TOMNET Transportation Center
Teaching Old Models New Tricks

UTC Semi-Annual Progress Report (SAPR#12)

ASU Arizona State University

Georgia Tech

UNIVERSITY of WASHINGTON

UNIVERSITY of SOUTH FLORIDA

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 that date. This SAPR, the twelfth 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 October 1, 2022 through March 31, 2023.

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 previous years or the current year have been completed (43 projects) or are continuing into their subsequent phases (16 projects). The list of all active and completed TOMNET projects is provided in Table 1 with the active period for each project (total of 59 projects). Additionally, all project entries in the RiP and/or TRiD databases have been completed. The TOMNET website project page is regularly updated to provide information and share outputs 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. Further details about the progress made for a sample of active projects are provided below.

Table 1. TOMNET Research Projects

	Project Topic/Title	Institution (PI)	Active Period	Status
1*	Does Ridehailing Use Affect Vehicle Ownership or Vice Versa? An Exploratory Investigation of the Relationship Using a Latent Market Segmentation Approach	ASU (Batur)	2022 - Present	⚙
2*	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 - Present	⚙
3*	Access to Food in a Severe Prolonged Disruption: The Case of Grocery and Meal Shopping During the COVID-19 Pandemic	ASU (Pendyala)	2022 - Present	⚙
4*	A Multidimensional Analysis of Willingness to Share Rides in a Future of Autonomous Vehicles	ASU (Batur)	2022 - Present	⚙
5*	Evolution of Mode Use Due to COVID-19 Pandemic in the United States: Implications for the Future of Transit	ASU (Pendyala)	2022 - Present	⚙
6*	Assessing the Impact of Ridehailing Service Use on Bus Ridership: A Joint Modeling Framework Accounting for Endogeneity and Latent Attitudes	ASU (Pendyala)	2021 - Present	⚙
7*	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	✓
8	The Stability of Transport-Related Attitudes over Time: A Case Study During COVID-19	ASU (Salon)	2021 - 2022	✓
9	Expected Change in US Air Travel After the COVID-19 Pandemic	ASU (Khoeini)	2020 - 2022	✓
10*	Investigating Attitudinal and Behavioral Changes in U.S. Households Before, During, and After the COVID-19 pandemic	ASU (Salon)	2020 - 2022	✓
11	Latent Variable Models of Attitudes and Preferences, and Their Prediction of Autonomous Vehicle Adoption Intent	ASU (Grimm)	2020 - Present	⚙
12	How Will Use of Autonomous Vehicles for Running Errands Affect Future Autonomous Vehicle Adoption and Ownership?	ASU (Batur)	2020 - 2022	✓
13	Interaction of Familiarity, Safety Perceptions, and Willingness to Use Autonomous Vehicles in A Structural Equation Modeling Framework	ASU (Khoeini)	2020 - 2022	✓
14	Investigating the Contributing Factors to Willingness to Share Automated Vehicles with Gender Focus	ASU (Khoeini)	2020 - 2022	✓
15	The Effect of Survey Methodology on The Collection of Attitudinal Data	ASU (Pendyala)	2020 - 2022	✓
16	Real-Time Transportation Social Media Analytics Using Pulse (Pulse-T)	ASU (Kandala)	2019 - 2021	✓
17	Consumer Attitudes and Behavioral Implications in the New Era of Shared Mobility	ASU (Zhang)	2019 - 2021	✓
18	Emerging Approaches to Autonomous Vehicles in Transportation Policy and Planning	ASU (Miller)	2019 - 2021	✓
19	Teaching the Travel Demand Flow Estimation Models: A New Deep-Learning Approach Using Multi-Source Data	ASU (Zhou)	2019 - 2021	✓
20	Causal Relationships Between Transportation Attitudes and Behaviors: Uncovering Latent Segments within a Heterogeneous Population	ASU (Pendyala)	2019 - 2021	✓
21*	The Impact of Non-Transportation Attitudes, Preferences, and Personality Characteristics on Residential Location and Travel Choices	ASU (Salon)	2019 - Present	⚙
22	Development of an Integrated Model System of Transport and Residential Energy Consumption	ASU (Pendyala)	2019 - 2022	✓
23*	Attitudes Towards Emerging Mobility Options and Technologies – Phase 3: Survey Data Compilation and Analysis for Phoenix, AZ	ASU (Khoeini)	2019 - 2021	✓
24	How Important are Attitudes in Travel Behavior Models? A Comprehensive Review	ASU (Salon)	2018 - 2019	✓
25	Heterogeneity in the Relationship Between the Built Environment and Bicycling	ASU (Salon)	2018 - 2019	✓

