TOMNET Transportation Center
Teaching Old Models New Tricks

UTC Semi-Annual Progress Report (SAPR#4)

ASU Arizona State University

Georgia Tech

W UNIVERSITY of WASHINGTON

USF UNIVERSITY OF SOUTH FLORIDA

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INTRODUCTION

This document constitutes the UTC Semi-Annual Progress Report (SAPR) for the Center for Teaching Old Models New Tricks (TOMNET), a Tier 1 University Transportation Center sponsored by the US Department of Transportation. The center commenced operation on November 30, 2016 and has been active during the period of December 1, 2016 through September 30, 2020. This SAPR covers work accomplished, collaborations with academic, government, and industry partners, and the center outputs, outcomes, and impacts for the period of April 1, 2020 through September 30, 2020. It should be noted that the reporting period covered by this SAPR corresponds completely with the COVID-19 pandemic which is still ongoing in the United States. However, various activities and endeavors of the TOMNET team have continued and are explained in detail. The format of some activities, such as seminars and courses, may have been altered, however, considering the health and safety recommendations.

1. ACCOMPLISHMENTS

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

What are the major goals of the program?

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

What was accomplished under these goals?

Within the reporting period, TOMNET researchers worked on several research projects. Projects launched in previous years have been completed or are continuing into their subsequent phases. The list of all active and accomplished TOMNET projects is provided in Table 1 with the active period for each project. The status column indicates whether the project is accomplished or is still in progress. All of the TOMNET

projects have been entered into the [RiP database](#) with associated details. It should be noted that for a multi-phase project, an individual scope is defined in the RiP database for each phase of the project.

Table 1. TOMNET Research Projects

	Project Topic/Title	Institution (PI)	Active Period	Status
1.	Development of an Integrated Model of Daily Activity-Travel Behavior and Well-Being	ASU (Pendyala)	Aug 2017-July 2018	✓
2.	To What Extent Are Millennials Really Different in Their Vehicle Miles of Travel Compared to Generation X?	ASU (Pendyala)	Aug 2018-July 2019	✓
3.	Do Attitudes Affect Behavioral Choices or Vice-Versa: Uncovering Latent Segments within a Heterogeneous Population	ASU (Pendyala)	Aug 2019-July 2020	✓
4.	Attitudes Towards Mobility Options/Technologies – A Multi-region Survey Design and Data Collection Effort	ASU (Khoeini)	Oct 2017-Present	⚙
5.	Assembling Integrated Data Sets for Analyzing Connections between Travel Behavior, Attitudes, and the Built Environment	ASU (Salon)	Aug 2017-July 2018	✓
6.	Heterogeneity in the Relationship Between the Built Environment and Bicycling	ASU (Salon)	Aug 2018-July 2019	✓
7.	The role of transport in how we choose where to live: A qualitative investigation of residential location choice in the Phoenix, AZ region	ASU (Salon)	Aug 2018-July 2019	✓
8.	Comprehensive Review of Attitudes-Travel Behavior Literature	ASU (Salon)	Aug 2018-July 2019	✓
9.	The impact of non-transportation attitudes, preferences, and personality characteristics on residential location and travel choices	ASU (Salon)	Aug 2019-Present	⚙
10.	Investigating Attitudinal and Behavioral Changes in U.S. Households Before, During, and After the COVID-19 pandemic	ASU (Salon)	Aug 2019-Present	⚙
11.	Consumer Attitudes and Behavioral Implications in the New Era of Shared Mobility	ASU (Zhang)	Aug 2019 - Present	⚙
12.	Emerging Approaches to Autonomous Vehicles in Transportation Policy and Planning	ASU (Thad Miller)	Aug 2019 - Present	⚙
13.	Teaching the travel demand flow estimation models: a new deep-learning approach using multi-source data	ASU (Zhou)	Aug 2019 - Present	⚙
14.	Real-time Transportation Social Media Analytics using Pulse (Pulse-T)	ASU (Kandala)	Aug 2019 - Present	⚙
15.	Latent variable models of Attitudes and Preferences, and their Prediction of Autonomous Vehicle Adoption Intent	ASU (Grimm)	Aug 2020 - Present	⚙
16.	Attitudes Towards Mobility Options/Technologies – A Multi-region Survey Design and Data Collection Effort	GT (Circella)	Oct 2017-Present	⚙
17.	An Investigation of the Contribution of Targeted Marketing Data to the Prediction of Attitudes	GT (Mokhtarian)	Oct 2017-Present	⚙
18.	Latent Vehicle Type Propensity Segments: Considering the Influence of Household Vehicle Fleet Structure	GT (Mokhtarian)	Aug 2018-July 2019	✓
19.	Combining Disparate Surveys across Time to Study Satisfaction with Life	GT (Mokhtarian)	Aug 2019 - Present	⚙
20.	Attitudes Towards Mobility Options/Technologies – A Multi-region Survey Design and Data Collection Effort	USF (Maness)	Oct 2017-Present	⚙
21.	An exploration of contemporary issues in highway safety, evolving transportation alternatives, and activity and travel behavior modeling	USF (Maness)	Aug 2019-Present	⚙
22.	Investigation of the Role of Attitudinal Factors on Adoption of Emerging Automated Vehicle and Vehicle Safety Technologies	USF (Mannering)	Aug 2017-July 2018	✓
23.	Emerging econometric and data collection methods for capturing attitudinal and social factors in activity and travel behavior modeling	USF (Mannering)	Aug 2018-July 2019	✓
24.	Attitudes and Trust in Leveraging Integrated Sociotechnical Systems for Enhancing Community Adaptive Capacity	UW (Chen)	Oct 2017-Present	⚙

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

Furthermore, the TOMNET website project page has been comprehensively updated and now includes all of the research projects categorized by year and the lead university. Project scopes for all TOMNET research projects that have been initiated in the years 2017, 2018, 2019, and 2020 are available at the website. The projects that have been initiated in 2017 and 2018 have completed annual reports uploaded to the website as well. These projects will be moved to the TRID database soon. The annual reports of the projects initiated in 2019 and ended in 2020 are under review and will be posted on the website during the next reporting cycle. Moreover, the forthcoming projects' scopes for the year 2020 are also in submission and review phase and all selected/finalized scopes will be posted to the website in the next reporting cycle as well. For the multi-phase projects (projects 4, 16, 17, 20, and 24 in Table 1), annual research scopes and reports have been published for the first two completed cycles and published on the website to cover progress and results to date. Further information about the active projects that made substantial progress during the reporting period can be found below.

Progress on Active Research Projects
Project Title: Attitudes Towards Emerging Mobility Options and Technologies – A Multi-region Survey Design and Data Collection Effort; Phase 3: Survey Data Compilation, and Analysis
PIs: Sara Khoeini, ASU; Giovanni Circella, GT; Michael Maness, USF
Co-PIs: Ram Pendyala, ASU; Patricia Mokhtarian, GT; and Fred Mannering, USF
Description of Progress: The T4 survey (TOMNET Transformative Transportation in Technologies Survey) collected very detailed and in-depth data about people's mobility patterns, as well as attitudes towards and perceptions of emerging transportation options such as ridehailing services and autonomous vehicles. This signature TOMNET project is a multi-year, multi-institution project that consists of survey design, data collection, and data analysis. The survey design and data collection were conducted in two phases in the form of a pilot followed by a full deployment, yielding a respondent sample of 3,358 individuals who answered the survey through a Qualtrics platform. During the reporting period, the research team worked on data cleaning, preparation, imputation, weighting, geocoding, descriptive analysis, and dissemination of results.

