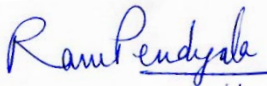




UTC Semi-Annual Progress Report (SAPR#2)



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Center Director:	Ram M. Pendyala, Professor, Arizona State University ram.pendyala@asu.edu , 480-727-4587
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Submitting Official:	Ram M. Pendyala, Director of TOMNET UTC Professor, Arizona State University 480-727-4587; ram.pendyala@asu.edu
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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 to September 30, 2019. 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, 2019 to September 30, 2019.

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 in 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 with disparate information thus facilitating the development of comprehensive models of travel demand that reflect the effects of attitudinal variables.

What are the major goals of the program?

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 center aims to accomplish this by fusing information about attitudes, behaviors, socio-economic characteristics, built environment attributes, and transportation networks contained in different data sets using machine learning algorithms; and developing new models capable of providing deep insights into underlying relationships among the myriad variables in the fused data sets.

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. Solutions to transportation challenges require the ability to leverage concepts, methods, and tools in engineering, humanities, social sciences, behavioral sciences, management sciences, geographical sciences, urban and regional planning, health, economics, and psychology. Through a multi-disciplinary approach to education and training, the center aims to train a cadre of professionals who can work in industry, public agencies, academia, and non-profit organizations. 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 school 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 overall goal of the center is to move advanced data fusion approaches and modeling methods into practice. TOMNET's mission is to develop tools and methods that would allow agencies to account for attitudes, values, perceptions, and lifestyle and mobility preferences in their travel demand forecasting and modeling processes.

What was accomplished under these goals?

Within the reporting period, TOMNET researchers worked on and launched a number of research projects in 2019. Projects launched in 2017 and 2018 have been completed or are continuing into their subsequent phases. Annual project reports for these projects have been published on the center website and will also be referenced in the later sections of this report. The list of all sixteen active TOMNET projects is provided in Table 1 with the active time period for each project. It should be noted that three new projects are those proposed by faculty members at Arizona State University, who are outside of the TOMNET core group and submitted their proposals in response to an open TOMNET Call for Proposals and selected through the peer review process conducted by the leadership team. In addition to these three, three other new research projects have also been initiated in the reporting period at Arizona State University. The new projects are marked with asterisk in Table 1.

Table 1. TOMNET Research Projects

	Project Topic/Title	Lead Institution (Institution PI)	Active Period
1.	Development of an Integrated Model of Daily Activity-Travel Behavior and Well-Being	ASU (Ram Pendyala)	Jan 2019 - Present
2.	Studying Perception towards Risky Driver Behavior and Secondary Task Engagement Using the Naturalistic Driving Study (NDS) Data*	ASU (Ram Pendyala)	Jan 2019 - Present
3.	Exploring Electric Vehicles Adoption and Utilization in the United States*	ASU (Sara Khoeini)	Aug 2019 - Present
4.	Data Fusion to Model Residential and Transport Energy Footprint of Households While Considering Attitudinal Variables	ASU (Sara Khoeini)	Jan 2019 - Present
5.	Attitudes Towards Mobility Options/Technologies – A Multi-region Survey Design and Data Collection Effort	ASU (Sara Khoeini)	Oct 2017- Present
6.	Comprehensive Review of Attitudes-Travel Behavior Literature	ASU (Deborah Salon)	Oct 2017- Present
7.	Assembling Integrated Data Sets for Analyzing Connections between Travel Behavior, Attitudes, and the Built Environment	ASU (Deborah Salon)	Oct 2017- Present
8.	How Do We Choose Where to Live (and what is the role of transportation)?*	ASU (Deborah Salon)	Aug 2019 - Present
9.	Consumer Attitudes and Behavioral Implications in the New Era of Shared Mobility*	ASU (Zhongju Zhang)	Aug 2019 - Present
10.	Emerging Approaches to Autonomous Vehicles in Transportation Policy and Planning*	ASU (Thad Miller)	Aug 2019 - Present
11.	Consistency Guarantee of Transportation Modeling Calibration and Validation Using Multi-Source Data in a Computational Graph Approach*	ASU (Xuesong Zhou)	Aug 2019 - Present
12.	Attitudes Towards Mobility Options/Technologies – A Multi-region Survey Design and Data Collection Effort	GT (Giovanni Circella)	Oct 2017- Present
13.	An Investigation of the Contribution of Targeted Marketing Data to the Prediction of Attitudes	GT (Pat Mokhtarian)	Oct 2017- Present
14.	Attitudes Towards Mobility Options/Technologies – A Multi-region Survey Design and Data Collection Effort	USF (Michael Maness)	Oct 2017- Present
15.	Investigation of the Role of Attitudinal Factors on Adoption of Emerging Automated Vehicle and Vehicle Safety Technologies	USF (Fred Mannering)	Oct 2017- Present
16.	Understanding Community Behaviors and Attitudes for Resilience: Developing and Implementing a Scalable Survey Methodology	UW (Cynthia Chen)	Oct 2017- Present