	Project Topic/Title	Institution (PI)	Active Period	Status
26	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	✓
27	A Comparison of Vehicle Miles of Travel Between Two Generations: Millennials versus Generation X	ASU (Pendyala)	2018 - 2019	✓
28	Attitudes Towards Emerging Mobility Options and Technologies – Phase 2: Data Collection in Phoenix, AZ	ASU (Khoeini)	2018 - 2019	✓
29	Assembling Integrated Data Sets for Analyzing Connections between Travel Behavior, Attitudes, and the Built Environment	ASU (Salon)	2017 - 2018	✓
30*	An Integrated Model of Daily Activity-Travel Behavior and Well-Being	ASU (Pendyala)	2017 - Present	⚙
31	Comprehensive Literature Synthesis on the Role of Attitudes in Shaping Mobility/Location Choices	ASU (Salon)	2017 - Present	⚙
32	Attitudes Towards Emerging Mobility Options and Technologies – Phase 1: Survey Design for Phoenix, AZ	ASU (Khoeini)	2017 - 2018	✓
33*	Drivers' Attitudes toward Rerouting: Impacts on Network Congestion	GT (Laval)	2021 - Present	⚙
34*	What is the New Normal? An Analysis of Post-COVID-19 Commute and Work Patterns	GT (Circella)	2021 - Present	⚙
35	Mode Substitutional Patterns of Ridehailing and Micro-Mobility Services	GT (Circella)	2020 - Present	⚙
36	Response Willingness in Consecutive Travel Surveys	GT (Mokhtarian)	2020 - 2021	✓
37	Combining Disparate Surveys across Time to Study Satisfaction with Life	GT (Mokhtarian)	2019 - 2020	✓
38*	Attitudes Towards Emerging Mobility Options and Technologies – Phase 3: Survey Data Compilation and Analysis for Atlanta, GA	GT (Circella)	2019 - Present	⚙
39	Latent Vehicle Type Propensity Segments: Considering the Influence of Household Vehicle Fleet Structure	GT (Mokhtarian)	2018 - 2019	✓
40	Attitudes Towards Emerging Mobility Options and Technologies – Phase 2: Data Collection in Atlanta, GA	GT (Circella)	2018 - 2019	✓
41	An Investigation of the Contribution of Targeted Marketing Data to the Prediction of Attitudes	GT (Mokhtarian)	2017 - 2019	✓
42	Attitudes Towards Emerging Mobility Options and Technologies – Phase 1: Survey Design for Atlanta, GA	GT (Circella)	2017 - 2018	✓
43	An Empirical Assessment of the Role of Attitudes and Identification in Safety Research	USF (Mannering)	2020 - 2021	✓
44	Addressing Potentially Missing Relevant Information on Attitudes and Other Behavioral Elements as Unobserved Heterogeneity in Highway Safety Studies	USF (Mannering)	2020 - 2022	✓
45*	Exploration of the Relationships between Leisure Activity Participation Frequency and Social Capital	USF (Maness)	2020 - 2022	✓
46*	An Exploratory Analysis to Estimate the Value of Free Charging Bundle in Electric Vehicle Purchases	USF (Maness)	2020 - 2021	✓
47	An Exploration of Contemporary Issues in Highway Safety, Evolving Transportation Alternatives, and Activity and Travel Behavior Modeling	USF (Maness)	2019 - 2020	✓
48*	Attitudes Towards Emerging Mobility Options and Technologies – Phase 3: Survey Data Compilation and Analysis for Tampa, FL	USF (Maness)	2019 - 2022	✓
49	Emerging Econometric and Data Collection Methods for Capturing Attitudinal and Social Factors in Activity and Travel Behavior Modeling	USF (Mannering)	2018 - 2019	✓
50	Attitudes Towards Emerging Mobility Options and Technologies – Phase 2: Data Collection in Tampa, FL	USF (Maness)	2018 - 2019	✓
51	Investigation of the Role of Attitudinal Factors on Adoption of Emerging Automated Vehicle and Vehicle Safety Technologies	USF (Mannering)	2017 - 2018	✓
52	Attitudes Towards Emerging Mobility Options and Technologies – Phase 1: Survey Design for Tampa, FL	USF (Maness)	2017 - 2018	✓
53*	Are On-Demand Mobility Services Cost-Effective for First/Last Mile Travel? A Comparative Analysis	UW (Shen)	2022 - Present	⚙

Project Topic/Title		Institution (PI)	Active Period	Status
54*	Grid-Aware Robust Fast-Charging Station Deployment for Electric Buses Under Socioeconomic Considerations	UW (Zhao)	2022 - Present	⚙
55	Mobility Analysis Workflow (MAW): An Accessible, Interoperable, and Reproducible Container System for Processing Raw Mobile Data	UW (Chen)	2021 - 2022	✓
56	Attitudes and Trust in Leveraging Integrated Sociotechnical Systems for Enhancing Community Adaptive Capacity – Phase IV	UW (Chen)	2020 - 2021	✓
57	Attitudes and Trust in Leveraging Integrated Sociotechnical Systems for Enhancing Community Adaptive Capacity – Phase III	UW (Chen)	2019 - 2020	✓
58	Attitudes and Trust in Leveraging Integrated Sociotechnical Systems for Enhancing Community Adaptive Capacity – Phase II	UW (Chen)	2018 - 2019	✓
59	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

Project #1: 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 team conducted an extensive literature review, completed an exploratory analysis to investigate the relationship between ridehailing use and vehicle ownership, and estimated the joint latent segmentation model system. Within this period, the project findings were presented at the 2023 TRB Annual Meeting as well as at the seminar series of the UCI Institute of Transportation Studies and the IIM Ahmedabad Center for Transportation Logistics. A manuscript is also being reviewed by the *Transportation Research Record journal* for publication. In the next reporting period, the team will finalize the journal publication and continue to disseminate findings.

Project #2: 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
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 reviewed the relevant literature, assembled datasets for the study, conducted an exploratory analysis, and applied wellbeing and time poverty methods to identify the *winners* and *losers* during the pandemic. Within this period, the project results were presented at the 2023 TRB Annual Meeting, and the corresponding manuscript is currently being reviewed for publication in the *Transportation Research Record* journal. The team will finalize the journal publication and continue to disseminate research findings over the next reporting period.

