (Pendyala)	2020 - 2022	✓
18 Real-Time Transportation Social Media Analytics Using Pulse (Pulse-T)	ASU (Kandala)	2019 - 2021	✓
19 Consumer Attitudes and Behavioral Implications in the New Era of Shared Mobility	ASU (Zhang)	2019 - 2021	✓

Project Topic/Title	Institution (PI)	Active Period	Status
20 Emerging Approaches to Autonomous Vehicles in Transportation Policy and Planning	ASU (Miller)	2019 - 2021	✓
21 Teaching the Travel Demand Flow Estimation Models: A New Deep-Learning Approach Using Multi-Source Data	ASU (Zhou)	2019 - 2021	✓
22 Causal Relationships Between Transportation Attitudes and Behaviors: Uncovering Latent Segments within a Heterogeneous Population	ASU (Pendyala)	2019 - 2021	✓
23* The Impact of Non-Transportation Attitudes, Preferences, and Personality Characteristics on Residential Location and Travel Choices	ASU (Salon)	2019 - Present	⚙️
24 Development of an Integrated Model System of Transport and Residential Energy Consumption	ASU (Pendyala)	2019 - 2022	✓
25* Attitudes Towards Emerging Mobility Options and Technologies – Phase 3: Survey Data Compilation and Analysis for Phoenix, AZ	ASU (Khoeini)	2019 - 2021	✓
26 How Important are Attitudes in Travel Behavior Models? A Comprehensive Review	ASU (Salon)	2018 - 2019	✓
27 Heterogeneity in the Relationship Between the Built Environment and Bicycling	ASU (Salon)	2018 - 2019	✓
28 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)	2018 - 2019	✓
29 A Comparison of Vehicle Miles of Travel Between Two Generations: Millennials versus Generation X	ASU (Pendyala)	2018 - 2019	✓
30 Attitudes Towards Emerging Mobility Options and Technologies – Phase 2: Data Collection in Phoenix, AZ	ASU (Khoeini)	2018 - 2019	✓
31 Assembling Integrated Data Sets for Analyzing Connections between Travel Behavior, Attitudes, and the Built Environment	ASU (Salon)	2017 - 2018	✓
32* An Integrated Model of Daily Activity-Travel Behavior and Well-Being	ASU (Pendyala)	2017 - Present	⚙️
33 Attitudes Towards Emerging Mobility Options and Technologies – Phase 1: Survey Design for Phoenix, AZ	ASU (Khoeini)	2017 - 2018	✓
34* Drivers' Attitudes Toward Rerouting: Impacts on Network Congestion	GT (Laval)	2021 - Present	⚙️
35* What is the New Normal? An Analysis of Post-COVID-19 Commute and Work Patterns	GT (Mokhtarian)	2021 - Present	⚙️
36 Mode Substitutional Patterns of Ridehailing and Micro-Mobility Services	GT (Circella)	2020 - 2023	✓
37 Response Willingness in Consecutive Travel Surveys	GT (Mokhtarian)	2020 - 2021	✓
38 Combining Disparate Surveys across Time to Study Satisfaction with Life	GT (Mokhtarian)	2019 - 2020	✓
39* Attitudes Towards Emerging Mobility Options and Technologies – Phase 3: Survey Data Compilation and Analysis for Atlanta, GA	GT (Circella)	2019 - Present	⚙️
40 Latent Vehicle Type Propensity Segments: Considering the Influence of Household Vehicle Fleet Structure	GT (Mokhtarian)	2018 - 2019	✓
41 Attitudes Towards Emerging Mobility Options and Technologies – Phase 2: Data Collection in Atlanta, GA	GT (Circella)	2018 - 2019	✓
42 An Investigation of the Contribution of Targeted Marketing Data to the Prediction of Attitudes	GT (Mokhtarian)	2017 - 2019	✓
43 Attitudes Towards Emerging Mobility Options and Technologies – Phase 1: Survey Design for Atlanta, GA	GT (Circella)	2017 - 2018	✓
44 An Empirical Assessment of the Role of Attitudes and Identification in Safety Research	USF (Mannering)	2020 - 2021	✓
45* Addressing Potentially Missing Relevant Information on Attitudes and Other Behavioral Elements as Unobserved Heterogeneity in Highway Safety Studies	USF (Mannering)	2020 - 2022	✓
46 Exploration of the Relationships between Leisure Activity Participation Frequency and Social Capital	USF (Maness)	2020 - 2022	✓
47 An Exploratory Analysis to Estimate the Value of Free Charging Bundle in Electric Vehicle Purchases	USF (Maness)	2020 - 2021	✓

Project Topic/Title	Institution (PI)	Active Period	Status	
48	An Exploration of Contemporary Issues in Highway Safety, Evolving Transportation Alternatives, and Activity and Travel Behavior Modeling	USF (Maness)	2019 - 2020	✓
49*	Attitudes Towards Emerging Mobility Options and Technologies – Phase 3: Survey Data Compilation and Analysis for Tampa, FL	USF (Maness)	2019 - 2022	✓
50	Emerging Econometric and Data Collection Methods for Capturing Attitudinal and Social Factors in Activity and Travel Behavior Modeling	USF (Mannering)	2018 - 2019	✓
51	Attitudes Towards Emerging Mobility Options and Technologies – Phase 2: Data Collection in Tampa, FL	USF (Maness)	2018 - 2019	✓
52	Investigation of the Role of Attitudinal Factors on Adoption of Emerging Automated Vehicle and Vehicle Safety Technologies	USF (Mannering)	2017 - 2018	✓
53	Attitudes Towards Emerging Mobility Options and Technologies – Phase 1: Survey Design for Tampa, FL	USF (Maness)	2017 - 2018	✓
54*	Incorporating Mobility on Demand into Public Transit in Suburban Areas: A Comparative Evaluation of Cost-Effectiveness	UW (Shen)	2022 - Present	⚙️
55*	Grid-Aware Robust Fast-Charging Station Deployment for Electric Buses Under Socioeconomic Considerations	UW (Zhao)	2022 - Present	⚙️
56	Mobility Analysis Workflow (MAW): An Accessible, Interoperable, and Reproducible Container System for Processing Raw Mobile Data	UW (Chen)	2021 - 2022	✓
57	Attitudes and Trust in Leveraging Integrated Sociotechnical Systems for Enhancing Community Adaptive Capacity – Phase IV	UW (Chen)	2020 - 2021	✓
58	Attitudes and Trust in Leveraging Integrated Sociotechnical Systems for Enhancing Community Adaptive Capacity – Phase III	UW (Chen)	2019 - 2020	✓
59	Attitudes and Trust in Leveraging Integrated Sociotechnical Systems for Enhancing Community Adaptive Capacity – Phase II	UW (Chen)	2018 - 2019	✓
60	Attitudes and Trust in Leveraging Integrated Sociotechnical Systems for Enhancing Community Adaptive Capacity – Phase I	UW (Chen)	2017 - 2018	✓

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

TOMNET center’s topical expertise and center goals were very conducive to allowing the center’s activities to address emerging issues, specifically, the impacts of COVID on travel behavior. This capability has enabled critical projects that add significant insights into emerging travel behaviors and support industry efforts to update planning and modeling methods and tools to respond to post-COVID conditions. Those activities, including numerous presentations and publications, are enumerated in this report.