Preliminary descriptive analysis of the data revealed that a little over half of the respondents are familiar with the mobility-on-demand services including private and shared ridehailing services, carsharing, and micro-mobility services (bike and e-scooter sharing). However, only a small percent of the participants is using these services frequently. Ridehailing users believe that their usage of these services decreased their walk, bike, e-scooter, and transit trips between 8 and 13 percent. Concerning automated technology in transportation, a little over half (54 percent) of the respondents stated they are very or somewhat familiar with AVs. Despite or because of this high rate of familiarity, 22 percent stated that they would not ride in an AV and 42 percent stated that they would not purchase an AV. In general, safety and data security are among the top concerns for respondents, despite the recognized benefits of AVs. However, almost half of the respondents believe that they can tolerate congestion better in an AV; however, this does not necessarily mean that they would be interested in commuting for much longer durations than they do now. Concerning sharing, more than half of the respondents are uncomfortable sharing their ride with people they do not know and only 28 percent think that the lower cost of shared ride hailing services is worth the addition of travel time.

To disseminate the initial results, the entire research team participated in an online webinar event on Friday, June 12, 2020 from 8 am to 1 pm (Pacific time). Survey results comprising of detailed descriptions of attitudes, choices, preferences, perceptions, and behaviors were presented in a comprehensive fashion with 10 informative presentations that cover various sections of the survey. The entire recording of the webinar in addition to the presentation files is available on this page on the TOMNET website. This event was very well received and had more than 350 registrants from across academia, industry, and government sectors. This event also led to a news article on the ASU website and

a radio interview with NPR. The link to the news article is available here and the link to the radio interview is available here. During the next reporting period, the research team will heavily focus on presenting and publishing more in-depth results of the survey using various econometric analysis and modeling methods.

Project Title: Investigating Attitudinal and Behavioral Changes in U.S. Households Before, During, and After the COVID-19 pandemic (a.k.a. COVID Future Survey)
PI: Deborah Salon, ASU; Co-PIs: Ram Pendyala & Sara Khoeini, ASU
Description of Progress: In this project, TOMNET researchers are interested to know, after the threat of contagion is gone, to what extent will American society "go back" to pre-COVID-19 ways of life? Which behavioral changes will be long-lasting, and for whom? How, if at all, are the attitudes that enabled the shifts in American lifestyles in this crisis, and will these shifts be long-term? Moreover, what are the largest impacts of confinement in terms of attitudes and behavior, particularly towards mobility options? In this period, TOMNET researchers:

1. Secured additional funding for the project from the National Science Foundation (together with partners at the University of Illinois, Chicago), the Knowledge Exchange for Resilience at ASU, and the ASU CONVERGE program
2. Designed and implemented an extensive survey to begin to answer the research questions listed above, collecting nearly 9000 responses from across the US
3. Created and added content to a new website for the project at covidfuture.org
4. Gave multiple virtual webinars on preliminary results
5. Submitted one paper for publication based on results from the first set of respondents
6. Published one co-authored public-facing piece on the Conversation
7. Contributed preliminary data to many news stories related to the effects of the COVID pandemic
8. Worked towards getting the collected survey data weighted properly and ready to be shared publicly, which will occur before the end of the calendar year
9. Began to draft a "data paper" for publication, which details data collection, cleaning, and weighting process and will be submitted in November 2020
10. Designed a "wave 2" follow up survey to capture trends over time, which we will be deployed between October and December 2020 (approximately 4 months from when respondents took the initial survey)

Continuing this project, TOMNET researchers will be conducting data analysis and will aim to publish results in multiple journal articles in the coming months, present the results at multiple webinars and virtual conferences, continue to update the website with new findings as they come in, and publicize the efforts in the popular press as opportunities arise.

Project Title: An Investigation of the Contribution of Targeted Marketing Data to the Prediction of Attitudes
PI: Patricia Mokhtarian, GT; Co-PIs: Giovanni Circella & Kari Watkins, GT
Description of Progress: This project involves the "fusion" of two datasets collected in 2016-2017 in Georgia: the behaviorally-rich Georgia add-on to the National Household Travel Survey ("NHTS", N ~ 8,000), and the attitudinally-rich survey designed by the project team and funded by the Georgia Department of Transportation (the "GDOT survey" or dataset, N ~ 3,500, before cleaning). The goal of the project is to use machine learning methods to develop attitude-prediction training functions on the GDOT (donor, or source) sample, which are then applied to the NHTS (recipient) sample to impute (or "transfer") attitudes into the latter. The inputs to the training function must be variables that are common, or available, to both datasets. A distinctive feature of the current study is the addition of targeted marketing (TM) variables to the common variable (CV) set that previously contained only socioeconomic/demographic (SED) and land use (LU) characteristics. TM variables can be purchased economically from third-party providers (such as Experian), and include a host of indicators of lifestyle

and various behaviors. The premise of the current study is that such variables may be very informative about individuals' attitudes, and thus substantially improve our ability to predict attitudes. If so, this methodology will be of great value to Metropolitan Planning Organizations, because it offers an economically viable way to obtain attitudinal variables for use in regional models.

At the end of the previous reporting period, the team had obtained "draft final" transfer functions on the GDOT sample and performed initial internal and external validation checks. With respect to internal validation, the team found that correlations between the observed and predicted attitudes ranged from 0.18 to 0.51, which is quite good. With respect to external validation, the team found substantial improvements in model fit and predictive accuracy using the imputed attitudes, e.g. 30+% improvements in R^2 for regression models of ridehailing adoption.

Progress during the present reporting period (April – Sept. 2020) has been slower than expected, due to (1) the adjustment to pandemic conditions; (2) **the wedding of two of TOMNET scholars!** including the key student working on this project; (3) the fact that the study is in a fine-tuning phase of the research, where considerable time is spent experimenting with changes that may result in only minor improvements; and (4) the fact that there are a large number of "moving parts" to the complex methodology that is being built and tested, with the results that (a) optimizing analysis options across the entire "operation" involves substantial iteration across multiple time-consuming steps, and (b) it has proved challenging to write up results in a clear and helpful way, providing the right amount of detail to enable future scholars to replicate and extend this work. However, the investment of time made during this period is paying off in terms of non-trivial improvements in the ability to predict attitudes and greater clarity of presentation of the results. Within the next reporting period, the team plans to complete two important papers on this centerpiece TOMNET project: one detailing the attitude imputation methodology and internal validation results, and one on the external validation results. Also, the primary PhD student on this project, Atiyya Shaw, is expected to complete her dissertation based on this project.

Project Title: An Exploration of Contemporary Issues in Highway Safety, Evolving Transportation Alternatives, and Activity and Travel Behavior Modelling
PI: Michael Maness, USF; Co-PI: Fred Mannering, USF
Description of Progress: The project team addressed several critical issues in the fields of highway safety, alternative transportation modes, and activity and travel behavior modeling. Regarding highway safety, the project team addressed motorcycle safety using new econometric methods. The project team followed the crash history of trained motorcyclists for up to 5 years after they are licensed. Specifically, attention is focused on the time until motorcyclists' first crash. Using data from over 40,000 Florida motorcyclists, Weibull hazard-based duration models were estimated with gamma heterogeneity, and full random parameters, to determine the factors that affect the duration until motorcyclists' first crash. The estimation results show that age and gender are driving factors in determining this duration and ultimately crash risk. Besides, estimation results show that most gender-age groups have an initial period of increasing crash risk, ranging from 30 to 96 days, where the likelihood of a crash increases the longer motorcyclists go without having a crash. After this initial period, crash risk declines over time as increasing riding experience reduces overall risk. This particular finding points to a critical motorcycle-safety opportunity in that policies and/or training can be modified to attempt to eliminate this initial high-risk period to arrive at a desirable lower initial risk and a declining risk over time with experience.