Project #3: 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 presents estimation results for a simultaneous equations model of 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 reviewed the relevant literature, assembled the dataset, conducted exploratory analyses, and estimated the joint simultaneous equation model to identify user characteristics for each food-purchasing arrangement. Within this period, the project's findings were presented at the 2023 TRB Annual Meeting, and a manuscript is currently being reviewed by *Travel Behavior and Society* for publication. The team will finalize the journal article and continue to disseminate research findings over the next reporting period.

Project #4: 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 project team reviewed the relevant literature, assembled the dataset, performed an exploratory analysis of the variables of interest, and estimated a joint model to identify the impact of current ridehailing usage on the intentions to use AV-based ridehailing services in the future. During this period, the results of the project were presented at the 2023 TRB Annual Meeting. A manuscript is also currently being considered for publication in the *Transportation Research Record* journal. The team will finalize the journal article during the next reporting period and continue to share the project findings.

Project #5: 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. The project team reviewed the relevant literature, compiled the dataset, conducted exploratory analyses, and completed model estimation during this reporting period. The project results were presented at the 2023 Transportation Research Board Annual Meeting, and a manuscript is currently being considered for publication in the *Transportation Research Record* journal. The team will finalize the journal article during the next reporting period and continue to engage in technology transfer activities to disseminate the project findings.

Project #6: 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 #7: 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 project. Utilizing data collected through the TOMNET's 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. Although this project was fully completed in the summer of 2021, the technology transfer activities have been continuing. The paper also won the prestigious Pyke Johnson Award, given by the Transportation Research Board in recognition of the best paper in the field of Planning and Environment. During this reporting period, the project team attended the 2023 TRB Annual Meeting's award ceremony to receive the award.

Project #10: Investigating Attitudinal and Behavioral Changes in U.S. Households Before, During, and After the COVID-19 Pandemic **| PI:** Deborah Salon (ASU), **Co-PI:** Ram Pendyala (ASU)

Progress: This project is concerned with the following questions: (1) to what extent will American society "go back" to our pre-COVID-19 way of life after the threat of contagion is gone? (2) which behavioral changes will be long-lasting, and for whom? (3) how, if at all, are the attitudes that underpinned our American lifestyle shifting in this crisis, and will these shifts be long-term? (4) what are the largest impacts of confinement in terms of attitudes and behavior? In this reporting period, the project lead-PI delivered an invited talk at Portland State University, based on the project's findings. Additionally, a team member gave a presentation on the remote work results of the survey to TRB's Standing Committee on Economic Development and Land Use. At the 2023 TRB annual meeting, the research team presented three papers and gave two invited talks at a workshop. The team also made progress on a manuscript that will provide a summary of the key findings from the panel survey regarding the future of cities and urban planning. In the next reporting period, the team plans to continue presenting their findings and analyzing the survey data, revise existing publications, and prepare a limited number of new manuscripts for publication.

Project #21: 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 regarding car ownership and usage. During the reporting period, the team added a new collaborator and deployed a national survey in partnership with Culdesac Tempe to collect data on car dependence in the US. The team collected, cleaned, and analyzed the survey data, which supported the hypothesis that people compromise on their preferred transportation environment to obtain desired housing features. The project team plans to prepare three additional manuscripts for publication using the survey data on car dependence in the U.S. The topics will 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. The project is expected to continue through late 2023 or into 2024.

Projects #23, #38, #48: 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, #4, #6, #7, #11, #12, #13, #14, #15, and #35 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 2023 TRB Annual Meeting and (possible) publication in the Transportation Research Record and other journals.

Project #30: 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. In this reporting period, the team has made significant progress and released the beta version of the tool, named the TOMNET Wellbeing Platform, which is available [here](#).

Project #33: Drivers' Attitudes Towards Rerouting: Impacts on Network Congestion
PI: Jorge Laval (GT)

Progress: This project aims to answer the following questions: (1) What machine learning (ML) approaches are useful to help people make rerouting decisions in congestion? (2) When we apply machine learning methods to the rerouting decision, what other elements need to be considered? (3) Can we obtain a well-trained rerouting policy? (4) If so, the project will apply it in simulation and find out how it influences network efficiency. The team will compare the policy based on the macroscopic fundamental diagram (MFD). After building a realistic simulation environment, the project team tested two types of driver rerouting tendencies and trained these two models at various density levels. The investigation revealed that deep reinforcement learning (DRL) faces difficulties in delaying the onset of gridlock and providing satisfactory training results in high-density environments. The focus was on the relationship between bifurcation and rerouting behavior, and it was found that training the rerouting behavior with a DRL policy can either postpone or eliminate the occurrence of bifurcation. However, it is also found that the convergence results are not up to the expectations in both free-flow and high-density environments. In contrast to traffic signal control, machine learning applied to drivers' adaptive behavior has yielded unsatisfactory results in both low-density and high-density traffic scenarios, but moderate density environments have shown more promising outcomes. However, based on the findings of this study, drivers' adaptive behavior remains a promising factor for traffic control and warrants further research. The final report on this project is being drafted and should be completed in the following review period.