A Sampling of Progress on Active Research Projects

Further details about the progress made for a sample of active projects or projects completed within this reporting period are provided below.

Project #1: Induced Demand Implications of Alternative Adoption Modalities of Automated Vehicles
PI: Irfan Batur (ASU) **Co-PI:** Ram Pendyala (ASU) – in collaboration with D-STOP, Univ of Texas at Austin

Progress: There is considerable concern about the induced demand implications of the advent of automated vehicles (AVs). In a future with AVs, people may undertake more trips, shift away from alternative modes of transportation, increase their trip lengths, and even consider relocating to more distant residential areas where land is cheaper. This is because both drivers and passengers will be relieved of the driving task, which makes car travel more convenient and less burdensome. This research project recognizes that induced demand resulting from the adoption of AVs is inter-related to the adoption modality. AVs may be purchased and owned personally or used as a mobility-on-demand service (or both). Launched within this reporting period, this project aims to shed light on the relationship between AV adoption modality and the likelihood of making additional trips in an AV future. The relevant literature was reviewed and a joint model of two outcome variables was estimated, wherein AV adoption

modality affects the likelihood of making additional trips. The manuscript resulting from this project has been submitted and accepted for presentation at the 2024 TRB Annual Meeting. In the next reporting period, the team will refine the manuscript based on feedback received from the TRB review and submit it to the journal, *Transportation Research Part C* for potential publication consideration.

Project #2: Understanding the Impacts of Extreme Heat on Human Activity-Mobility and Time Use Patterns | **PI:** Irfan Batur (ASU) **Co-PI:** Ram Pendyala (ASU)

Progress: There is growing interest in understanding the interaction between weather and transportation and the ability of communities and the nation's infrastructure to withstand extreme conditions and events. In recent years, extreme heat conditions are being felt across the globe with increasing frequency. This research project aims to provide detailed insights into how people adjust and change their activity-travel patterns and time use behavior in the face of extreme heat conditions. This project was launched within this reporting period. So far, the project team has conducted an extensive literature review and merged the American Time Use Survey (ATUS) data series with weather data to facilitate a comparison of activity-mobility patterns between extreme heat days and non-extreme days. Additionally, the team has estimated a series of models to understand the impact of extreme heat, even after accounting for other variables. The manuscript resulting from this project has been submitted and accepted for presentation at the 2024 TRB Annual Meeting and has also been submitted to the *Transportation Research Part D* journal for potential publication consideration. In the upcoming reporting period, the team's primary focus will be on refining the manuscript based on feedback received during both the TRB Annual Meeting and the journal's review process. In addition, the team will continue to disseminate the project's findings through various other venues and channels.

Project #3: Does Ridehailing Use Affect Vehicle Ownership or Vice Versa? An Exploratory Investigation of the Relationship Using a Latent Market Segmentation Approach

PI: Irfan Batur (ASU) **Co-PI:** Ram Pendyala (ASU) – in collaboration with D-STOP, Univ of Texas at Austin

Progress: This research project examines the inter-relationship between household vehicle ownership and ridehailing use frequency. While it is generally known that these two behavioral phenomena are inversely related to one another, the direction of causality is rather ambiguous. To explore the degree to which these causal relationships are prevalent in the population, a joint latent segmentation model system is formulated and estimated on a survey dataset collected in four automobile-oriented metro areas of the United States. The findings reveal whether there is considerable structural heterogeneity in the population with respect to causal structures and whether ridehailing use could affect changes in vehicle ownership in the future. In the previous reporting periods, the research team presented the project's findings at the 2023 TRB Annual Meeting and submitted the resulting manuscript for publication consideration to the *Transportation Research Record* journal. During the current reporting period, the team enhanced the manuscript based on feedback received during the TRB Annual Meeting and the journal's review process and successfully [published](#) it.

Project #4: An Analysis of Changes in Time Use and Activity Participation in Response to the COVID-19 Pandemic in the United States: Implications for Well-being

PI: Steve E. Polzin (ASU) **Co-PI:** Irfan Batur (ASU)

Progress: This research project aims to investigate the well-being implications of changes in activity-travel and time use patterns brought about by the COVID-19 pandemic. The study uses American Time Use Survey (ATUS) data from 2019 and 2020 to assess changes in activity-travel and time use patterns. It applies two methods – a wellbeing scoring method and a time poverty analysis method – to evaluate the impacts of these changes on society. The findings reveal how individuals allocated their time across a

limited set of activities available during the pandemic, as well as whether individuals experienced diminished (or improved) well-being as a result of changes in their activity time use patterns during the pandemic. In the previous reporting periods, the research team presented the project's findings at the 2023 TRB Annual Meeting and submitted the resulting manuscript for publication consideration to the *Transportation Research Record* journal. Within this reporting period, the team further improved the manuscript based on feedback received during the TRB Annual Meeting and the journal's review process. The manuscript has now been successfully [published](#).

Project #5: Access to Food in a Severe Prolonged Disruption: The Case of Grocery and Meal Shopping During the COVID-19 Pandemic

PI: Ram Pendyala (ASU) **Co-PI:** Irfan Batur (ASU) – in collaboration with D-STOP, Univ of Texas at Austin

Progress: This project aims to identify vulnerable and less adaptable groups in the context of access to food, using a comprehensive survey dataset collected during the height of the COVID-19 pandemic in 2020. The project provides insights into the groups that may have experienced food access vulnerability when businesses and establishments were restricted, the risk of contagion was high, and accessing online platforms required technology-savviness and the ability to afford delivery charges. The project involves the estimation of a simultaneous equations model that incorporates six endogenous choice variables defined by a combination of two food types (groceries and meals) and three access modalities (in-person, online with in-person pickup, and online with delivery). In the previous reporting periods, the research team presented the project's findings at the 2023 TRB Annual Meeting. The findings of this project were also disseminated through the master's thesis of a student funded by the project. The student successfully defended her thesis and graduated in May 2023.