ASU = Arizona State University; GT = Georgia Institute of Technology; USF = University of South Florida; UW = University of Washington. * New Projects commenced in the reporting phase of this semi-annual progress report.

The following is a summary of progress made on various projects listed in Table 1, with descriptions, accomplishments, and plans for the next year if applicable. Progress for the six new projects (indicated by * in Table 1) that commenced in July 2019 will be presented in the next progress report.

PROGRESS ON SELECTED RESEARCH PROJECTS

Project Title: Development of an Integrated Model of Daily Activity-Travel Behavior and Well-Being

PI: Ram Pendyala, ASU; Co-PI: Sara Khoeini, ASU

Description: The notion that people's activity-travel patterns influence well-being, health and overall quality of their life is well recognized. Nonetheless, activity-travel demand model outputs do not provide explicit measures of well-being that can be used to assess the impacts of alternative policies, investments, and technologies. This study relates the activity and time use patterns of different individuals with their subjective measures of wellbeing and objective health records. In addition, subjective wellbeing of people with zero trips (immobile) and low leisure time (time poor) is also investigated. Using data fusion techniques, information from the National Household Travel Survey 2017, American Time Use Survey (2010, 2012, and 2013 wellbeing module), and National Health and Nutrition Examination Survey (NHANES) is integrated so that holistic models of travel and wellbeing can be specified and estimated.

- Batur, S. Sharda, T. Kim, S. Khoeini, R. Pendyala, & C.R. Bhat. "Mobility, time poverty, and well-being: how are they connected and how much does mobility matter?", Submitted to Transportation Research Record: Journal of the Transportation Research Board, 2020.
- S. Khoeini, D. Silva, S. Sharda, T. Magassy, and R. Pendyala. "An Integrated Model of Activity-Travel Behavior and Subjective Well-being"; Submitted to Transportation Letters, 2020.

Project Title: Studying Perceptions Towards Risky Driver Behavior and Secondary Task Engagement Using the SHRP2 Naturalistic Driving Study (NDS) data

PI: Ram Pendyala, ASU; Co-PI: Sara Khoeini, ASU

Description: The goal of this project is to understand the determinants of risky driving behaviors (e.g., speeding and reckless driving) and secondary task engagement (e.g., cell phone use and eating/drinking) that may lead to a crash or near-crash. The SHRP2 Naturalistic Driving Study (NDS) data is used in this study to analyze human behaviors and actions in the course of driving a vehicle. While errors in human driver behavior is said to contribute to 94 percent of traffic crashes on the nation's highways, this project is trying to identify and better understand the determinants of risky driving behaviors and secondary task engagement so that appropriate countermeasures and interventions can be implemented. Models have been developed and application of model to demonstrate its efficacy is underway.

- S. Sharda, D. Silva, K. Grimm, S. Khoeini, and R. Pendyala. "Modeling Determinants of Risky Driving Behaviors and Secondary Task Engagement Using Naturalistic Driving Data"; Transportation Research E-Circular E-C243, Transportation Research Board, National Academies, 2019, pp. 41-56.