Project #34: 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 addresses the following questions: (1a) What are the adoption rates and frequencies of working from home in Spring 2022 and what are the intentions to continue to work remotely in the future? (1b) What demographic, geographic, and attitudinal characteristics are associated with adoption frequencies? (2a) What is the distribution of one-way commute lengths, and how has that distribution changed since before COVID-19? (2b) Combining one-way commute lengths with commute frequencies, what is the distribution of total weekly commute distance traveled, and how has that distribution changed since before the pandemic? (2c) What socio-economic and other characteristics are associated with one-way commute lengths and total weekly commute distances? (3) How have the shares of commute modes changed since before the pandemic, and what are the associated characteristics? During this reporting period, the project team (i) finished data cleaning, (ii) weighted the sample to be representative of the state's employed population with respect to age, gender, income, education, race/ethnicity, region, and estimated telework status, (iii) prepared descriptive statistics to address the key questions of the study, and (iv) presented interim results to GDOT. The team now are in the process of developing models of key behavioral indicators, and drafting the final report, which should be complete within the next reporting period.

Project #45: Exploration of the Relationships between Leisure Activity Participation Frequency and Social Capital **| PI:** Fred Mannering (USF) **Co-PI:** Michael Maness (USF)

Progress: This project examines the effects of social capital on the increased frequency of leisure activity

participation. It is hypothesized that leisure activity frequency is an expressive outcome of social capital which is used by people to maintain and strengthen their social connections. This project aims to test this hypothesis using insights gathered from a self-administered web-based survey designed specifically to test differences in social capital and its relevance in a leisure activity context. The project team completed the final report in June 2022, which is available on the TOMNET website. During this reporting period, the team continued analysis of data after comments were received from peer-reviewed journal article suggestions. This included additional analysis of gendered effects and temporal effects using proper likelihood-based market segmentation and transferability tests. The paper was refined and is in final review for submission to a transportation journal.

Project #46: An Exploratory Analysis to Estimate the Value of Free Charging Bundle in Electric Vehicle Purchases | **PI:** Michael Maness (USF)

Progress: The aim of this research project is to determine the willingness-to-pay (WTP) for a free charging bundle in the electric vehicle market in the United States. A stated choice experiment was conducted, generating 36 choice scenarios with each respondent receiving nine scenarios. The scenarios involved choosing between three vehicles (two EVs and a gasoline vehicle) with varying vehicle attributes. For the EVs, the free charging bundle was offered at four different levels: zero, one, two, and three years. Results from mixed logit and latent class analysis showed that there was heterogeneity in sensitivity to the free charging time scale, with a significant portion of the population showing no sensitivity to a single year of free charging. Additional responses were collected during the reporting period for the vehicle choice experiment and sociodemographic differences for the zero price effect papers in response to peer review. Around 500 more responses were collected, and the team is currently analyzing the data and preparing to resubmit papers to peer-reviewed journals.

Project #53: Are On-Demand Mobility Services Cost-Effective for First/Last Mile Travel? A Comparative Analysis **| PI:** Qing Shen (UW) **Co-PI:** Cynthia Chen (UW)

Progress: This project addresses the following questions: (1) From a societal perspective, what factors determine the comparative cost-effectiveness of mobility service alternatives? For each alternative, what are the key elements of the cost, and how to measure them? (2) How to measure and compare the societal cost across different mobility services? (3) How do socioeconomic factors, built environment variables, and demand patterns affect the possibility of demand-responsive transit (DRT) being a comparatively cost-effective alternative? (4) Under what conditions and arrangements is each DRT service type (first/last mile, local activity centers, and other point-to-point services) most cost-effective? (5) What are the equity implications of each alternative mode? During this reporting period, the project team refined the research design to use Community Ride data and compare it against public transit and privately-operated mobility services. The team also expanded the literature review to cover various studies estimating cost-effectiveness for different mobility options. Data collection also began, and data analysis will be finalized in the next reporting period. The team plans to draft a manuscript for presentation at the 2024 TRB Annual Meeting, and a dissertation chapter for one team member will be written based on this research work.

Project #54: 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 aims to investigate 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 questions,

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, taking into consideration constraints from battery electric bus operation requirements, as well as power grid stability and security. 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. In the next reporting periods, the project results will be disseminated through journal publications, with a focus on flagship journals such as IEEE Transactions on Smart Grid or 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 Winter and Spring 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 Mission-Critical Faculty Members of TOMNET (Winter & Spring 2023)