Project #6: A Multidimensional Analysis of Willingness to Share Rides in a Future of AVs

PI: Irfan Batur (ASU) **Co-PI:** Ram Pendyala (ASU) – in collaboration with D-STOP, Univ of Texas at Austin

Progress: The traveling public has historically shown a disinclination towards sharing rides and carpooling with strangers. In a future of AV-based ridehailing services, it will be necessary for people to embrace both AVs and true ridesharing to fully realize the benefits of automated and shared mobility technologies. This project investigates the factors influencing the willingness to use AV-based ridehailing services in the future in a shared (with strangers) mode. This is done through the estimation of a comprehensive behavioral model system on a survey dataset that includes rich information about attitudes, perceptions, and preferences regarding the adoption of automated vehicles and shared mobility modes. In the previous reporting periods, the research team presented the project's findings at the 2023 TRB Annual Meeting and submitted the resulting manuscript for publication consideration to the *Transportation Research Record* journal. During the current reporting period, the team further improved the manuscript based on feedback received during the TRB Annual Meeting and the journal's review process. The team will finalize the journal article in the next reporting period and continue to engage in technology transfer activities to disseminate the project findings.

Project #7: Evolution of Mode Use Due to COVID-19 Pandemic in the United States: Implications for the Future of Transit

PI: Ram Pendyala (ASU) **Co-PI:** Irfan Batur (ASU) – in collaboration with D-STOP, Univ of Texas at Austin

Progress: The COVID-19 pandemic has brought about transformative changes in human activity-travel patterns, which were naturally accompanied by and associated with changes in transportation mode use and work arrangements. In the U.S., most transit agencies are still grappling with lower ridership levels, thus signifying the onset of a new normal for the future of transit. This project aims to address this challenge by leveraging a novel panel survey dataset to estimate a panel multinomial probit model of mode choice to capture both socio-economic effects and period (pre-, during-, and post-COVID) effects.

This work provides rich insights into the evolution of commute mode use as a result of the pandemic, with a focus on public transit. In the previous reporting periods, the research team presented the project's findings at the 2023 TRB Annual Meeting and submitted the resulting manuscript for publication consideration to the *Transportation Research Record* journal. During the current reporting period, the team further improved the manuscript based on feedback received during the TRB Annual Meeting and the journal's review process. The manuscript has now been successfully [published](#). Additionally, during this reporting period, one of the co-authors was invited by a sister UTC, Tran-Set at Louisiana State University, to deliver a [talk](#) based on the project findings as part of their webinar series.

Project #8: 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 TOMNET's T4 Survey dataset. 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 complement). The findings suggest that transit agencies need to explore pathways towards leveraging ridehailing services to better complement transit usage. The team presented the study findings on several occasions, including at the 2022 TRB annual meeting. Following feedback received during these presentations, the team conducted additional analysis during this reporting period to convert model estimation results into average treatment effects that can be useful for policymaking. The team has also been working on improving the manuscript and plans to submit it to *Travel Behavior and Society* for publication in the next period.

Project #23: The Impact of Non-Transportation Attitudes, Preferences, and Personality Characteristics on Residential Location and Travel Choices | **PI:** Deborah Salon (ASU), **Co-PI:** Hue-Tam Jamme (ASU)

Progress: This project aims to assess how non-transportation housing preferences impact transportation choices, especially car ownership and use. The research is based on an original national survey with over 2,000 respondents collected in Fall 2022. During this reporting period, the team drafted three full manuscripts for publication using the survey data. The topics include interest in car-free living, the correlation between car dependence and life satisfaction, and how parents' travel to school affects their children's current school travel mode. Additional work was also done on analysis for the main project listed here. The research team will give two presentations at the upcoming ACSP (urban planning) conference. This project is expected to continue into 2024, as the final report is currently in production.

Projects #25, #39, #49: 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 continued work on data analysis and behavioral choice modeling, presenting the results at various venues and writing scientific papers. The project [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 has been continuing (projects #1, #3, #6, #8, #9, #14, #15, #16, #17, 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 presentation at the 2024 TRB Annual Meeting and (possible) publication in the Transportation Research Record and in the other journals. The T4 Survey dataset is also being prepared to be made publicly available in the next reporting period(s).

Project #32: An Integrated Model of Daily Activity-Travel Behavior and Subjective Well-Being
PI: Ram Pendyala (ASU) **Co-PI:** Sara Khoeini (ASU), Irfan Batur (ASU)

Progress: This project is an effort to develop models of well-being that explicitly account for time allocation to different in-home, out-of-home, and travel activities. The models are estimated using the 2010, 2012, and 2013 well-being modules of the American Time Use Survey (ATUS). The dataset includes activity-time use information for an entire day together with feelings on six different emotions using a seven-point scale for three random activity-travel episodes pursued in the day. A wellbeing score indicated by these emotion measures is jointly modeled for in-home, out-of-home, and travel activities as a function of a detailed set of activity-travel episode attributes and socio-economic characteristics. The developed models are then used to estimate individual-level wellbeing scores. The final product of this well-being model provides a robust behavioral approach to assess the quality-of-life implications of transportation investments and policies for all segments of society. As stated in previous progress reports, technology transfer activities for this project have been ongoing, with the team working on developing an open-source tool for public use. The team has released the beta version of the tool, named the TOMNET Wellbeing Platform, in the last reporting period, which is available [here](#). In this reporting period, the team improved the platform by adding additional variables and reflecting the latest 2022 ATUS data.

Project #35: What is the New Normal? An Analysis of Post-COVID-19 Commute and Work Patterns
PI: Patricia Mokhtarian (GT) **Co-PI:** Giovanni Circella

Progress: This project is partially funded through UTC match funding provided by the Georgia Department of Transportation (GDOT); however, TOMNET funding is also being used, to augment the sample size and to enable launching the survey in a timely manner despite a 9-month delay in receiving the GDOT funding. The study addresses a number of questions associated with changes in telework adoption and travel patterns on the “back side” of the COVID-19 pandemic (if not yet, at the time of data collection, completely post-COVID), and intentions to continue to work remotely in the future. To that end, the project team designed and fielded an online survey of employed Georgia residents. Data collection closed on June 30, 2022, and netted around 1,900 responses after data cleaning. The sample has been weighted to be representative of the employed Georgia population with respect to 10 variables. The 166-page final report will be completed early in the next reporting period (the GDOT project ends November 1, 2023).

Project #45: Addressing Potentially Missing Relevant Information on Attitudes and Other Behavioral Elements as Unobserved Heterogeneity in Highway Safety Studies | **PI:** Fred Mannering (USF)

Progress: This project explores the relationship between the pedestrian-injury severity and time of day over a five-year period using accident data from Kansas. Separate statistical models were estimated for different times of day and years to examine different pedestrian injury severity outcomes. Likelihood ratio tests were conducted to explore the temporal stability of the model estimations over different times of day and years. The findings indicate that the factors affecting pedestrian injury severities did change over time but that there is a clear day-night difference in the resulting injury severities of pedestrians, with nighttime crashes consistently resulting in more severe injuries over time. In the previous reporting periods, the team finished the project's final report and a paper based on the project findings has been published in the journal *Analytic Methods in Accident Research*. In this reporting period, the team continued on the dissemination of results through publications.