Project Title: Data Fusion to Model Residential and Transport Energy Footprint of Households

PI: Sara Khoeini, ASU; Co-PI: Ram Pendyala, ASU

Description: People consume energy during travel and in-home/out-of-home activities. The energy footprint of households is inextricably tied to the amount of travel undertaken by households. The travel energy footprint of a household is dependent on the mix of vehicles owned and used by members of the household, and the extent to which different vehicles in a household are driven. If people travel more (and spend more time outside home), they may consume more travel energy, but consume less in-home residential energy. Thus, an integrated model system that tightly connects activity-travel demand, travel energy consumption (sensitive to vehicle fleet/fuel type), and residential energy consumption (sensitive to activity-travel choices) is needed to obtain a holistic picture of household energy footprint with respect to socioeconomic and attitudinal variables. This project is fusing information from different datasets including National Household Travel Survey (NHTS) 2017 and the Residential Energy Consumption Survey (RECS). The fused data set is used to develop a holistic model of transport and residential energy consumption while explicitly considering the inter-relationship between them.

- S. Sharda, T. Kim, S. Khoeini, I. Batur, and R. Pendyala; “Development of an Integrated Model System of Transport and Residential Energy Consumption”, submitted to Transportation Research Record: Journal of the Transportation Research Board, 2020.

Project Title: Attitudes Towards Mobility Options/Technologies – A Multi-region Survey

PIs: Sara Khoeini, ASU; Giovanni Circella, GT; Michael Maness, USF

Description: To enhance transportation forecasting models so that they can consider the increasing penetration of disruptive mobility options and technologies, people’s attitudes towards and perceptions of these technologies and services need to be measured and understood. This project involved the design of a survey, two phases of respondent recruitment, and subsequent data analysis and modeling for a sample of more than 5000 individuals across Phoenix, Atlanta, Tampa, and Austin metro areas. The collected dataset is unique in terms of sample size, content, and spatial coverage across multiple southern metro areas. The project team plans to undertake a comparison of attitudes and perceptions with respect to new transportation technologies across metro areas. In the Phoenix metropolitan area, a pilot survey was conducted; the pilot yielded 262 responses. The full survey was conducted in all four metropolitan areas in Summer/Fall 2019, with all areas reporting more than 1000 responses each. A number of reports, papers, and data sets are being prepared and will be described in the next semi-annual progress report.

Project Title: Comprehensive Review of Attitudes-Travel Behavior Literature

PI: Deborah Salon, ASU

Description: The objective of this project is to review the literature on attitudes and travel behavior in order to answer the following key TOMNET research questions:

- How much do attitudinal variables improve the predictive power of travel behavior models?
- Which attitudes are most important, and for which travel behavior outcome variables?
- How does the attitude-travel behavior connection vary by population segment and geographic area?

A lot of progress was made on the literature review project during this reporting period. Matt Conway (PhD student) and Deborah Salon worked together to recruit four undergraduate students and one graduate student to begin systematically working through the literature in this area during Fall 2019. TOMNET designed a once-weekly course to train these students to read the literature and critically evaluate studies. TOMNET also developed a database format so that all of the literature could be catalogued effectively. The database includes key features of each study, together with details of the actual attitudinal data and modeling results in each paper. This reporting period included the first 1.5 months of the training course, and TOMNET envisions having presented the work at a conference and submitted a literature review paper to a peer-reviewed journal by the end of the next reporting period.

Project Title: Assembling Integrated Data Sets for Analyzing Connections between Travel Behavior, Attitudes, and the Built Environment

PI: Deborah Salon, ASU

Description: Transport-related preferences and attitudes have been found to be important determinants of travel choices, given an already-chosen residential location. The hypothesis is that attitudes, preferences, and personality characteristics that are unrelated to transport substantially influence travel choices through their impact on residential location choices. So far, three survey data sets that focused on travel choices and attitudes have been merged with detailed information from the Zillow corporation about the neighborhoods and specific residences that survey respondents chose to live in. The survey data sets included the 2012 ASU Travel Survey, the 2011 Northern California Commuter Multitasking Survey, and the 2015 California Millennials Survey. Statistical models are being estimated using these three merged datasets to identify common threads that indicate generalizability of results. The primary model

specification is a hybrid-choice latent-class model of the choice of residential location that incorporates attitudinal variables. During the next reporting period, progress will be made on the hybrid modeling of the data, and a fourth very comprehensive dataset will be built based on the TOMNET survey on attitudes towards transformative technologies in transportation.

Project Title: How Do We Choose Where to Live (and what is the role of transportation)?