Semester	Course Level	Course No	Course Title	No	Instructor	Unit
Arizona State University						
Spring 23	Undergrad	CEE 372	Transportation Engineering	80	Zhou	SSEBE
Spring 23	Grad	CEE 598	Public Transportation	15	Zhou	SSEBE
Spring 23	Undergrad	PUP 424	Planning Methods	19	Salon	SGSUP
Georgia Institute of Technology						
Spring 23	Undergrad	CEE 6601	Statistics in Transport	39	Mokhtarian	CEE
University of South Florida						
Spring 23	Undergrad	TTE 4004	Transportation Engineering I	60	Maness	CEE
Spring 23	Grad	TTE 6507	Travel Demand Modeling	6	Maness	CEE
Spring 23	Grad	TTE 6307	Statistical and Econometric Methods I	17	Mannering	CEE
Spring 23	Undergrad	CGN 4933	Sustainable Transportation	27	Yu Zhang	CEE
Spring 23	Grad	CGN 6311	Introduction to Data Science	21	Qing Lu	CEE
University of Washington						
Winter 23	Grad	CET 512	Transportation Data Collection	21	Chen	CEE
Winter 23	Grad	INDE 524	Robust Design For Process Improvement	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 a number of 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			
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
P. Srikanth Kini	MS Student	Comp Science	Pendyala
Nicole Corcoran	PhD Student	SGSUP	Salon
Rababe Saadaoui	PhD Student	SGSUP	Salon
Danielle Manapat	PhD Student	Psychology	Grimm
GEORGIA INSTITUTE OF TECHNOLOGY			
Jason Soria	Postdoc	CEE	Mokhtarian
Ziming Liu	PhD Student	CEE	Laval
Xinyi Wang	PhD Student	CEE	Mokhtarian
Seung-Eun Choi	PhD Student	CEE	Mokhtarian
Ilsu Kim	PhD Student	CEE	Mokhtarian/Circella
UNIVERSITY OF SOUTH FLORIDA			
Trang Luong	Graduate Student	CEE	Maness
Divyamita Mishra	Graduate Student	CEE	Maness
Tung Vo	Graduate Student	CEE	Maness
UNIVERSITY OF WASHINGTON			
Ekin Ugurel	PhD Student	CEE	Chen
Grace Jia	PhD Student	CEE	Chen
Arsalan Esmaeili	PhD Student	CEE	Chen
Kaitlyn Ng	MS Student	CEE	Chen
Ameer Hamza Shakur	PhD Student	ISE	Huang
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	How Critical Conflicts are Transforming Road Safety and Operations Management Practice	Simon Washington, PhD | Advanced Mobility Analytics Group Pty Ltd, Brisbane, Australia	11/10/2022
ASU	Location Selection and Investment Sequencing for Transit Priority	Ilgin Guler, PhD | Pennsylvania State University	02/03/2023
ASU	An Integrative Theory of Transportation and Location Decision-Making	Jason Hawkins, PhD | University of Nebraska–Lincoln	02/27/2023
GT	MaaS: Mobility as a Service	Aurélien Cottet | West EMEA	02/23/2023
USF	Next Generation Urban Transportation: Quo Vadis?	Kumares C. Sinha | Purdue University	10/07/2022
USF	Impacts of the COVID-19 Pandemic on Travel Behavior, Work-From-Home, and Cycling	Natalia Barbour |University of Central Florida	02/03/2023
USF	Computational Methods for Large-Scale Vehicle Routing Problems	Changhyun Kwon | University of South Florida	02/17/2023
USF	Transportation in California	Zhongren Wang | California DOT	02/24/2023

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

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. Using these diverse and rich datasets, in the next reporting period, TOMNET researchers will continue to produce tangible research outputs that can significantly benefit policy and decision making in the transport sector, particularly in the wake of recent natural and technological disruptions. The TOMNET research team will continue to wrap up ongoing research projects (besides the specific research efforts based on these surveys) and 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 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 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 culminating symposium, called the A^4 Symposium. This symposium will focus on *modeling* Attitudes, Automation, Autonomy, and Access (hence, A^4) and bring together the many key themes addressed by TOMNET. 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. Patricia Mokhtarian of Georgia Tech is working with a PhD student, Rachael Panik, on a 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. The TOMNET researchers at the University of Washington are planning to organize an online webinar with King County Metro (KCM), to bring together the research team of Project#53, and planners and decision-makers from KCM, and possibly professionals from other transportation planning agencies. The webinar will focus on the research outcomes, the methodological approach used, data requirements, key findings, and significant policy implications, related to the project. TOMNET scholars will continue to engage in 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. TOMNET will be participating in the 2023 National Summer Transportation Institute (NSTI) at ASU; this is a week-long residential immersive experience for middle and high school students to learn about transportation as a field of study and career choice.

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?
- *Oak Ridge National Laboratory – National Transportation Research Center: Collaborative research*
- *Northwestern University: Collaborative research*
- *Atlanta Regional Commission: Collaborative research and personnel exchange*
- *Georgia Department of Transportation: In-kind support, datasets, collaborative research, funding of matching-project research*

- *King County Metro, Seattle, WA: In-kind support, datasets, collaborative research*
- *Washington State Department of Transportation: Collaborative research and 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*
- *Mobility Innovation Center, Seattle, Washington: Collaborative research and funding of matching-project research*
- *Maricopa Association of Governments, Phoenix, Arizona: In-kind support, datasets, collaborative research*
- *The AAA Foundation for Traffic Safety*
- *Culdesac Tempe, Tempe, AZ, Collaborative research*
- *D-STOP University Transportation Center, University of Texas at Austin*
- *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*

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 include:

- *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. Yongsung Lee, University of Hong Kong, Hong Kong*
- *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, University of Washington Mobility Innovation Center, WA*
- *Anthony Buckley, Washington State DOT, WA*
- *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. Taplin, D., Kuby, M., Salon, D., & King, D. (2023). Analysis of Airports Served by Ultra Low-Cost Carriers. *Transportation Research Record*, 0(0).
2. Nafakh, A., Mohammadian, A., Derrible, S., Pendyala, R. and Salon, D. (2022) Examining the Impacts of the Pandemic on Employment for Women. *Open Journal of Social Sciences*, 10, 318-334.
3. Nafakh, A., Mohammadian, A., Derrible, S., Pendyala, R. and Salon, D. (2022) Examining the Impacts of the Pandemic on Work-from-Home for Individuals with Disabilities. *Open Journal of Social Sciences*, 10, 167-183.