Project #54: Incorporating Mobility on Demand into Public Transit in Suburban Areas: A Comparative Evaluation of Cost-Effectiveness | **PI:** Qing Shen (UW) **Co-PI:** Cynthia Chen (UW)

Progress: This research project aims to develop a framework for comparing the cost-effectiveness of transit services incorporated with mobility-on-demand (TIMOD) to fixed-route bus transit, individual car commuting, and commercial ride-hailing services. The goal is to provide insights into the potential benefits and trade-offs of introducing TIMOD services in suburban areas. During this reporting period, to estimate the cost of TIMOD trips, the research team conducted data collection and analysis within two Metro Flex service areas (representing TIMOD services in the Seattle area) characterized by distinct built environments. The team developed a transportation simulation procedure that estimates travel times and costs for the alternative modes and essentially compared the costs of alternative modes to that of TIMOD. Additionally, the team authored a research paper that has been selected for presentation at the 2024 TRB Annual Meeting. In the next reporting period, the team plans to incorporate equity considerations into the cost-effectiveness analytical framework by assessing the net equity impact of TIMOD and alternative scenarios for various groups. Ultimately, the project's findings will be disseminated through journal paper(s) and integrated into the dissertation of a PhD student funded by this project.

Project #55: Grid-Aware Robust Fast-Charging Station Deployment for Electric Buses Under Socioeconomic Considerations | **PI:** Chaoyue Zhao (UW) **Co-PI:** Cynthia Chen (UW)

Progress: This project investigates three key questions related to planning fast-charging stations for electric buses in the context of transportation and power systems: (1) How can interactions between transportation and power systems be integrated into the planning of fast-charging stations for electric buses? (2) How can the dynamic nature of fleet management be incorporated into the location selection process for fast-charging stations? (3) How can equity and fairness be ensured in the deployment of electric bus fast-charging stations, particularly in low-income communities? To address these, the project team has developed a coupled network that integrates transportation and power networks, accounting for the functional coupling features of the nodes through on-route charging stations. The team also created an optimization model for determining the optimal locations of fast-charging stations for electric buses. Jain's index was utilized in the developed model to ensure equity and fairness, and Seattle was partitioned into regions using Fair Zone data and Census Tracts as a test case. Specifically, in this reporting period, the research team uploaded the node selection rules and algorithms utilized in the design of the transportation network and virtual power grid to Github. The team also documented the project results in a manuscript and submitted it for publication consideration in the journal Applied Energy.

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 the Summer and Fall of 2023. 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 who are *deeply engaged* in advancing the activities and mission of the center.

Table 2. Courses Offered by Core Faculty Members of TOMNET (Winter & Spring 2023)

Semester	Course Level	Course No	Course Title	No	Instructor	Unit
Arizona State University						
Fall 23	Grad	CEE 598	Traffic Simulation Modelling and Applications	6	Zhou	SSEBE
Fall 23	Undergrad	PUP 424	Planning Methods	23	Salon	SGSUP
Fall 23	Undergrad	PUP 642	Urban Economics	14	Salon	SGSUP

Georgia Institute of Technology						
Fall 23	Grad	CEE 6650	Discrete Choice Modeling	10	Mokhtarian	CEE
Fall 23	Grad	CEE 6636	Traffic Flow Theory	4	Laval	CEE
University of South Florida						
Fall 23	Undergrad	TTE4004	Transportation Engineering I	68	Maness	CEE
Fall 23	Grad	TTE6507	Travel Demand Modeling	4	Maness	CEE
Fall 23	Grad	TTE 6307	Statistical and Econometric Methods I	5	Mannering	CEE
Fall 23	Graduate	TTE5205	Traffic Systems Engineering	19	Lin	CUTR
Fall 23	Undergrad	CGN4933	Sustainable Transportation	26	Zhang	CEE
University of Washington						
Fall 23	Graduate	URBDP 593	Doctoral Seminar III	3	Shen	Urban Plng
Fall 23	Grad	INDE 513	Linear Programming	13	Zhao	ISE

Notes: SSEBE = School of Sustainable Engineering and the Built Environment; SGSUP = School of Geographical Sciences and Urban Planning; CEE = Civil and Environmental Engineering; URBDP = Urban Planning.

In addition, TOMNET faculty supervised several students and post-doctoral scholars, providing them guidance and mentorship necessary to pursue independent research and discovery or secure positions in academia or government and industry. Students currently 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 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			
Eleanor Hennessy	Postdoc	SSEBE	Pendyala
Roberto Dimas Valle	PhD Student	SSEBE	Pendyala
Fan Yu	PhD Student	SSEBE	Pendyala
Victor O. Alhassan	PhD Student	SSEBE	Pendyala
Irfan Batur	PhD Student	SSEBE	Pendyala
Tassio B. Magassy	PhD Student	SSEBE	Pendyala
Abbie Dirks	MS Student	SSEBE	Pendyala
Miguel Rodriguez Ocana	MS Student	SSEBE	Pendyala
P. Srikanth Kini	MS Student	Comp Science	Pendyala
Ashwath Bhat Laxminarayana	MS Student	Comp Science	Pendyala
Nicole Corcoran	PhD Student	SGSUP	Salon
Rababe Saadaoui	PhD Student	SGSUP	Salon
GEORGIA INSTITUTE OF TECHNOLOGY			
Jason Soria	Postdoc	CEE	Mokhtarian
Xinyi Wang	PhD Student	CEE	Mokhtarian
Seung-Eun Choi	PhD Student	CEE	Mokhtarian
Ilsu Kim	PhD Student	CEE	Mokhtarian
UNIVERSITY OF SOUTH FLORIDA			
Trang Luong	Graduate Student	CEE	Maness
Divyamita Mishra	Graduate Student	CEE	Maness
Tung Vo	Graduate Student	CEE	Maness
Eren Yuksel	Graduate Student	CEE	Mannering
UNIVERSITY OF WASHINGTON			
Ekin Ugurel	PhD Student	CEE	Chen
Grace Jia	PhD Student	CEE	Chen
Arsalan Esmaeili	PhD Student	CEE	Chen
Zhengyang Li	PhD student	CEE	Chen
Kaitlyn Ng	MS Student	CEE	Chen

Kittibhum Tasanasuwan	MS student	CEE	Chen
Xinyi Zhao	PhD Student	ISE	Zhao
Lamis Ashour	PhD Student	Urban Pln	Shen
Mingming Cai	PhD Student	Urban Pln	Shen
Hoseok Sa	PhD Student	Urban Pln	Shen

In the *technology transfer* domain, Arizona State University continued the [TOMNET webinar series](#) that is presented to a worldwide audience. The webinars are provided in a hybrid or full remote format with recordings available on the TOMNET website. In addition to ASU, GT and USF were also active in organizing transportation webinars. These events are advertised widely and very well attended. Table 4 presents a list of TOMNET-sponsored seminars at ASU, GT, and USF for the period covered by this SAPR.