PI: Deborah Salon, ASU

Description: This project began as an undergraduate honors thesis and is continuing as ongoing work related to the TOMNET Southern Cities Transformative Technologies in Transportation Survey project. The objective of this project is to answer the research question: How do people choose where to live, and what is the role of transportation considerations in that choice? Between March and September 2019, the research team completed the first round of in-depth household interviews with recent homebuyers in the Phoenix region and conducted preliminary analysis of the resulting qualitative data. Elyse Kats – the honors student working on the project – completed and defended her thesis and presented results at the Annual Meeting of the American Association of Geographers in April 2019. Salon continued conducting additional data analysis and presented next-stage results in a TOMNET webinar in May 2019. As is common for qualitative research projects, this project has generated more specific hypotheses, but the results are not yet definitive due to the small sample size. The clearest finding is that there is tremendous diversity in how households choose their homes – not just which homes they choose, but also which factors they consider at all. Salon is continuing to further analyze the data and will be submitting a paper to a conference in the next reporting period.

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

PI: Patricia Mokhtarian, GT; Co-PI: Giovanni Circella, Kari Watkins, GT

This project involves the “fusion” of two datasets collected in 2016-2017 in Georgia: the behaviorally-rich Georgia add-on to the National Household Travel Survey (“NHTS”, $N \sim 8,000$), and the attitudinally-rich survey designed by the project team and funded by the Georgia Department of Transportation (the “GDOT survey” or dataset, $N \sim 3,500$, before cleaning). The goal of the current project is to use machine learning methods to develop attitude-prediction training functions on the GDOT (donor, or source) sample, which will then be 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 previous study used socioeconomic/demographic (SED) and land use (LU) characteristics as the common variables (CVs); a distinctive feature of the current study is the addition of targeted marketing (TM) variables to the CV set. TM variables can be purchased economically from third-party providers (such as the consumer credit reporting agency Experian), and include a host of indicators of lifestyle and various behaviors. The premise of the current study is that these kinds of variables may be very informative about individuals’ attitudes, and thus substantially improve the ability to predict attitudes. During this reporting period, the team continued to clean the TM variables and perform dimension reduction on them (principal components analysis, to reduce thousands of individual variables to a smaller number of “components”, or linear combinations of strongly related groups of those variables). The team made progress on several efforts that are very relevant to the TOMNET mission. Specifically, 13 papers are in various stages of completion. In summary (some papers fall into more than one category but are *not* double-counted), two papers are under revision for peer-reviewed journals, three more have been submitted to peer-reviewed journals, two were presented at the Women’s Issues in Transportation conference in Irvine, CA in September, two have been accepted for presentation at the 2020 TRB meeting, and four are in preparation for submission to journals. The next reporting period should continue to see substantial progress on these papers, as well as on the main project. The team expects to have imputed attitudes appended to the GA NHTS sample, and at least preliminary external validation models estimated.

Project Title: Emerging Econometric and Data Collection Methods for Capturing Attitudinal and Social Factors in Activity, Travel Behavior and Safety modeling

PI: Fred Mannering, USF; Co-PI: Michael Maness, USF

Description: The project team completed work in a number of project areas. The effect of information on changing opinions toward autonomous vehicle adoption was the focus of one of the efforts. Specifically, the team studied how people's initial autonomous-vehicle adoption likelihoods change after being asked a common set of questions that leads them through an assessment of factors involved in adoption. A series of discrete outcome models were estimated to determine the factors that influence the likelihood of people changing their initial opinions. Bikesharing use and its potential as an auto-trip substitute was also studied. A survey of individuals was conducted, and random parameters logit models were estimated to study bikesharing usage rates and modal substitution. In addition to standard socio-demographic and travel behavior characteristics of the survey respondents, health-related indicators were considered as explanatory variables in the estimated models. It was found that gender, age, income, household size, commute type and length, and vehicle ownership all played significant roles in bikesharing usage and modal substitution decisions. Regarding health measures, respondents' body mass index (BMI) was also a significant predictor of bikesharing usage. Model estimation findings provide initial insights into the bikesharing decision-making process that can help in the development of policies to improve the performance of bikesharing systems and making them a more viable transportation option. To address the emerging issue of temporal instability in travel and safety models, two studies were conducted. One dealt with the temporal analysis of factors that determine motorcyclist injury severities (using data from Florida) and the other by assessing time-of-day variations and temporal instability of the factors affecting injury severities in large-truck crashes in Los Angeles. Both studies found statistically significant temporal instability which has implications for current and future travel forecasting models. Finally, the team undertook an application of Lin's conception of social capital as resources embedded in social networks as a basis for describing leisure activity outcomes. This was accomplished through using a position generator for indirect resource access, a resource generator for direct resource access, and a global name generator for social support size. This work provides evidence towards the conclusion that social capital is positively correlated with leisure activity variety, which has important implications for the practice of travel forecasting.