Presentations Within Reporting Period

1. Batur, I., Dirks, A. C., Magassy, T., Pendyala, R. M., & Bhat C.R.. Changes in Time Use and Activity Participation in During the COVID-2019 Pandemic in the US: Implications for Well-being and Time Poverty. Presented at the 16th International Conference on Travel Behaviour Research, Santiago, Chile, Dec. 11-15, 2022.
2. Magassy, T. B., Batur, I., Dirks, A.C., Bhat, C. R., & Pendyala, R. M. Evolution of Mode Use Due to COVID-19 Pandemic in the United States: Implications for the Future of Transit. Presented at the 16th International Conference on Travel Behaviour Research, Santiago, Chile, Dec. 11-15, 2022.
3. Asmussen, K. E., Mondal, A., Batur, I., Dirks, A., Bhat, C. R., & Pendyala, R. M. An Investigation of Evolving COVID-Era Remote Work Arrangements. Presented at the 16th International Conference on Travel Behaviour Research, Santiago, Chile, Dec. 11-15, 2022.
4. Haddad, A., Mondal, A., Batur, I., Dirks, A., Bhat, C. R., & Pendyala, R. M. On the Interplay Between Online and In-person Shopping in a Transformed Activity-Travel Environment. Presented at the 16th International Conference on Travel Behaviour Research, Santiago, Chile, Dec. 11-15, 2022.
5. Batur, I., Dirks, A. C., Mondal, A., Pendyala, R. M., & Bhat, C. R. Does Ridehailing Use Affect Vehicle Ownership or Vice Versa? An Exploratory Investigation of the Relationship Using a Latent Market Segmentation Approach. Presented at the 102nd TRB Annual Meeting, Washington, DC, Jan 8-12, 2023.
6. Batur, I., Dirks, A. C., Pendyala, R. M., Bhat, C. R., Polzin, S. E., & Chen, C. 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. Presented at the 102nd TRB Annual Meeting, Washington, DC, Jan 8-12, 2023.
7. Dirks, A. C., Batur, I., Mondal, A., Magassy, T. B., Haddad, A., Bhat, C. R … & Pendyala, R. M. Access to Food in a Severe Prolonged Disruption: The Case of Grocery and Meal Shopping During the COVID-19 Pandemic. Presented at the 102nd TRB Annual Meeting, Washington, DC, Jan 8-12, 2023.
8. Magassy, T. B., Batur, I., Mondal, A., Asmussen, K. E., Bhat, C. R., … & Pendyala, R. M. Evolution of Mode Use Due to COVID-19 Pandemic in the United States: Implications for the Future of Transit. Presented at the 102nd TRB Annual Meeting, Washington, DC, Jan 8-12, 2023.
9. Magassy, T. B., Batur, I., Mondal, A., Asmussen, K. E., Pendyala, R. M., & Bhat, C. R. A Multidimensional Analysis of Willingness to Share Rides in a Future of Autonomous Vehicles. Presented at the 102nd TRB Annual Meeting, Washington, DC, Jan 8-12, 2023.
10. Verma, V., Mondal, A., Asmussen, K. E., Batur, I., Magassy, T. B., Bhat, C. R., & Pendyala, R. M. A Joint Behavioral Choice Model of Carpool Formation and Frequency. Presented at the 102nd TRB Annual Meeting, Washington, DC, Jan 8-12, 2023.
11. Asmussen, K. E., Mondal, A., Batur, I., Dirks, A., Bhat, C. R., & Pendyala, R. M. An Investigation of Evolving COVID-Era Remote Work Arrangements. Presented at the 102nd TRB Annual Meeting, Washington, DC, Jan 8-12, 2023.
12. Matthew Bhagat-Conway (filling in for Deborah Salon): The COVID-19 pandemic and the future of telecommuting in the US. TRB Standing Committee on Economic Development and Land Use (AMS50) Webinar. December 14, 2022.
13. Hayley Wiers (with Deborah Salon and others): Electric Vehicles for All?: Key Opportunities and Challenges for Mass Market Electric Vehicle Adoption in the Southwestern United States. Presented at the 102nd TRB Annual Meeting, Washington, DC, Jan 8-12, 2023.
14. Nicole Corcoran: The evolution of pandemic-induced behaviors and expectations for the post-pandemic future: Results from the COVID FUTURE 3-wave panel survey. Presented at the 102nd TRB Annual Meeting, Washington, DC, Jan 8-12, 2023.

Georgia Tech

Papers Published Within Reporting Period

1. Laval, Jorge (2023) Self-organized Criticality of traffic flow: Implications for congestion management technologies. *Transportation Research Part C: Emerging Technologies*, Volume 149, 104056.
2. Laval, Jorge (in press) Traffic Flow as a Simple Fluid: Towards a Scaling Theory of Urban Congestion. *Transportation Research Record*.
3. Laval, Jorge (2023) Effect of the Trip-Length Distribution on Network-Level Traffic Dynamics: Exact and Statistical Results. *Transportation Research Part C: Emerging Technologies*, Volume 148, 104036, 023.
4. Laval, Jorge and Hao Zhou (2022) Congested Urban Networks Tend to Be Insensitive to Signal Settings: Implications for Learning-Based Control. *IEEE Transactions on Intelligent Transportation Systems* 23.12: 24904-24917.