The project team also studied the renting of personal vehicles for monetary compensation. To explore individuals' attitudes and perceptions regarding the act of supplying a personal vehicle to a peer-to-peer vehicle fleet, a stated preference survey was designed and disseminated. The survey questionnaire collected detailed socio-demographic information, as well as data on travel behavior and travel patterns. These data were then used to estimate a random parameters ordered probit model of their likelihood of renting their car. Some of the variables found to be statistically significant determinants

of the willingness to rent a personal vehicle were gender, age, income, household composition, vehicle ownership, living location with respect to a grocery store, and participation in other shared mobility modes. The above findings and especially the gender and income-related variables were found to complement prior literature and offered an additional layer of understanding of the factors determining the supply side of peer-to-peer carsharing. The findings of this study offer some initial insights into the factors that may determine the success or failure of this novel transportation alternative.

The team has refined the leisure activity and social capital survey and completed data collection for the survey. A new sampling plan was formulated using three different internet panel sources (Qualtrics Panels, Mechanical Turk, and Prolific). The web-based survey was also modified to tailor it to both PC and mobile users based on the platform used by the respondent. Survey data collection occurred during November and December 2019 with a sample of approximately 1300 respondents. The team compiled the dataset and began the preliminary analysis of the impacts of social capital on leisure activity diversity. Preliminary results show that social capital (access to social resources) is correlated with greater leisure activity diversity. Additionally, access to instrumental social resources was found to impact leisure activity diversity more than expressive/emotional support resources. Over the next quarter, the project team will produce a working paper to communicate these results as well as to conduct a sensitivity analysis of the effect size of social capital on leisure activity diversity.

Finally, the team began a data collection and analysis effort to understand the zero-price effect on preferences for free electric vehicle charging. The project team has designed two stated preference surveys exploring this effect including a charger choice experiment and a vehicle purchase bundle experiment. A preliminary trial survey was conducted using the charger choice experiment. Results showed that a free-price effect could be observed. Preliminary results showed an approximate $1.50 value for each free charge event. The team also continued to develop the survey design and is currently developing a sampling plan combining a probability-based Internet panel sample with a non-probability-based internet panel. Over the next quarter, the research team will conduct the data collection effort to establish a distributional estimate of a free-price effect for public electric vehicle charging.

Project Title: Attitudes and Trust in Leveraging Integrated Sociotechnical Systems for Enhancing Community Adaptive Capacity: Project Phase III
PI: Cynthia Chen, UW; Co-PI: Daniel B. Abramson, UW
Description of Progress: The overarching goal of the project is to understand, model and develop ways in which communities can leverage unique – and interconnected – physical and social resources of place to enhance their adaptive capacity. This current phase builds upon findings from previous project phases, including a pilot survey and follow-up full-community surveys, to implement a full-scale sample survey focused on issues of social connectivity, trust, place attachment, and disaster preparedness and response, in relation to different modes of transportation and communication services. Understanding the interactions among these three aspects of the community will provide data to inform strategies for enhancing community adaptive capacity in future phases.

During this reporting phase, data recording and analysis from a full-scale community resilience survey in Laurelhurst, Westport, and South Park were conducted. The other major accomplishment during this phase is the implementation of Wave 2 of the COVID-19 follow-on survey (separate from the COVID Future Survey). On April 20, the team launched a second 10-question follow-up survey that included some preparedness questions from the previous survey as well as some new questions about behavioral changes in the context of the COVID-19 epidemic. The survey was sent to respondents from the Laurelhurst, South Park and Westport communities who had indicated in the previous survey that they would be interested in participating in future waves of the survey. The team also asked people if they would be willing to continue to participate in future waves of the survey over time, with an intent to collect ephemeral longitudinal data as the epidemic unfolds.

Findings to date reveal a negative association between the level of concern and actual disaster preparedness, while the willingness to share is most strongly influenced by trust. Additional observed relationships between trust, place attachment and community social network size suggest a need for further research in this area. A better understanding of willingness to share and available resources at the community level can help to inform both grassroots efforts and more formal disaster preparedness efforts involving targeted interventions by organizations. More in-depth analysis of the survey results and dissemination via presentations, workshops, and publications are upcoming tasks.

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 semesters of 2020 (that spans the reporting period covered by this SAPR). Please note that the courses offered during spring 2020 have been reported in the previous SAPR. Table 2 offers a detailed summary of the courses offered by faculty members closely affiliated with the TOMNET center.

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

Table 2. Courses Offered by Mission-Critical Faculty Members of TOMNET (Spring and Summer 2020)

Semester	Course Level	Course No	Course Title	No	Instructor	Unit
			Arizona State University			
Fall 20	Undergrad	ASU101	The ASU Experience	18	Pendyala	SSEBE
Fall 20	Under/ Grad	PUP430/550	Transportation Planning and the Env	78	Salon	SGSUP
Fall 20	Grad	PUP642	Urban Economics	35	Salon	SGSUP
			Georgia Institute of Technology			
Fall 20	Grad	CEE6623	Transportation Survey Methods	15	Mokhtarian	CEE
			University of South Florida			
Fall 20	Grad	TTE6507	Travel Demand Modeling	6	Maness	CEE
Fall 20	Grad	TTE6307	Statistical and Econometric Methods I	11	Mannering	CEE
			University of Washington			
Fall 20	Grad	CET581	Travel Demand Forecasting	15	Chen	CEE
Fall 20	Under/ Grad	URBDP424/524	Site Planning: Issues & Techniques	23	Abramson	Urban Pln

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

In addition, TOMNET faculty supervised a number of students and post-doctoral scholars, providing them guidance and mentorship necessary to pursue independent research and discovery. Students engaged in TOMNET related research and education activities are listed in Table 3. Besides graduate students pursuing Master's and PhD degrees, the TOMNET consortium engages six undergraduate students in various research endeavors in an effort to provide research experiences for undergraduate students and inspire them to pursue advanced studies and a career in transportation systems engineering and planning.