Table 4. Key TOMNET-Sponsored Technology Transfer Events

Inst.	Title of Seminar/ Webinar	Speaker Name and Affiliation	Date
ASU	Choice Models with Errors in Human Perception of Physical Quantities: Applications in Driver Behavior Modeling	Abdul Pinjari, PhD Indian Institute of Science (IISc), Bengaluru, India	5/11/2023
ASU	Micromobility Policy Insights Drawn from Emerging Data Sources	Chris Cherry, PhD University of Tennessee	4/27/2023
ASU	Improving Mobility in Urban Street Networks via Network-Wide and Decentralized Traffic Signal Control Strategies	Vikash Gayah, PhD Pennsylvania State University	4/13/2023
USF	Complete Streets and Vision Zero Towards Zero Fatal and Serious Injuries	Angelo Rao, P.E. S&ME, Inc.	4/14/2023
USF	The Capacity of Urban Traffic Networks: Multiple Perspectives	Monica Menedez, PhD New York University Abu Dhabi	5/24/2023

Note: ASU = Arizona State University; USF = University of South Florida

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

As we enter the final year of the center, TOMNET has planned several activities for the next reporting period to ensure the center's portfolio of accomplishments is widely recognized and to bring it to a proper closure. 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. Using these diverse and rich datasets, TOMNET researchers will continue to produce tangible research outputs that can significantly benefit policy and decision making in the transportation sector, particularly in the wake of recent natural and technological disruptions. The TOMNET research team will publish findings in journal and conference papers. The working papers from TOMNET's active research projects are being finalized and planned for publication in books and peer-reviewed journals. Dissemination of these research products will further advance TOMNET education and workforce development goals as well as technology transfer mission.

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 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.

TOMNET Scholars at University of Washington plan to collaborate with King County Metro (KCM) to hold an online webinar bringing together the TOMNET research team of Project #54, planners, and decision-makers from KCM and potentially professionals from other transportation planning agencies to discuss their research outcomes, including the methodological approach, data, main findings, and important policy implications. Researchers at Georgia Tech plan to continue giving presentations to

academic and practitioner audiences on the post-pandemic outlook for teleworking, and other topics of current research interest. As mentioned in the previous SAPR, Patricia Mokhtarian is working with a PhD student, Rachael Panik, on an unfunded study of engineering students' attitudes toward work-related safety issues. This is the continuation of research Rachael began with an Aerospace Engineering professor, Joseph Saleh, who passed away unexpectedly during the project. For this reporting period, we are pleased to report that a paper on this work has been accepted for publication in the Journal of Safety Research. Rachael plans to continue work in this area, and Dr. Mokhtarian plans to continue to be involved. During this reporting period, Dr. Mokhtarian has also collaborated with: (1) noted Dutch scholar Prof. Bert van Wee (Technical University of Delft), on a "meta-theory for travel choices" and they plan to submit a paper on this work to Transport Reviews, (2) Prof. Francisco Bahamonde-Birke (Tilburg University, the Netherlands) on a paper introducing a new goodness-of-fit measure for multinomial choice models, which is nearly ready for journal submission, and (3) Prof. Vivien Lim (National University of Singapore), to revise their Transportation submission on the Pre-trip/In-trip/Post-trip (PIP) model of commuting.

At University of South Florida (USF), the research team will continue to perform research and disseminate their work through journal and conference papers. The research team has working papers in preparation and planned for submission to peer-reviewed journals and books in the following topic areas: (1) purchasing intent and familiarity with autonomous vehicle technology, and (2) analysis of driving safety and pandemic attitudes outcomes.

TOMNET will continue to engage in K-12 outreach activities. In a post-COVID era, online platforms have been used to continue K-12 outreach programs. However, Arizona State University conducted an [in-person summer transportation institute](#) during June 4-9, 2023. High school students lived on campus and immersed themselves in a summer transportation experience that saw them enjoy activities and field trips organized by Arizona Department of Transportation, Valley Metro, and City of Phoenix.

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 the Atlanta Regional Commission, the Maricopa Association of Governments, the Georgia Department of Transportation, and the King County Metro Transit Department.

What organizations have been involved as partners?

- *Asian Development Bank Institute (ADB): Collaborative research*
- *Atlanta Regional Commission: Collaborative research and personnel exchange*
- *City of Westport, Westport, WA: Collaborative research, supplied facilities*
- *Culdesac Tempe, Tempe, AZ, Collaborative research*
- *D-STOP University Transportation Center, University of Texas at Austin*
- *Georgia Department of Transportation: In-kind support, datasets, collaborative research, funding of matching-project research*
- *Grays Harbor County Emergency Management*
- *King County Metro, Seattle, WA: In-kind support, datasets, collaborative research*
- *Laurelhurst Earthquake Action Preparedness, Seattle, WA: Collaborative research*
- *Maricopa Association of Governments, Phoenix, Arizona: In-kind support, datasets, collaborative research*
- *Mobility Innovation Center, Seattle, Washington: Collaborative research and funding of matching-project research*
- *Northwest Healthcare Response Network*
- *Northwestern University: Collaborative research*
- *Oak Ridge National Laboratory – National Transportation Research Center: Collaborative research*
- *Ocosta Public School District*
- *Office of Emergency Management, City of Seattle: Collaborative research*
- *Office of Planning and Community Development, City of Seattle: Collaborative research*
- *Shoalwater Bay Tribe*

- South Beach Regional Fire Authority
- South Park Information and Resource Center
- The AAA Foundation for Traffic Safety
- Universidad de Chile and Universidad de Concepcion (Chile), University of Leeds (UK) and German Aerospace Institute – DLR (Germany): Collaborative research
- University of Washington School of Public Health
- Washington Emergency Management Division
- Washington State Department of Transportation: Collaborative research and funding of matching-project research
- Washington State Parks
- Westport Police Department
- Westport Tsunami Safety Committee, Westport, WA: Collaborative research
- World Conference for Transport Research Society (WCTRS): Writing of a chapter, larger international collaboration

Have other collaborators or contacts been involved?