Project Title: Laurelhurst Community Resilience Survey

PI: Cynthia Chen, UW; Co-PI: Daniel Abramson, UW

Description: The overarching goal of the project is to understand, model and develop ways in which communities can leverage unique – and interconnected – physical and social resources of place to enhance their own adaptive capacity. This current phase builds upon findings from previous project phases, including a pilot survey, to implement a full-scale sample survey focused on issues of social trust, place attachment, and disaster preparedness and response as relevant to different modes of transportation and communication services. Understanding the interactions among these three aspects of community will provide data to inform strategies for enhancing adaptive capacity via collaborative infrastructure in future phases. Building upon information gathered from the pilot survey and community workshops, this project will further define the concept of collaborative infrastructure. The data from the Laurelhurst (Seattle) pilot survey was collected and reviewed. For the pilot survey, 200 surveys were mailed with a 37.5% response rate, resulting in a preliminary data set of 75 responses. Preliminary findings of interest include differences in willingness to share certain vital resources (e.g., food, water, shelter, transportation, communication); differences in concern about being able to carry out everyday activities in the case of a disaster (e.g., cooking, bathing, staying healthy); and patterns of social connections within the community. Some revisions were made to the survey instrument based on the initial responses. In

September 2019, a first mailing with an invitation to complete an online version of the modified community resilience survey was sent to 733 residential addresses in Laurelhurst (in addition to the 200 residences included in the pilot survey) and 1243 residential addresses in Westport. Online responses are currently being received. To help engage an additional study community that would serve as a contrast to urban, high-income Laurelhurst and rural, low-income Westport, the team began working in partnership with the City of Seattle’s Office of Emergency Management (OEM) to identify an urban, low-income community in which to implement the survey. Working together with OEM, the team has begun to engage the South Park community, which is a historically vulnerable neighborhood in South Seattle. This partnership additionally involves refining a new protocol for engaging communities around multiple future scenarios based on both chronic (everyday) and episodic (rare and infrequent) hazard threats.

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 summer and fall semesters of 2019 (that spans the reporting period covered by this SAPR). Table 2 offers a detailed summary of the courses offered by faculty members closely affiliated with the TOMNET center.

Table 2. Courses Offered by Mission-Critical Faculty Members of TOMNET (Summer & Fall 2019)

Semester	Course Level	Course No	Course Title	No	Instructor	Unit
Arizona State University						
Sum19	Undergrad	CEE494	Intermodal Transportation Facilities Eng	27	Zhou	SSEBE
Fall19	Undergrad	CEE372	Transportation Engineering	92	Pendyala	SSEBE
Fall19	Undergrad	CEE591	Interdisciplinary Transportation Seminar	4	Pendyala	SSEBE
Fall19	Grad	PUP642	Urban & Regional Economic Analysis	35	Salon	SGSUP
Georgia Institute of Technology						
Fall19	Undergrad	CEE 4090	Capstone Design	55	Watkins/Rodgers	CEE
Fall19	Undergrad	CEE 4610	Multimodal Transportation	31	Watkins	CEE
Fall19	Grad	CEE 6623	Transportation Survey Methods	5	Mokhtarian	CEE
University of South Florida						
Fall19	Undergrad	TTE4003	Transportation and Society	34	Islam	CUTR
Fall19	Undergrad	TTE4004	Transportation Engineering I (Section 1)	50	Bertini	CEE
Fall19	Undergrad	TTE4004	Transportation Engineering I (Section 2)	28	Maness	CEE
Fall19	Grad	CGN 6311C	Data Science for Civil Engineers	10	Maness	CEE
Fall19	Grad	TTE6307	Statistical and Econometric Methods I	22	Mannering	CEE
Fall19	Grad	TTE5501	Transportation Planning & Economics	29	Menon	CUTR
Fall19	Grad	TTE5205	Traffic Systems Engineering	25	Lin	CUTR
Fall19	Grad	TTE6930	Graduate Transportation Seminar	7	Zhang	CEE
Fall19	Grad	TTE6835	Pavement Design	15	Lu	CEE
Fall19	Grad	TTE6267	Traffic Flow Theory	6	Li	CEE
University of Washington						
Fall19	Grad/UG	URBDP 424/524	Site Planning: Issues and Techniques	22	Abramson	UrbPln