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

Name of Scholar	Level	Major/ Unit	Supervisor/ Advisor
	ARIZONA STATE UNIVERSITY		
Irfan Batur	PhD Student	SSEBE	Pendyala
Amanda Minutello	Undergrad	SSEBE	Pendyala
Tae Hooie Kim	PhD Student	SSEBE	Pendyala

Tassio Bezerra Magassy	PhD Student	SSEBE	Pendyala
Shivam Sharda	PhD Student	SSEBE	Pendyala
Denise Capasso da Silva	PhD Student	SSEBE	Pendyala/Khoeini
Matthew Wigginton Conway	PhD Student	SGSUP	Salon
Alexis Ross	Undergrad	Economics	Salon
Nathan Harness	Undergrad	SSEBE	Salon
Laura Mirtich	Undergrad	SOLS	Salon
Shuyao Hong	PhD Student	SGSUP	Salon
GEORGIA INSTITUTE OF TECHNOLOGY			
Gwen Kash	Postdoc	CEE	Mokhtarian
Yongsung Lee	Postdoc	CEE	Circella
Sungtaek Choi	Postdoc	CEE	Circella
Ali Etezady	PhD Student	CEE	Circella/Mokhtarian
Alyas Widita	PhD Student	SCaRP	Circella
Xinyi Wang	PhD Student	CEE	Mokhtarian
Faaiqa (Atiyya) Shaw	PhD Student	CEE	Mokhtarian
Sung Hoo Kim	PhD Student	CEE	Mokhtarian
Yun-Hsuan (Grace) Chen	MS Student	SCaRP/CEE	Circella
Kara Todd	MS Student	CEE	Circella
UNIVERSITY OF SOUTH FLORIDA			
Asim Alogaili	Grad Student	CEE	Mannering
Suryaprasanna Balusu	Grad Student	CEE	Mannering/Pinjari
Natalia Barbour	Postdoc	CEE	Maness
Nawaf Alnawmasi	Grad Student	CEE	Mannering
Trang Luong	Grad Student	CEE	Maness
Divyamita Mishra	Grad Student	CEE	Maness
Nameetha Ramachandra	Grad Student	BAIS	Maness
Lori Palaio	Grad Student	CEE	Bertini/Maness
Madisen Kerr	Undergrad	CEE	Maness
Tung Vo	Grad Student	CEE	Maness
Dr. Nikhil Menon	Postdoc	CEE	Maness/Bertini
UNIVERSITY OF WASHINGTON			
Katherine Idziorek	PhD Student	Urban Planning	Chen/Abramson
Matthew Bloch	Undergrad	CEE	Chen/Idziorek
James Eager	Masters Student	Urban Planning	Abramson/Idziorek
Xi Zhu	PhD student	CEE	Chen

In the *technology transfer* domain, Arizona State University continued the weekly **TOMNET webinar series** that is presented to a worldwide audience. Due to the pandemic, the pace and frequency of seminars was deliberately reduced to avoid virtual meeting/webinar overload. Table 4 presents a list of ASU TOMNET-sponsored seminars for the period covered by this SAPR. These events are advertised widely and very well attended. It should be noted that other TOMNET partner institutions have transportation webinar series that are open to the public and professionals in the community (also impacted by the pandemic). ASU and other TOMNET partners have organized a series of fully online webinars for the next reporting period as well to respect safety protocols as well as advance the technology transfer mission of TOMNET. Forthcoming webinars organized by ASU are listed here.

Table 4. Key TOMNET-Sponsored Technology Transfer Events

Institution	Title of Seminar/ Webinar	Speaker Name and Affiliation	Date	No.
ASU	Towards Intelligent Transportation in Smart Cities: Flocking Control of Connected and Automated Vehicles	Yan Chen, Assistant Professor, The Polytechnic School, ASU	April 23, 2020	45
ASU	ASU COVID-19 Transportation Survey: Results and Insights	Deborah Salon, Associate Professor, School of Geographical Sciences and Urban Planning, ASU	May 7, 2020	110

ASU	The ABCs of Future Mobility (TOMNET T4 Survey Showcase)	Ram M. Pendyala, Denise Capasso da Silva, Deborah Salon and Sara Khoeini, ASU Yongsung Lee, Giovanni Circella, and Patricia Mokhtarian, GT Nikhil Menon and Michael Maness, USF Katherine Asmussen, Shuqing Kang and Chandra Bhat, UT	June 12, 2020	120
ASU	The Future of Transportation Engineering	Imad L. Al-Qadi, PhD, PE, Dist.M.ASCE Professor of Civil and Environmental Engineering, University of Illinois at Urbana-Champaign	Sep 29, 2020	30
USF	Cooperative Control of Connected and Automated Vehicles at General Conflict Areas	Xiaopeng Li, Associate Professor, Civil and Environmental Engineering, USF	Sep 4, 2020	18
USF	The impacts of the automated vehicles on future traffic flow	Xiaowei Shi, PhD student, Civil and Environmental Engineering, USF	Sep 11, 2020	19
USF	A Transit-Oriented Highway	Ming Gao, Modal Development Administrator, Florida Department of Transportation, District 7	Sep 18, 2020	18
USF	Infrastructure and Mobility in the City of Tampa	Jean Duncan, Infrastructure and Mobility Administrator, City of Tampa	Sep 25, 2020	22

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

TOMNET faculty members are heavily engaged in technology transfer. To present results from the T^4 survey on emerging transportation technologies, all TOMNET team members took part in a 5-hour webinar (The ABCs of Future Mobility) event on June 12, 2020. The recording of the meeting and the presentation files are available on the TOMNET website at this link. Moreover, Dr. Salon, Associate Director of TOMNET and lead PI of the COVIDFUTURE survey presented initial findings of the survey (which is partially sponsored by TOMNET) describing the impact of the pandemic on current and future travel behavior. The recording of this event plus more information about the project, blog posts, link to the next phase of the survey, and the research team can be found on the project website.

TOMNET offered a two-day workshop that provides in-depth coverage of Highway Capacity Manual (HCM) procedures – including updates in the HCM 6th Edition, during May 19-21, 2020. The class was held virtually. Step-by-step instruction of the HCM methodologies was provided for each analytical chapter of the HCM. Attendees undertook hands-on exercises with the Highway Capacity Software (HCS) which automates the HCM procedures.

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

Organizing Institution	Title of Workshop or Short Course	Workshop Instructors	Date of Event	Location of Event	Number of Attendees
ASU	Highway Capacity Analysis	William M. Sampson, PE, University of Florida	May 19-21, 2020	Zoom	20

What do you plan to do during the next reporting period to accomplish the goals?
TOMNET has a number of activities planned for the next reporting period to ensure rapid growth in the portfolio of accomplishments of the center. In the research domain, TOMNET faculty members will continue making progress on research projects and the results will be disseminated widely through various channels. TOMNET team members were supposed to meet during this reporting period at Georgia Tech to talk about TOMNET Center plans, including selection of projects for the upcoming year. However, this meeting has been canceled due to COVID-19 and has been postponed to the next reporting period. In the meantime, the TOMNET leadership team had a short virtual meeting on April 13th.

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

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

Discussions are underway to organize a symposium, called the A^4 Symposium. This symposium will focus on Attitudes, Automation, Autonomy, and Access (hence, A^4) and bring together the many key themes addressed by TOMNET. TOMNET will be launching a data science challenge, inviting students from around the world to participate in a data challenge and student paper competition. Students will be required to submit entries that aim to enhance the profession's understanding of the relationships between traveler attitudes, behaviors, perceptions, and preferences, while clearly explaining how their submissions can be translated into real-world tools and models that can be implemented in planning agencies to advance the state-of-the-practice. This data challenge and student paper competition were planned to be launched in Spring 2020, potentially in conjunction with A^4 symposium. These initiatives have also been postponed to the next reporting period due to the current pandemic.

TOMNET scholars will continue to engage in considerable K-12 outreach activities. Due to the pandemic, TOMNET in-person summer outreach activities were canceled. As a substitute, Dr. Sara Khoeini and Dr. Ram Pendyala, with the assistance of TOMNET PhD student Irfan Batur, are designing online outreach modules for high school students. These modules will have interesting field activities such as completing and analyzing a household travel survey, traffic count and signal timing analysis, and global transportation research topics such as climate change. The goal is to inspire high school students to pursue a career in transportation. These modules will be provided to a group of Arizona high school students in collaboration with an education initiative at ASU. After successful implementation and potential revisions, the modules will be posted on the TOMNET website so that other universities and stakeholders can take advantage of them during and after the COVID-19 pandemic. Moreover, Dr. Giovanni Circella is teaching a short online training course on "quantitative methods for transportation planning", organized by the Libera Università Mediterranea Jean Monnet University in Italy, which serves as an important workforce development institution and encourages students to choose a career in transportation.