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, values, and attitudes. The list of researchers that work closely with TOMNET researchers includes:

- Dr. Chandra Bhat, PhD, University of Texas at Austin, TX
- Dr. Abolfazl Mohammadian, University of Illinois-Chicago, IL
- Dr. Sybil Derrible University of Illinois-Chicago, IL
- Dr. Laurie Garrow, Georgia Tech, Atlanta, GA
- Dr. Brian German, Georgia Tech, Atlanta, GA
- Dr. Joseph Saleh, Georgia Tech, Atlanta, GA
- Dr. Patrick Singleton, Utah State University, Logan, UT
- Dr. Lauren Steimle, Georgia Tech, Atlanta, GA
- Dr. Dima Nazzal, Georgia Tech, Atlanta, GA
- Dr. Timor Besedes, Georgia Tech, Atlanta, GA
- Dr. Rolf Moeckel, Technical University of Munich, Germany
- Dr. Alejandro Tirachini, University of Chile, Chile
- Dr. Konstadinos Antoniou, TU Munich, Germany
- Dr. Barbara Lenz, German Aerospace Institute
- Dr. Dick Ettema, Utrecht University, Utrecht, Netherlands
- Dr. Clark Miller, Arizona State University, Tempe, AZ
- Dr. Vivien K. G. Lim, the National University of Singapore
- Dr. Bert van Wee, TU Delft, the Netherlands
- Dr. Francisco Bahamonde-Birke, Tilburg Uni., Netherlands
- Dr. Veronique Van Acker, Luxembourg Institute of Socio-Economic Research (LISER)
- Dr. Sangho Choo, Hongik University, South Korea
- Dr. Yongsung Lee, University of California at Davis
- Dr. Seung-Nam Kim, Chung Ang University
- Dr. Calvin Thigpen, Lime
- Dr. Hue-Tam Jamme, Arizona State University, Tempe, AZ
- Dr. Matthew Bhagat-Conway, UNC Chapel Hill
- Dr. Natalia Barbour, TU Delft, the Netherlands
- Jia Tang, PhD student from Nanjing University
- Casey Gifford, King County Metro, WA
- Brian Van Abbema, King County Metro, WA
- Nicole Aguirre, King County Metro, WA
- Ryan Miller, King County Metro, WA
- Bart Treece, Uni. of Wash. Mobility Innovation Center, WA
- Anthony Buckley, Washington State DOT, WA
- Tim Lehman, Indigenous Planning Strategist, City of Seattle
- Executive Board of the Intl Assoc of Trav Beh Research

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. Batur, I., Dirks, A.C., Mondal, A., Bhat, C.R. and Pendyala, R.M., 2023. Does Ridehailing Use Affect Vehicle Ownership or Vice Versa? An Exploratory Investigation of the Relationship Using a Latent Market Segmentation Approach. Transportation Research Record, p.03611981231179470.
2. Batur, I., Dirks, A.C., Bhat, C.R., Polzin, S.E., Chen, C. and Pendyala, R.M., 2023. Analysis of changes in time use and activity participation in response to the COVID-19 pandemic in the United States: Implications for well-being. Transportation Research Record, p.03611981231165020.
3. Magassy, T. B., Batur, I., Mondal, A., Asmussen, K. E., Bhat, C. R., Salon, D., Bhagat-Conway, M., Javadinasr, M., Chauhan, R., Mohammadian, A. (Kouros), Derrible, S., & Pendyala, R. M., 2023. Evolution of Mode Use During the COVID-19 Pandemic in the United States: Implications for the Future of Transit. Transportation Research Record, <https://doi.org/10.1177/03611981231166942>

4. Mohammadi, M., Rahimi, E., Davatgari, A., Javadinasr, M., Mohammadian, A., Bhagat-Conway, M.W., Salon, D., Derrible, S., Pendyala, R.M. and Khoeini, S., 2023. Examining the persistence of telecommuting after the COVID-19 pandemic. *Transportation Letters*, 15(6), pp.608-621.
5. Asmussen, K.E., Mondal, A., Bhat, C.R. and Pendyala, R.M., 2023. On modeling future workplace location decisions: An analysis of Texas employees. *Transportation Research Part A: Policy and Practice*, 172, p.103671.
6. Looking forward: The long-term implications of COVID-19 for transportation. Pengyu Zhu, Deborah Salon, Abolfazl Mohammadian, Yuqing Guo. *Transportation Research Part D: Transport and Environment*. <https://doi.org/10.1016/j.trd.2023.103910>

Presentations Within Reporting Period

1. Deborah Salon: The Effects of the COVID-19 Pandemic on Telecommuting in the United States. Cornell University, April 2023.
2. Irfan Batur, "Impact of Covid-19 on Travel Behavior". Tran-Set Webinar Series, Louisiana State University. August 3, 2023.
3. Steven Polzin, "Change and Uncertainty in Transportation," Keynote Speech, American Automotive Leasing Association, Annual Meeting, September 18, 2023.

Policy Briefs Within Reporting Period

1. Polzin, S. Leveraging the Choice Not to Travel . Planetizen, August, 2023.

Georgia Institute of Technology

Papers Published Within Reporting Period

1. Panik, R.T., Nazemi, H., Saleh, J.H., Fitzpatrick, B., and Mokhtarian, P.L. (in press) Precursory Elements of Safety Culture: Exploratory Analyses of Engineering Students' Safety Attitudes. *Journal of Safety Research*.
2. Wang, X., Kim, S.H. and Mokhtarian, P.L. (2023) Teleworking Behavior Pre-, During, and Expected Post-COVID: Identification and Empirical Description of Trajectory Types. *Travel Behaviour and Society* 33, 100628.

Edited Book Published Within Reporting Period

1. Van Acker, V., Choo, S., and Mokhtarian, P.L. (eds.) *Advances in Transport Policy and Planning*, Vol. 11. Part 1: Long-term Impacts of COVID-19 on Mobility and Travel Behavior. Cambridge, Mass.: Academic Press, 2023.

Presentations Within Reporting Period

1. Mokhtarian, P. Does Teleworking Increase or Decrease Travel? Using Selection Models to Obtain (Counterfactual) Longitudinal Results from Cross-Sectional Data. "Headliner" address to the (worldwide, online) Bridging Transportation Researchers conference, August 10, 2023.

University of South Florida

Papers Published Within Reporting Period

1. Islam, M. and Mannering, F., 2023. An empirical analysis of how asleep/fatigued driving injury severities have changed over time. *Journal of Transportation Safety and Security*, 15(4), 397-420.
2. Alnawmasi, N. and Mannering, F., 2023. An analysis of day and night bicyclist injury severities in vehicle/bicycle crashes: A comparison of unconstrained and partially constrained temporal modeling approaches. *Analytic Methods in Accident Research* 40, 100301.
3. Barbour, N. and Mannering, F., 2023. Intended cycling frequency and the role of happiness and environmental friendliness after COVID-19. *Scientific Reports* 13, 636.
4. Luong, T. and Maness, M., 2023. Leisure activity variety before and during the COVID-19 Pandemic: Focus on temporal Stability, gender Differences, and social capital. *Transportation Research Interdisciplinary Perspectives*, 22, p.100913.
5. Luong, T., Barbour, N. and Maness, M., 2023. Analyzing the Relationships Between Frequency of Leisure Activity Participation and Social Capital. *Transportation Research Record*, p.03611981231171154.