5. Kim, Sung Hoo & Patricia L. Mokhtarian (in press) A note on the sample selection (switching regression) model and treatment effects for a log-transformed outcome variable, in the context of residential self-selection. *Transportation*.
6. Kim, Sung Hoo & Patricia L. Mokhtarian (in press) Finite mixture (or latent class) modeling in transportation: Trends, usage, potential, and future directions. *Transportation Research Part B*.
7. Kim, Sung Hoo & Patricia L. Mokhtarian (in press) Comparisons of observed and unobserved parameter heterogeneity in modeling vehicle-miles driven. *Transportation Research Part A*.
8. van Wee, Bert & Patricia L. Mokhtarian (2023) Escape theory: explaining a negative motivation to travel. *Transportation Research Part A*, 103603.

Forthcoming Book Chapters Accepted for Publication in Reporting Period

1. "The state of travel behavior research: a bibliometric assessment", by Sung Hoo Kim and Patricia Mokhtarian. Handbook of Travel Behaviour, eds. Dimitris Potoglou and Justin Spinney, Edward Elgar Publishing, forthcoming 2023.

Presentations Within Reporting Period

1. Patricia Mokhtarian: Teleworking in Atlanta: Findings from a New Survey. Transportation Demand Management Coordinating Committee of the Atlanta Regional Commission, October 18, 2022.
2. Xinyi Wang: Identifying Teleworking-Related Motives and Comparing Telework Frequency Expectations in the Post-Pandemic World: A Latent Class Choice Modeling Approach. Presented at the 16th International Conference on Travel Behaviour Research, Santiago, Chile, Dec. 11-15, 2022.
3. Ilsu Kim: Heterogeneous Preferences for Activities while Traveling in Autonomous Vehicles. Presented at the 16th International Conference on Travel Behaviour Research, Santiago, Chile, Dec. 11-15, 2022.
4. Patricia Mokhtarian: Is Teleworking Always a "Treatment" for Reducing Distance Traveled? Investigating the Roles of Telework Motivations and Frequency Using Switching Regression Models. Presented at the 16th International Conference on Travel Behaviour Research, Santiago, Chile, Dec. 11-15, 2022.
5. Patricia Mokhtarian: Pursuing the Impossible (?) Dream: Incorporating Attitudes into Regional Models. Lifetime Achievement Award keynote talk, at the 16th International Conference on Travel Behaviour Research, Santiago, Chile, Dec. 11-15, 2022.
6. Patricia Mokhtarian: Panel participant in the workshop on "Moving Toward a New Normal: Behavioral Transitions and Their Impacts on Travel in the Post-Pandemic Era." Presented at the 102nd TRB Annual Meeting, Washington, DC, Jan 8-12, 2023.
7. Xinyi Wang: Is Teleworking Always a "Treatment" for Reducing Distance Traveled? Investigating the Roles of Telework Motivations and Frequency Using Switching Regression Models. Presented at the 102nd TRB Annual Meeting, Washington, DC, Jan 8-12, 2023.

University of South Florida
Papers Published Within Reporting Period

1. Islam, M., Alogaili, A., Mannering, F., Maness, M., 2023. Evidence of sample selectivity in highway injury-severity models: The case of risky driving during COVID-19. *Analytic Methods in Accident Research,* 38, 100263.
2. Luong, T. and Maness, M., 2023. Leisure activity variety seeking as an instrumental outcome of social capital. *Travel Behaviour and Society*, 31, pp.254-270.
3. Vo, T., Barbour, N., Palaio, L. and Maness, M., 2022. Impacts of the COVID-19 Pandemic on Bikeshare Usage by Rider Membership Status Across Selected US Cities. *Transportation Research Record*.

Presentations Within Reporting Period

1. Luong, T., Barbour, N., Maness, M. Analyzing the Relationships Between Frequency of Leisure Activity Participation and Social Capital. Presented at the 102nd TRB Annual Meeting, Washington, DC, Jan 8-12, 2023.
2. Lozano, W., Barbeau, S., Turner, S., Luong, T., Maness, M., Sener, I. N. Evaluating the Accuracy of Smartphone-Based Travel Behavior Data. Presented at the 102nd TRB Annual Meeting, Washington, DC, Jan 8-12, 2023.

University of Washington
Papers Published Within Reporting Period

1. Wang, Y. & Shen, Q. (2022). A latent class analysis to understand riders' adoption of on-demand mobility services as a complement to transit. *Transportation*, 1-19.
2. Zhao, X., Yao, Y., Liu, W., Jain, R., & Zhao, C. (2023). A Hydrogen Load Modeling Method for Integrated Hydrogen Energy System Planning. In 2023 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (ISGT) (pp. 1-5). *IEEE*.
3. Pan, W., Zhao, C., Fan, L., & Huang, S. (2023). Efficient Optimal Power Flow Flexibility Assessment: A Machine Learning Approach. In 2023 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (ISGT) (pp. 1-5). *IEEE.*
4. Song, J. and Zhao, C., Towards Optimal Pricing of Demand Response - A Nonparametric Constrained Policy Optimization Approach, accepted for publication in 2023 *IEEE Power & Energy Society General Meeting*.

Presentations Within Reporting Period

1. Chen, Cynthia. Learning big and small, heterogenous datasets for transportation planning resilience analyses, Drexel University, Jan. 17, 2023.