The multi-city TOMNET survey is largely complete (more responses need to be collected from the Tampa Bay region of Florida), and the existing data set has been compiled, cleaned, and weighted. The current data set comprises 3740 complete responses from across four southern metro areas. The first outreach event for this project was conducted during a one-day (June 12, 2020) series of webinars, with participation of all project researchers from all four participating universities. Furthermore, TOMNET team members are creating final reports for each location, a summary paper, and more in-depth publications addressing specific research questions. Therefore, it is envisioned that during the next reporting period, the results of the survey will be disseminated widely through different channels including, but not limited to, presentations at local agencies as well as national and international conferences, research briefs, project reports, and academic journal papers.

TOMNET will heavily engage in analyzing the impacts of COVID-19 on human activities and travel behavior, attitudes towards work-from-home and online shopping, impact on disadvantaged groups, use of various transport modes including air travel, and other remote activity engagement. Two of the existing TOMNET projects (No. 10 and 24 in Table 1) are exploring the impacts of COVID-19 on community

responsiveness and travel behavior and lifestyle attitudes. Collected data for project no. 10, and the results from both efforts will continue to be disseminated during the next reporting period. The goal of these projects is to shed light on people's perceptions and behaviors during and after the pandemic to make effective and helpful policies and decisions.

Another major task that is in the planning phase is to collect a new survey on people's perceptions toward electric vehicle purchase and use. While the featured T^4 survey covered shared and automated aspects of transportation futures, this survey will cover electrification which is a technology already available in the market and can advance the cause of sustainability. Discussions are also ongoing to add several questions related to health and wellbeing to the survey with the goal of connecting these research efforts to people's quality of life, which eventually matters the most.

2. PARTICIPANTS & COLLABORATING ORGANIZATIONS

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

What organizations have been involved as partners?
- Maricopa Association of Governments, Phoenix, Arizona: In-kind support, data, collaborative research
- Atlanta Regional Commission, Atlanta, Georgia: Planning has begun for collaborative research and personnel exchange but suspended due to the pandemic.
- Georgia Department of Transportation, Atlanta, Georgia: In-kind support, data sets, collaborative research, funding of matching-project 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
- University of Illinois, Chicago: Collaborative research
- National Science Foundation: Financial support
- Knowledge Exchange for Resilience: Financial support
- CONVERGE: Financial support
- Oak Ridge National Laboratory – National Transportation Research Center: Collaborative research
- University of Leeds: Collaborative research
- University of Warsaw: Collaborative research
- South Park Information and Resource Center
- Washington Emergency Management Division
- Washington State Parks
- Shoalwater Bay Tribe
- Westport Police Department
- Grays Harbor County Emergency Management
- South Beach Regional Fire Authority
- Ocosta Public School District
- University of Washington School of Public Health

- Seattle Emergency Hubs
- Northwest Healthcare Response Network
- International Association for Travel Behavior Research

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

Have other collaborators or contacts been involved?
- Professor Chandra Bhat, the University of Texas at Austin, TX
- Professor Abolfazl Mohammadian, University of Illinois-Chicago, IL
- Professor Sybil Derrible, University of Illinois-Chicago, IL
- Professor Laurie Garrow, Georgia Tech, Atlanta, GA
- Professor Brian German, Georgia Tech, Atlanta, GA
- Professor Joseph Saleh, Georgia Tech, Atlanta, GA
- Professor Patrick Singleton, Utah State University, Logan, UT
- Professor Lauren Steimle, Georgia Tech, Atlanta, GA
- Professor Dima Nazzal, Georgia Tech, Atlanta, GA
- Professor Timor Besedes, Georgia Tech, Atlanta, GA
- Jia Tang, PhD student from Nanjing University
- Professor Rolf Moeckel, Technical University of Munich, Germany
- Professor Alejandro Tirachini, University of Chile, Chile
- Professor Konstadinos Antoniou, Technical University of Munich, Germany
- Professor Barbara Lenz, German Aerospace Institute

TOMNET works closely with members of the D-STOP University Transportation Center at the University of Texas at Austin. A key element of the strategic partnership between the two centers is the participation of D-STOP in the multicity T^4 survey on attitudes towards and adoption of transformative technologies in transportation. TOMNET team members are pursuing close working relationships with other University Transportation Centers, including the Regional UTC in the Pacific Northwest, the National UTC led by the University of California at Davis, and the Regional UTC in Region 9 led by the University of Southern California.

One major collaboration that was initiated during the last reporting period is between ASU and the University of Illinois at Chicago (UIC), specifically involving Dr. Deborah Salon, Dr. Ram Pendyala, and Dr. Sara Khoeini from ASU and Dr. Abolfazl Mohammadian and Dr. Sybil Derrible from UIC. This collaboration, aimed at understanding the impact of COVID-19 on people's lives, activities, attitudes, and future behaviors, has resulted in the administration of a nationwide survey and analysis of survey data to understand what a post-pandemic future might look like. The research team members meet every Monday to discuss the research plan and progress, with a view to find insights and solutions that can decrease the negative impacts of the pandemic for various segments of the population and help agencies plan for an uncertain future.

Another key collaboration involves TOMNET Senior Researcher, Dr. Giovanni Circella, working with a group of researchers to write a chapter reviewing COVID-19 transportation research to date, under the auspices of the World Conference for Transport Research Society (WCTRS).

3. OUTPUTS

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

Arizona State University
Papers Published Within Reporting Period
1. Devaraj, A., Ramakrishnan, G.A, Nair, G.S., Srinivasan, K.K., Bhat, C.R., Pinjari, A.R., Ramadurai, G., & Pendyala, R.M. (2020). Joint model of application-based ride hailing adoption, intensity of use, and intermediate public transport consideration among workers in Chennai City. *Transportation Research Record 4,* 2647, 152-164.
2. Dias, F.F., Lavieri, P.S., Sharda, S., Khoeini, S., Bhat, C.R., Pendyala, R.M., Pinjari, A.R., Ramadurai, G., & Srinivasan, K.K. (2020). A comparison of online and in-person activity engagement: The case of shopping and eating meals. *Transportation Research Part C: Emerging Technologies 114,* 643-656.
3. King, D., Conway, M., & Salon, D. (2020). Do for-hire vehicles provide first mile/last mile access to transit? *Transport Findings*, DOI: 10.32866/001c.12872.
4. Mondal, A., Bhat, C.R., Costey, M.C., Bhat, A.C., Webb, T., Magassy, T.B., Pendyala, R.M., & Lam, W.H.K. (2020). How do people feel while walking? A multivariate analysis of emotional well-being for utilitarian and recreational walking episodes. *International Journal of Sustainable Transportation*, 1-16.
5. Nair, G.S., Bhat, C.R., Batur, I., Pendyala, R.M., & Lam, W.H.K. (2020). A model of deadheading trips and pick-up locations for ride-hailing service vehicles. *Transportation Research Part A: Policy and Practice 135,* 289-308.