Notes: *Arizona State University*: SSEBE = School of Sustainable Engineering and the Built Environment; SGSUP = School of Geographical Sciences and Urban Planning; CIDSE = School of Computing, Informatics, and Decision Systems Engineering; BS = Biological Sciences; SOS = School of Sustainability. *Georgia Institute of Technology*: CEE = School of Civil and Environmental Engineering; SCaRP = School of City and Regional Planning. *University of South Florida*: CEE = Department of Civil and Environmental Engineering; CUTR = Center for Urban Transportation Research. *University of Washington*: CEE = Department of Civil and Environmental Engineering; CEE/ST = Civil and Environmental Engineering/Sustainable Transportation Online Program; UrbPln = Department of Urban Design and Planning

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.

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 is involving nine 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. Two of the undergrads are Native American students who are attending Diné College and spent the summer as paid interns to study transportation behaviors of their race. More information about their visit is provided later in the report.

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			
Xin Ye	Assistant Research Professor	SSEBE	Pendyala
Jie Ma	PhD Student	SSEBE	Pendyala/Ye
Andrew Tso	Undergrad (Diné College)	SSEBE	Khoeini/Pendyala
Waycee Harvey	Undergrad (Diné College)	SSEBE	Khoeini/Pendyala
Irfan Batur	PhD Student	SSEBE	Pendyala
Matthew Conway	PhD Student	SGSUP	Salon
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
Laura Mirtich	Undergrad	BS	Salon
Shuyao Hong	PhD	SGSUP	Salon
Nathan Harness	Undergrad	SEESE	Salon
Alexis Ross	Undergrad	Economics	Salon
Kelly Baker	Undergrad	SOS	Salon
Elyse Kats	Undergrad	SOS	Salon
GEORGIA INSTITUTE OF TECHNOLOGY			
Ali Etezady	PhD Student	CEE	Circella/Mokhtarian
Gwen Kash	Postdoc	CEE	Mokhtarian
Sung Hoo Kim	PhD Student	CEE	Mokhtarian
Yongsung Lee	Postdoc	CEE	Circella
Aliaksandr Malokin	PhD Student	CEE	Mokhtarian
Faiqa (Atiyya) Shaw	PhD Student	CEE	Mokhtarian
Xinyi Wang	PhD Student	CEE	Mokhtarian
Alyas Widita	PhD Student	SCaRP	Circella
UNIVERSITY OF SOUTH FLORIDA			
Nawaf Alnawmasi	Grad Student	CEE	Mannering
Suryaprasanna Balusu	Grad Student	CEE	Pinjari/Mannering
Natalia Barbour	Grad Student	CEE	Zhang/Mannering
Madisen Kerr	Undergrad	CEE	Maness
Trang Luong	Grad Student	CEE	Maness
Dr. Nikhil Menon	Postdoctoral Associate	CEE	Bertini/Maness
Divymitra Mishra	Grad Student	CEE	Maness
Nameetha Ramachandra	Grad Student	CEE	Maness

UNIVERSITY OF WASHINGTON			
Andres Arjona	Masters Student	UrbPln	Abramson
Asela Chavez Basurto	Masters Student	UrbPln	Abramson
Xiangyang Guan	Postdoc fellow	CEE	Chen
Katherine Idziorek	PhD Student	UrbPln	Chen/Abramson
Yuanjie Tu	PhD Student	CEE	Chen
Feilong Wang	PhD Student	CEE	Chen
Xi Zhu	PhD Student	CEE	Chen

In the *technology transfer* domain, Arizona State University continued the weekly [TOMNET webinar/seminar series](#) that is presented to a worldwide audience. Table 4 presents a list of TOMNET-sponsored seminars for the period covered by this SAPR. Speakers met with TOMNET faculty and students, thus enabling the development of collaborative ties. TOMNET also launched a [TOMNET Leadership Webinar Series](#) featuring research by core/lead faculty members of the TOMNET Center during the reporting period of the previous SAPR. Webinars are generally one hour long and provide additional outreach for TOMNET work. Three TOMNET leadership webinars were presented during this reporting period as noted in Table 4. These events are advertised widely and very well attended.