University of Washington

Papers Published Within Reporting Period

1. Lin, J., Chen, C. and Ohay, A. (2022) Socioeconomic and spatial disparity of bus ridership impacts in King County, WA, during COVID-19. *Transportation Research Record*, Sept. 1, <https://doi.org/10.1177/03611981221116366>
2. Cai, M., Acolin, A., Moudon, V.A., and Shen, Q. (2023). Developing a multi-criteria prioritization tool to catalyze TOD on publicly owned land areas. *Cities*. <https://doi.org/10.1016/j.cities.2023.104606>.
3. Wang, Y, & Shen, Q. (2023). An economic analysis of incorporating new shared mobility into public transportation provision, *Transport Policy*. ISSN 0967-070X, <https://doi.org/10.1016/j.tranpol.2023.07.025>

Presentations Within Reporting Period

1. Shen, Q., M. Cai, and Others. 2023. Catalyzing TOD by Leveraging Publicly Owned Land: A Multi-criteria Planning Tool for Identifying Promising Locations. Presentation given at the World Conference on Transport Research Society (WCTR 2023), Montreal, Canada, July 19.
2. Shen, Q. 2023. Understanding Activity-Travel Behavior in the "New Normal". IACP Annual Conference Keynote Speech, Tianjin, July 2.

In summary, TOMNET core faculty generated 16 journal articles and 1 book chapter within the reporting period covered by this SAPR. These publications are attributable to funding provided by the TOMNET UTC. During this reporting period, the **core** TOMNET researchers delivered 6 presentations at various venues.

Website(s) or other Internet site(s)

One of the center's significant products is the TOMNET [website](#), which includes dedicated pages for showcasing descriptions and updates on TOMNET research [projects](#) and reports, as well as the [datasets, surveys, software, and tools](#) developed and produced by TOMNET researchers. It also functions as a platform for sharing policy [briefs](#) and disseminating TOMNET [events](#) and [news](#) to a global online audience. Similar to previous reporting periods, the TOMNET website has been consistently maintained to reflect developments in TOMNET’s research, education, workforce development, and outreach activities.

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](#) and the beta version of the [TOMNET Wellbeing Platform](#) have been created and made available for public use. These tools have been explained in previous reports in detail (interested readers can also refer to the hyperlinked websites for further information). Updated versions of these tools developed in open-source format are being 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, including the TOMNET GitHub [page](#). The TOMNET team at the University of Washington has also developed Mobility Analysis Workflows Tutorials, which can be found at this [link](#). Furthermore, they have been actively working on developing a toolkit designed to assist transit agencies in evaluating the distributional cost-effectiveness of TIMOD services within their respective communities.

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 datasets are based on native survey data collection efforts undertaken by the TOMNET team. Other datasets have been assembled by integrating and fusing data that is already available in the public domain. All datasets assembled by TOMNET are being 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.

Table 5. TOMNET Metrics on Products

Metric	Annual Target	Previous Period	This Period	Annual Total	Assessment
Number of software/data/models	2	3	1	4	Datasets are being cleaned, weighted, and documented. The codes are in beta versions.
Number of journal publications	15	18	16	34	Greatly exceeded the annual target.

As mentioned in the previous SAPR, the COVID Future Survey Waves 1-3 data 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 to better model the recent changes 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.

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. Three new studies based on the T4 survey were presented at various venues during the past six months. Additionally, a new project (#1) was launched within this reporting period, focusing on the induced demand implications of automated vehicles based on data from the T4 survey.

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.

TOMNET researchers are also 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-induced new normal. The COVID-19 wave 1-3 datasets have 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](#), by a team led by TOMNET Associate Director Deborah Salon. During the reporting period covered by this report, the team has published a series of additional papers, based on these datasets, documenting *changes* in traveler behavior and values that occurred over the course of the pandemic, and the likely changes that may stick into a new normal.

During this reporting period, TOMNET researchers at ASU also launched an important project to examine the impacts of extreme heat on human activity and mobility patterns. This study is among the first, if not the very first, to focus on this specific research question. By merging weather data with time use data spanning 14 years across 11 major US metro areas (including Seattle, Phoenix, and Atlanta, where three TOMNET Universities are located), the project seeks to shed light on the adaptability and resilience of communities in the face of increasing extreme heat events. This research is pivotal for transportation and urban planning as it will reveal how extreme heat impacts human mobility and daily activities, identify socio-economic groups most vulnerable to extreme heat, and guide decision-making in developing adaptable urban spaces. The findings will also facilitate targeted policy interventions to ensure equitable access to transportation and safe urban environments during extreme weather conditions.

Finally, the TOMNET team at ASU has updated its interactive activity-based well-being assessment tool, the [TOMNET Wellbeing Platform](#), to incorporate the most recent 2022 ATUS data. This tool consists of three activity and time use-based well-being metrics that are designed to analyze how well-being varies over time and space for different population groups. The platform provides policymakers and the public with much-needed measures of well-being, which are critical to uncovering and addressing social disparities and thus effectively allocating resources to promote equitable and sustainable living.

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 who responded 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 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. Together with the TOMNET study to evaluate the usefulness of targeted marketing data in attitudinal travel behavior research, these research outcomes have collectively enhanced knowledge regarding data collection and utilization and advance the profession’s ability to maximize 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 names, affiliations, degrees, and headshots of over 100 students and scholars who have been deeply engaged in TOMNET research during their education. During this reporting period, three TOMNET students at ASU completed their studies and transitioned into their respective jobs after graduation. Abbie Dirks, an MS student, is now a transportation planner at CDM Smith. Tassio Magassy, who earned his PhD, has joined Argonne National Laboratory as a post-doctoral research associate. Irfan Batur, who has served as TOMNET’s Research Communications and Technology Transfer Coordinator for the past two years while also pursuing his PhD at ASU, has taken up a position as an Assistant Research Professor at ASU. In other notable news, TOMNET graduate student Xinyi Wang, who earned her PhD in July 2023 under the supervision of Dr. Mokhtarian at Georgia Tech, is currently a postdoctoral scholar at the Massachusetts Institute of Technology. TOMNET has been tracking progress in achieving outcomes relative to targets established in the Technology Transfer Plan. Table 6 shows a summary of progress.

A highlight of this review period at ASU is that three graduate students, who were heavily involved in TOMNET activities, have graduated. Dr. Tassio Magassy, Abbie Dirks, and Dr. Irfan Batur (from left to right) have since moved on to their respective jobs.