Presentations Within Reporting Period
1. Salon, D. (2020, May). *Will we ever "go back" to our pre-COVID way of life? Not completely, initial results suggest.* Presented at TOMNET webinar series, Online.
2. Salon, D. (2020, June). Home and neighborhood preferences and choices. Presented at the ABCs (Attitudes – Behaviors – Choices) of Future Mobility TOMNET webinar, Online.
3. Pendyala, R.M., Silva, D.C. & Khoeini, S. (2020, June). Project overview and results from the initial Phoenix pilot survey. Presented at the ABCs (Attitudes – Behaviors – Choices) of Future Mobility TOMNET webinar, Online.
4. Khoeini, S. (2020, June). Autonomous vehicles: Familiarity, awareness, and perceptions. Presented at the ABCs (Attitudes – Behaviors – Choices) of Future Mobility TOMNET webinar, Online.
5. Khoeini, S. (2020, June). Exploring willingness to pay for autonomous vehicles. Presented at the ABCs (Attitudes – Behaviors – Choices) of Future Mobility TOMNET webinar, Online.
6. Salon, D. (2020, August). How will the COVID-19 pandemic affect the future of transport? Presented at Bridging Transport Researchers Conference, Online.
7. Silva, D.C., Khoeini, S., Salon, D., & Pendyala, R.M. (2020, August). Impacts of COVID-19 pandemic on long-distance air trips: A look at American's expectations. Presented at Bridging Transportation Researchers (BTR) Conference, Online.

Other Publications Within Reporting Period
1. Humberd B, Salon D, and Latham S. (2020). The office is dead! Long live the office in a post-pandemic world. Online.
2. Ram Pendyala. (2020). The Long View: COVID-19 Impacts on Human Activity-Travel Patterns-Part 1. Medium. Online.
3. Ram Pendyala. (2020). The Long View: COVID-19 Impacts on Human Activity-Travel Patterns-Part 2. Medium. Online.

Georgia Tech
Papers Published Within Reporting Period
1. Kim, S.H., P.L. Mokhtarian, & G. Circella (2020). Will autonomous vehicles change residential location and vehicle ownership? Glimpses from Georgia. *Transportation Research D 82,* 102291.
2. Kim, S.H., P.L. Mokhtarian, & G. Circella (2020). How, and for whom, will activity patterns be modified by self-driving cars? Expectations from the state of Georgia. *Transportation Research Part F: 70,* 68-80.
3. Choi, S. & P. L. Mokhtarian (2020). How attractive is it to use the internet while commuting? A work-attitude-based segmentation of Northern California commuters. *Transportation Research Part A 138*, 37-50.
4. Tang, J., F. Zhen, & P.L. Mokhtarian (2020). How do passengers allocate and evaluate their travel time? Evidence from a survey on the Shanghai–Nanjing high speed rail corridor, China. *Journal of Transport Geography 85*, 102701.

Presentations Within Reporting Period
1. Mokhtarian, P.L. (2020, September). Panel webinar: The new reality of teleworking: People, firms, places. OECD & Regional Studies Association (112 attendees from 25 countries).
2. Mokhtarian, P.L. (2020, August). The adoption and travel impacts of teleworking: Will it be different this time? Community Planning Association of Southwest Idaho.

3. Mokhtarian, P.L. (2020, July). The adoption and travel impacts of teleworking: Will it be different this time? New Mobility virtual luncheon, Bay Area, California.
4. Mokhtarian, P.L. (2020, July). How attractive is it to use the internet while commuting? TU Delft TRAIL (Research School for Transport, Infrastructure and Logistics) Seminar.
5. Mokhtarian, P.L. (2020, July). The adoption and travel impacts of teleworking: Will it be different this time? AITPM webinar, Melbourne Australia.
6. Mokhtarian, P.L. (2020, June). Keynote speaker: The Adoption and Travel Impacts of Teleworking: Will it be Different this Time? Transformative Transportation '20 - the iCity CATTS (Centre for Automated and Transformative Transportation Systems) Symposium hosted by the University of Toronto.
7. Mokhtarian, P.L. (2020, May). The adoption and travel impacts of teleworking: Will it be different this time? Webinar for the Eno Center for Transportation. Online.
8. Circella, G. (2020, October). Policy Measures for Addressing the Impacts of COVID-19 in United States, Asian Development Bank Institute (ADBI)-Chubu University Conference on Transport Infrastructure Development, Spillover Effects and Quality of Life.
9. Circella, G. (2020). The Impacts of the COVID-19 Pandemic on Travel Behaviors, Caltrans Planning Horizons. Online.
10. Circella, G. (2020, September). Emerging Transportation Technologies and Trends in California, Fueling the Future Conference: Pure Electric and Beyond, German American Chamber of Commerce, online conference.
11. Circella, G. (2020, September). The COVID-19 Pandemic: What Does It Mean for Mobility? What the Temporary vs. Longer-term Impacts? Modeling Task Force Meeting, Southern California Association of Governments, online meeting
12. Circella, G. (2020, July). The Impacts of the COVID-19 Pandemic on Mobility, COVID Response: Lessons for Climate Action, Capital Region Climate Readiness Collaborative Quarterly Meeting. Online.
13. Circella, G. (2020, July). Opportunities and Challenges for the Three Transportation Revolutions, California Energy Commission 2020 Integrated Energy Policy Report Update. Online.
14. Circella, G. (2020, June). Comparison of Alternative Survey Recruitment/Deployment Methods, The ABCs (Attitudes – Behaviors – Choices) of Future Mobility, TOMNET online webinar. Online.
15. Circella, G. (2020, June). The Integration of MPO Models into the Georgia Statewide Travel Demand Model (GSTDM), ARC Model Users Group Meeting, Atlanta Regional Commission.
16. Chen, Y. H. (2020, September). Substitution or Complementarity? Ridehailing Impacts on Other Travel Modes, presentation in the UC Davis 3 Revolution Future Mobility Online Webinar.

University of South Florida
Papers Published Within Reporting Period
1. Barbour, N., Zhang, Y., Mannering, F. (2020). Individuals' willingness to rent their personal vehicle to others: An exploratory assessment of peer carsharing. *Transportation Research Interdisciplinary Perspectives 5, 100138*, 1-7.
2. Alogaili, A. Mannering, F. (2020). Unobserved heterogeneity and the effects of driver nationality on crash injury severities in Saudi Arabia. *Accident Analysis and Prevention 144, 105618*, 1-8.

University of Washington
Papers Published Within Reporting Period
1. Feng, J., Huang, S., and Chen, C. (2020). Modeling user interaction with app-based reward system: a graphical model approach integrated with max-margin learning. *Transportation Research Part C, 120*, 102814.
2. Abramson, D. B. (2020). Ancient and current resilience in the Chengdu Plain: Agropolitan development re-visited. *Urban Studies*, *57*(7), 1372-1397.
Presentations Within Reporting Period
1. Abramson, D. (June 2020). Community Engagement for Place-sensitive Resilience Planning: Multi-scenario Hazards Workshops, ArcDR³ Forum: New Agendas for Regenerative Urbanism.
2. Idziorek, K. (July 2020). Understanding the Potential for Resource Matching in Community Disaster Preparedness. Natural Hazards Center Researchers Meeting.
3. Idziorek, K. (July 2020). Social Ties, Attitudes, and Community Scale Disaster Preparedness, 45th Annual Natural Hazards Research & Applications Workshop.
Other Research Outputs Within Reporting Period
1. Idziorek, K. "Op-Ed: Preparing for the Next Disaster: Looking Beyond COVID-19 Toward Multi-Hazard Approaches to Transportation Planning." *Eno Transportation Weekly*.
2. Chen, C. "Pushing our cities to be smarter, healthier and more efficient for all." Healthy Planet, Healthy People. University of Washington Population Health.