2. Chen, Cynthia. Gainesville, FL. Learning big and small, heterogenous datasets for transportation planning resilience analyses. Female Leaders in Transportation Distinguished Seminar Series, University of Florida Transportation Center, Dec. 1, 2022.
3. Guan, X.; Wang, Y.; Ugurel, E.; Chen, C.; Wang, R. and Huang, S. (2023) Substitution patterns revealed from people's visit patterns to downtown and other urban cores from pre- to during-COVID-19. Presented at the 102nd TRB Annual Meeting, Washington, DC, Jan 8-12, 2023.
4. Jia, G.; Pendyala, R.; and Chen, C. (2023) Quantifying delivery service induced competition-complementary food accessibility: a modified two-step floating catchment area method. Presented at the 102nd TRB Annual Meeting, Washington, DC, Jan 8-12, 2023.
5. Ugurel, E.; Guan, X.; Wang, Y.; Huang, S.; and Chen, C. (2023) Correcting missingness in passively generated mobile data with a multi-task Gaussian Process regression model. Presented at the 102nd TRB Annual Meeting, Washington, DC, Jan 8-12, 2023.
6. Ashour, L.A. and Shen, Q. (2023) Understanding the impact of TNC pricing strategies on the prospect of transit agency-TNC partnerships. Presented at the 102nd TRB Annual Meeting, Washington, DC, Jan 8-12, 2023.
7. Cai, M., Shen, Q., Wang, Y., Brown, M., Ban, X., and Ashour, L.A. (2023). Examining Commute Mode Choice of Essential Workers Before and During the COVID-19 Pandemic Using Travel Survey Data. Presented at the 102nd TRB Annual Meeting, Washington, DC, Jan 8-12, 2023.
8. Cai, M., Shen, Q., Wang, Y., Brown, M., Ban, X., and Ashour, L.A. (2022). Examining Commute Mode Choice of Essential Workers Before and During the COVID-19 Pandemic Using Travel Survey Data. 62nd Annual Conference, Association of Collegiate Schools of Planning (ACSP), Toronto.
9. Shen, Q., and Wang, Y., (2023) An Economic Analysis of Incorporating New Shared Mobility into Public Transportation Provision. Presented at the 102nd TRB Annual Meeting, Washington, DC, Jan 8-12, 2023.

In summary, TOMNET core faculty generated 18 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 34 presentations at various venues.

Website(s) or other Internet site(s)

One major product of the center is the TOMNET website that has been reorganized and updated during the reporting period. The research page of the TOMNET website has been updated to reflect project descriptions and reports, with additional updates scheduled to be made in the next reporting period. Also, a dedicated page is developed to effectively introduce software and tools developed within the TOMNET enterprise. In addition, a TOMNET Briefs page is designated to disseminate policy briefs produced by TOMNET research team members. During this reporting period, **two new policy briefs** were published.

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 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.

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 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 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. 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 (#41 by the 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 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	15	18	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. Three new studies based on the T4 survey were presented at various venues during the past six months.

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.

Finally, the TOMNET team at ASU has released the beta version of an interactive activity-based wellbeing assessment tool. This tool, called TOMNET Wellbeing Platform, consists of three activity and time use-based wellbeing metrics that are designed to analyze how wellbeing varies over time and space for different population groups. The platform provides policymakers and public with much needed measures of wellbeing, 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 name, affiliation, degree, and profile pictures of all 91 students and scholars who have been deeply engaged in TOMNET research during their education. In this reporting period, two TOMNET Students at ASU, who will graduate this academic year, are preparing to transition to their respective jobs after graduation. Abbie Dirks, an MS student, will become a transportation planner at CDM Smith, while Tassio Magassy, a PhD student, will join Argonne National Laboratory as a post-doctoral researcher. Abbie Dirks received the 2022 TOMNET Outstanding Student Award during the prestigious CUTC Annual Student Awards Banquet. TOMNET has been tracking progress in achieving outcomes relative to targets established in the Technology Transfer Plan. Table 6 shows a summary of progress.

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 COVID Future Survey (wave 1-3) and T4 Survey Results + TOMNET Wellbeing Platform
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 assessment and data analysis 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, TOMNET researchers analyzed 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 explored 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.

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**. 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 Behavior Research** for her significant contributions to the field and received her award at the 16th International Conference on Travel Behaviour Research. Mokhtarian is the first woman to receive this prestigious honor since its creation in 2003.

A highlight of this reporting period was the 16th International Conference on Travel Behaviour Research in Santiago, Chile in December 2022. Numerous TOMNET-associated scholars attended and presented their research, and Patricia Mokhtarian received the International Association for Travel Behaviour Research (IATBR) Lifetime Achievement Award at the conference.

Moreover, TOMNET Researchers at the University of Washington, led by Qing Shen, collaborated with Commute Seattle to redesign the survey questionnaire for the 2022 Seattle Commute Survey. The new questionnaire covers employees' commute options and work modalities and aims to gain a comprehensive understanding of changes in spatiotemporal patterns of commute and non-commute trips, travel behavior, motives, and needs. The resulting data, which included more than 64,000 responses, revealed key characteristics of the new normal in urban transportation and highlighted important transportation equity issues. These findings have significant planning and policy implications and garnered attention from major media outlets, including the Seattle Times, King5, and GeekWire. The team also received a letter of recognition from the mayor of Seattle as well as the dean of graduate school.

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.

Table 7. TOMNET Metrics on Impacts

Metric	2018	2019	2020	2021	2022	2023	Total
Number of new agencies using TOMNET data/tools	2	1	1	1	3	2	10
Citations of TOMNET Publications	3,381	3,825	4,565	4,987	5,180	1,825	23,763

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, 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.

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.