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	~100	250	The main published data source in this reporting period is COVID Future Survey (wave 1-3) and T4 Survey Results
Number of students/scholars participating in TOMNET research	30	30	+7	37	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 the ability to formulate policies and strategies that foster a more effective and **equitable** transportation system. TOMNET’s work is accelerating a data-driven informed decision-making approach to transportation investments and improvements that will advance mobility for all. The overall impacts of multiple surveys funded by TOMNET, in understanding how travelers are affected by and respond to new technologies and disruptive forces, including mobility-on-demand services, automation, electrification, health and wellbeing, pricing and taxation, safety, COVID-19 pandemic, leisure activities, and community networks are very significant, and yet difficult to quantify. So far, the three waves of COVID Future Survey dataset have 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 documentation and weighting have been completed. It is envisioned that the findings, analytical models, and raw datasets can significantly enhance our understanding of people’s behaviors, perceptions, and choices and therefore substantially elevate 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 the 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.

At the University of Washington, the TOMNET researchers analyze the data gathered from the TOMNET surveys and community outreach activities to provide insights for transportation and emergency planners. This analysis aims to address uncertainties in preparing for disruptions, such as people’s expected responses to earthquakes and tsunamis, preferred locations for healthcare and medication, community resources available for alternative purposes in a time of need, and willingness to share resources within a community. Furthermore, the researchers aim to explore ways to optimize transportation and communication sources by leveraging social relationships and local knowledge. In addition to the earthquake and tsunami scenarios the team focused on prior to the COVID-19 pandemic, the research team has expanded their focus to include studying changes in travel behavior during pandemic scenarios. Furthermore, the TOMNET research project led by the University of Washington (Project #54) has led to advancements in addressing transportation challenges, particularly in evaluating the integration of mobility-on-demand (MOD) with public transit in suburban regions. The study offers insights into the cost-effectiveness of various transportation modes and the potential to innovate practices and adopt new techniques within the transportation sector.

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 (the TOMNET Wellbeing Platform). 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, COVID Future 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.

Researchers at the University of Washington are 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. The analysis conducted during this reporting period also highlights the importance of trust in supporting communities during a disaster. Trust in community networks turns out to be more important than other factors including socio-demographics, level of preparedness, and place attachment.

What is the impact on the body of scientific knowledge?

Table 7 presents the number of citations for research papers that were produced by the core TOMNET team since 2018. During these years, citations to publications are credited to TOMNET based on the financial resources provided by TOMNET for the specific studies and products. The two distinguished TOMNET faculty who have an outsized contribution to these citation statistics are Fred Mannering and Patricia Mokhtarian. Over the past year, **Professor Fred Mannering** received the **2021 HNTB-CUTC lifetime achievement award in transportation research and education** and **Professor Patricia Mokhtarian** was named the **2021 recipient of the Lifetime Achievement Award** by the **International Association for Travel Behavior Research** for her significant contributions to the field. Mokhtarian is the first woman to receive this prestigious honor since its creation in 2003.

Table 7. TOMNET Metrics on Impacts

Metric	2018	2019	2020	2021	2022	2023	Total
Number of new agencies adopting TOMNET data/tools	2	1	1	1	0	1	6
Citations of TOMNET Publications	3,381	3,825	4,565	4,987	5,180	4,706 (+)	26,644

The research team at the University of Washington has developed a comprehensive analytical framework to evaluate the cost-effectiveness of integrating mobility-on-demand (MOD) and public transit in suburban areas. The framework incorporates measurements of externalities that are related to GHG emissions. In addition, the empirical analysis involved a comparison of different suburban contexts with distinct built environment characteristics. This research also has important practical values, as it provides

an adaptable approach for transit agencies to make informed decisions about how to best meet the needs of their riders in a cost-effective manner.

The forthcoming report by Georgia Tech's TOMNET team about working from home in the state of Georgia will increase knowledge of teleworking and its related impacts as the pandemic dramatically waned in strength in 2022. Some key results are listed earlier in this SAPR. Pat Mokhtarian had a spate of media interviews in August and September:

1. Interviewed by *New York Times* journalist Lydia DePillis on commuting and teleworking, September 14, 2023. Have not seen (and couldn't find) the final result.
2. Interviewed August 31, 2023 for *Newsweek Global* cover story on the changing workplace, by David H. Freedman. Appeared with several quotes from me as "The Messy Future of Work", Vol. 181(8), September 29, 2023.
3. Interviewed on *WJR Radio (760AM)*, Detroit, *Focus with Paul W. Smith* show, regarding the *Detroit News* article below, August 30, 2023.
4. Quoted in *Detroit News* article by Abha Bhattarai, August 28, 2023: "Back in the office? Fine. But not from 9 to 5" (<https://www.detroitnews.com/story/business/2023/08/28/back-in-the-office-fine-but-not-from-9-to-5/70699304007/>). Related story by the same journalist also appeared in the *Washington Post*, August 31, 2023, titled, "Workers cash in on a new flexibility: Leaving the office after a few hours". Family in San Diego saw the same article in one of the papers there.

What is the impact on transportation workforce development?

To date, various TOMNET activities have engaged undergraduate, graduate, and postdoctoral scholars in research and technology transfer activities related to emerging transportation technologies, impacts of the pandemic, resilience issues in rural and remote areas, survey data collection, advanced statistical modeling, and data fusion. Consistent with the central theme of TOMNET, 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 TOMNET research results, data and software products, and policy implications through various webinars, conference presentations, reports, and publications.

At the University of Washington, TOMNET activities have engaged undergraduate, graduate and postdoctoral scholars in community-engaged research about transportation issues in rural and remote areas, particularly as related to emergency planning and hazard mitigation. In previous phases of the mega multiphase project, students were trained to use WeTable participatory GIS equipment to engage collaboratively with experts in urban planning, transportation planning, and hazard mitigation planning on potential planning interventions for remote coastal communities. In the community workshop activities to date, the TOMNET researchers provided opportunities for the public to learn about disaster planning best practices and to share local knowledge with planners and hazard mitigation specialists. They have also engaged multiple undergraduate students in this project so that they learn technical skills relevant to data collection and analysis.

At the University of Washington, TOMNET core faculty members have been working with PhD students/candidates to develop their skills and knowledge in emerging mobility services and the appropriate responses from transit agencies in response to rapidly changing mobility landscape. The activities in this program will provide students with the tools they need to succeed in the field and polish their skills for future academic and professional careers. The team has provided funding and support to support integration of TOMNET research findings into research and education experiences, with a view to generate new ideas and approaches for addressing transportation challenges and improve the efficiency and sustainability of transportation systems. Professors and investigators are integrating the results of this program into their courses, and providing students with the most updated knowledge and insights about topics related to emerging mobility.

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.