In summary, TOMNET core faculty generated 13 journal publications within the reporting period covered by this SAPR. These journal publications are directly attributable to funding provided by the TOMNET UTC. During the reporting period of this SAPR, the TOMNET researchers presented 26 papers and presentations at various venues. The two highlights of outputs are the TOMNET webinar "[ABCs (Attitudes – Behaviors – Choices) of Future Mobility](#)" which summarizes the findings of the T^4 survey in a series of presentations delivered by key TOMNET team members. The results were presented primarily by *students*, thus providing them rich experience in delivering a virtual presentation to a worldwide audience. The recorded video and all presentation are available on the TOMNET website. The second highlight is the considerable number of presentations and publications related to the COVID-19 pandemic and its impact on travel behavior (produced by TOMNET core team members). More publications and presentations relevant to the pandemic and new transportation technologies will be produced and disseminated during the next reporting period. Lastly, all TOMNET seminars and webinars have been recorded, streamed live, and archived on the TOMNET website for the general public. The seminar recordings can be accessed [here](#).

Website(s) or other Internet site(s)

One major product of the center is the [TOMNET website](#) that has been significantly updated during the reporting period. The website domain has moved to engineering.asu.edu which has more in-house technical support. The project section of the website has been noticeably updated by including all of the project scopes that are active or completed, and all of the reports/deliverables for the completed projects. More importantly, the link to the TOMNET COVID-19 survey is embedded on the first page of the website, enabling visitors to participate in the ongoing COVID-19 study (No. 1 in Table 1). Moreover, links to the two major TOMNET webinars are available on the home page. It is worth mentioning that the [COVID-19 website](#) was created during this reporting period, serving as a home to information about the COVID-19 project and featuring periodic blog posts that provide insights from the survey results on a continuous basis. The COVID-19 survey data will be made available to the public in the next reporting period.

Software Programs, Codes, and Products

TOMNET projects aim to collect rich attitudinal and behavioral data sets, enable fusion of the collected data with other existing or third-party data sets, and development of insightful models and tools that can be used to enhance policy and planning decisions that advance quality of life for all in communities across the nation. As noted in prior progress reports, the TOMNET team at ASU has been heavily involved in the development and application of open source tools that reflect model outputs of the TOMNET projects. So far, the beta version of the synthetic population generator called PopGen, the alpha version of the integrated Household Energy Analysis Tool (iHEAT), and the final models of the Wellbeing Estimator for Activities and Travel (WBEAT) have been created. These tools have been explained in previous reports in detail. Final versions of these tools will be developed in open-source format and will be posted on the TOMNET website. Moreover, R and Python codes associated with other TOMNET transportation model estimation and implementation efforts as well as data fusion procedures are being documented and will be posted to the TOMNET website. In particular, these software codes will enable the estimation of advanced econometric choice models (such as integrated choice latent variable or ICLV models) that are most suited to jointly modeling attitudes and behaviors in a simultaneous equations framework.

Databases and Research Materials

In a number of TOMNET projects, integrated datasets have been developed (or are under development) using data fusion techniques with a view to studying the impact of attitudes on different transportation-related choices such as residential location choice, mode choice, vehicle ownership, and adoption of emerging mobility services and automated vehicle technologies. Some of the data sets are based on native

survey data collection efforts undertaken by the TOMNET team. Other data sets have been assembled by integrating and fusing data that is already available in the public domain. All data sets assembled by TOMNET will be made available (without personally identifiable information) via the TOMNET website for the broader community. Over the past year, TOMNET has collected a large dataset on attitudes and perceptions toward new transportation technologies with rich sets of questions covering respondents socioeconomic attributes, attitudes, and travel characteristics (3740+ responses). After a comprehensive analysis of the data, data sets will be released for public use. In the meantime, the findings from the survey will be disseminated to the community through a series of webinars and research papers.

The University of Washington team has collected data on how communities access information and respond to disaster situations and crises. They have also added a follow-up survey to ask about community resilience during the COVID-19 pandemic. This survey and protocols for engaging with community groups constitute products that the TOMNET team envisions making available to any organization or agency that may wish to collect such data from their local communities.

Moreover, the COVID-19 survey data, which is being collected as part of a joint project of Arizona State University and the University of Illinois Chicago with support from the National Science Foundation and TOMNET, will produce a longitudinal database documenting various impacts of COVID-19 on people's lives across the United States. These impacts include current and future trends of telecommuting, e-shopping, mode choice, air travel, and income and employment. The dataset and analytical products will be key outputs that TOMNET will produce to help address the challenges that the pandemic has brought about. The dataset is planned to be released to the public during the next reporting period after the final phases of data cleaning and weighting.

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

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

Table 6. TOMNET Metrics on Products

Metric	Annual Target	Previous Reporting Period	This Reporting Period	Annual Total	Assessment
Number of software products, data sets, or model specifications released	2	1	1	2	Datasets are being cleaned, weighted, and documented. The codes are in beta versions.
Number of publications in refereed journals	15	14	13	27	Greatly exceeded annual target.

4. OUTCOMES

Increases in the body of knowledge
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 T^4 survey, and subsequent publications documenting survey results, will help provide critical information that agencies need to minimize the potential negative impacts and maximize the potential positive impacts of new transportation technologies.

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

Moreover, TOMNET research is resulting in increases in the body of knowledge related to behaviors around online shopping, ride hailing, and transit usage; emotional wellbeing associated with walking; willingness to share ride hailing trips; millennials' value of time; the impact of automated vehicles on residential location, vehicle ownership, and travel patterns; willingness to rent personal vehicles; and driver heterogeneity in the safety domain.

Lastly, TOMNET researchers are studying the potential impacts of COVID-19 on people's travel behavior, time use, and activities before, during, and after the pandemic to help decision-makers plan and adapt transportation systems to the crisis. The COVID-19 dataset will be released to the public during the next reporting period 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.

Improved techniques in addressing transportation issues

The analysis of the data collected in the T^4 Survey is already contributing to improved planning processes and informing policymakers about very important trends that are quickly reshaping mobility patterns. The TOMNET team is developing new techniques for crafting future automated vehicle and shared mobility scenarios for analysis in travel demand forecasting exercises. These scenarios are informed by the data collected in the survey, thus providing forecasts of scenarios that are more likely to play out. Techniques for developing scenarios and analyzing the scenarios are being developed for potential implementation in real-world travel demand forecasting models. Currently, travel demand models are not equipped to generate meaningful and empirically driven scenarios, and the techniques developed by TOMNET will help fill this gap. In addition, TOMNET developed an integrated household energy analysis tool and an integrated wellbeing analysis tool, both of which incorporate techniques and algorithms that can be implemented in conjunction with existing travel demand forecasting models and planning processes. The team has also developed novel methods for fusing data from targeted marketing firms with data from traditional household travel surveys; this results in highly enriched data that can be used to advance more accurate travel forecasts. Moreover, this project increased awareness of the importance of attitudes in shaping individual transportation decisions and is improving the ability of regional travel demand forecasting models to incorporate attitudinal variables so that predictions of behavioral trends and responses to policy are more accurate.

Enlargement of the pool of trained transportation professionals

TOMNET has been very successful and productive in engaging undergraduate and graduate students, besides post-doctoral researchers. TOMNET trainees include minorities and women, and the number of students engaged in TOMNET activities has grown considerably. These students are unlikely to have been involved in transportation research and education in the absence of TOMNET. The updated TOMNET website now includes the name, affiliation, degree, and profile pictures of all 64 students and scholars that have been deeply engaged in TOMNET research during their education. Additionally, TOMNET is actively disseminating research outputs through various channels and conducting short courses, thus enlarging the pool of "trained" transportation professionals. TOMNET has been tracking progress in achieving outcomes relative to targets established in the Technology Transfer Plan. A summary of progress is shown in Table 7 for two metrics.

Table 7. TOMNET Metrics on Products

Metric	Annual Target	Previous Reporting Period	This Reporting Period	Annual Total	Assessment/notes
Number of participants in workshops and short courses	50	22	20	44	This number does not include number of attendees at regular TOMNET webinars.
Number of students/scholars participating in TOMNET research	50	42	38	47	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?

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

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

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

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

ASU/GT/USF: Results from the **T⁴ Survey** are helping to craft realistic future scenarios that can drive travel forecasts. Several agencies have expressed interest in adopting and implementing the integrated household energy analysis tool (iHEAT) and well-being estimation and analysis tool (WBEAT). TOMNET research has also led to improved specification of transportation forecasting models in agencies by demonstrating the presence of market segments that follow different causal structures in decision-making and have different proclivities towards multitasking. 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).

UW: The community resilience project is building upon earlier work to test and promote an appreciative inquiry approach to disaster mitigation planning that highlights community strengths over vulnerabilities. Such an approach to hazard planning has the potential to help communities develop mitigation strategies

that will benefit them on an everyday basis as well as in the case of a disaster. Communities in the State of Washington have expressed interest in using the attitudinal and social resources data collected through the resilience study to help inform their own disaster management and recovery plans as well as their regular day-to-day services that they provide to their communities.

What is the impact on the body of scientific knowledge?

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

UW: The community-engaged workshops and the survey instruments that are being developed through the community resilience project is informing the body of knowledge on region-wide resilience strategies. By engaging both urban and rural communities, TOMNET is providing a better understanding of the differences in the needs of diverse communities representing a range of demographic and socioeconomic profiles. Within the fields of urban and hazard mitigation planning, for example, the further development of appreciative inquiry-based approaches for hazard mitigation planning is an emerging area that holds much promise for informing future hazard planning processes that can better take local needs, resources, knowledge, and strengths into account. Furthermore, the collection of ephemeral data during the COVID-19 epidemic will help to build an understanding of household- and community-level preparedness actions and attitudes in pandemic scenarios (which has been completely unknown thus far).

GT: As part of TOMNET-supported research activities, researchers at Georgia Tech investigated the potential impact of automated vehicles (AVs) on future vehicle ownership and residential location decisions. Although more than half of respondents expected "no change" in either of these decisions due to AVs, it has been found that younger, lower-income, pro-suburban, and pro-non-car-mode individuals were more likely to anticipate changing their selections. Notably different effects between Atlanta and non-Atlanta-region residents were found, signifying the existence of substantial geography-related taste heterogeneity. These results will provide useful insight to planners seeking to understand and prepare for longer-term changes brought about by AVs. A second TOMNET project investigated the prospects of recruiting respondents to a new survey from among those who completed a previous survey and expressed a willingness to be surveyed again. Such a practice can reduce the recruitment costs and effort arising from declining survey response rates but may exacerbate biases in the resulting samples. In this study, TOMNET researchers applied a probit with sample selection (PSS) model to analyze respondents' willingness to participate in a follow-up survey and their actual response behavior once contacted. The team found the existence of self-selection biases related to respondents' sociodemographic characteristics, their travel behavior, and item nonresponse to sensitive variables. It was found that age, homeownership, and medical conditions significantly impacted the relationship between respondents' willingness to participate in a future survey and their actual response behavior to that future survey. Overall, TOMNET research results can help future developers of transportation surveys, including academic researchers and practicing planners, to better understand and address such biases.

What is the impact on transportation workforce development?

Since TOMNET was established at the end of 2016, more than 60 undergraduate, graduate, post-doctoral, and visiting research scholars have conducted research and received education under the umbrella of TOMNET. The complete list of [TOMNET students and scholars](#) has been updated on the website. The diversity of their profile in terms of gender, age, degree, and nationality advances TOMNET's mission of enhancing diversity of the workforce.

ASU: Two TOMNET graduate students **(Denise Capasso da Silva and Shivam Sharda)** successfully presented their PhD proposals and advanced to candidacy. They are expecting to graduate during the next year. They were fully funded by TOMNET from the beginning of their PhD studies and very substantially enhanced the portfolio of TOMNET research projects and activities through their contributions.

GT: One TOMNET student, **Alyas Widita**, finished his PhD in City and Regional Planning during this reporting period. He is now working as a researcher for the Georgia Institute of Technology, helping with the improvement of the Georgia Statewide Travel Demand Model, in a project funded by the Georgia Department of Transportation. Other TOMNET students are in the process of completing MS degrees (Xinyi Wang and Kara Todd) and PhD degrees (**Atiyya Shaw, Ali Etezady, and Sung Hoo Kim**). It is expected that these students will complete their educational journey within the next year. By mentoring these students to degree completion, TOMNET will increase the diversity of the transportation workforce – given that they include three women and come from three different countries on three continents.

UW: Katherine Idziorek, TOMNET PhD student working with Dr. Chen in UW, was selected by the Eno Center for Transportation for the Summer 2020 Thomas J. O'Bryant Transportation Policy and Finance Fellowship. The O'Bryant Fellowship is designed to bridge research and policy while providing a professional development opportunity for aspiring transportation specialists. As an Eno Fellow, Katherine engaged with the transportation policymaking community while assisting in the development of Eno transportation research documents and policy recommendations. Katherine has also been selected to join a cohort of 20 of the nation's top graduate students participating in Eno's Future Leaders Development Conference, which is currently scheduled to take place in June of 2021.

USF: TOMNET graduate students at USF received prestigious honors during this reporting period. TOMNET graduate student, **Trang Luong**, has received the Dwight David Eisenhower Transportation Fellowship. The Dwight David Eisenhower Transportation Fellowship Program (DDETFP) awards fellowships to students pursuing degrees in transportation-related disciplines. This program advances the transportation workforce by helping to attract the nation's brightest minds to the field of transportation, encouraging future transportation professionals to seek advanced degrees, and helping to retain top talent in the U.S. transportation industry. Trang Luong is currently enrolled in the doctoral program at the University of South Florida (USF) specializing in transportation engineering. She earned her Bachelor's and Master of Science degrees in Civil Engineering at USF in 2015 and 2017, respectively.

TOMNET has been tracking progress in achieving impacts as outlined in the Technology Transfer Plan. A summary of progress is shown in table 8 for two metrics.

Table 8. TOMNET Metrics on Impacts

Metric	Annual Target	Previous Reporting Period	This Reporting Period	Annual Total	Assessment
Number of agencies adopting TOMNET tools	2	1	0	1	TOMNET is in talks with multiple agencies to enhance product adoption. Talks have slowed down during the pandemic.
Improvement in accuracy of travel forecasts due to TOMNET research methods	10%	5%	5%	5%	Initial efforts exhibit considerable promise in improving travel forecasts. Need to do more testing in the agency environment.

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.