Table 4. Key TOMNET-Sponsored Technology Transfer Events

Institution	Title of Seminar/ Webinar	Speaker Name and Affiliation	Date	Number
ASU	Transport Infrastructure LCA: Understanding Embodied Materials	Shoshanna Saxe, PhD University of Toronto	April 4, 2019	30
ASU	Defining Urban Engineering to Help Design Sustainable and Resilient Cities	Sybil Derrible, PhD University of Illinois, Chicago	April 8, 2019	30
ASU	The Dawn of Urban Aerial Ridesharing	Jon Petersen, PhD Uber Technologies	April 11, 2019	30
ASU	Traffic Safety Challenges & Potential of Emerging Technologies to Improve Safety	C. Y. David Yang, PhD AAA Foundation for Traffic Safety	April 18, 2019	30
ASU	Energy Efficient Urban Mobility Systems	Stanley E. Young, PE, PhD National Renewable Energy Laboratory	April 25, 2019	30
ASU	Imputing Attitudes into Travel/Activity Diary Databases: Does Targeted Marketing Information Help?*	Patricia L. Mokhtarian, PhD Georgia Institute of Technology	April 26, 2019	30
ASU	How Do We Choose Where to Live: Investigation of Residential Choice*	Deborah Salon, PhD Arizona State University	May 16, 2019	30
ASU	Sustainable Transportation Infrastructure: Assessment Methods and Research	Hasan Ozer, PhD Arizona State University	Sept 11, 2019	30
ASU	Planning for the Future: Transportation in Arizona	Gregory D. Byres, PE Arizona Department of Transportation	Sept 18, 2019	30
UW	Promises of big data in transportation planning applications: Puget Sound Case*	Cynthia Chen, PhD University of Washington	Sept 20, 2019	20

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

It should be noted that other TOMNET partner institutions have transportation seminar series that are open to the public and professionals in the community. These seminars are generally held on a weekly basis at each of the institutions and include a mix of attendees comprising of students, professionals, academics, scholars, and members of the public. TOMNET faculty members are heavily engaged in existing transportation seminar series at each institution, and helping to organize specific seminars that are badged as TOMNET-sponsored seminars. These seminars, delivered by renowned speakers, specifically address topic areas of relevance to TOMNET and are of broad interest to the professional community.

TOMNET at Arizona State University (ASU) hosted two motivated sophomore students Andruw Tso and Wayce Harvey (Figure 1) studying pre-engineering at Dine' College, an American Indian Tribal College, to participate in an intensive eight-week summer transportation research program from May 28 – July 27, 2019. The two students explored American Indian travel behavior data from the 2017 National Household Travel Survey. Their summer research project provided them an opportunity to engage in research that evaluated the differences in socioeconomic attributes and travel characteristics between American Indian and Alaska Native (AI/AN) populations versus non AI/AN populations in the United States. The students created a STEM research poster and powerpoint presentation that showcased their summer research process and findings. The students presented their work at Dine' College and are exploring opportunities to present their research poster at AI/AN STEM conferences organized by the American Indian Science and Engineering Society, the Society of the Advancement of Chicanos/Hispanics and Native American in Science, and the American Indian Higher Education Consortium. While at ASU, they also learned about educational resources for American Indian and Alaska Native students and met with a number of units on campus that assist students from these communities excel in higher education. They also participated in a number of field trips and professional activities. The students offered feedback on their experience; the feedback was very positive and they were very appreciative of the opportunity. Both students plan to attend ASU to complete their four-year degree. One quote from their feedback is:

This was overall a great experience for me. It opened a door to numerous possibilities. I thank all who were involved and that contributed to our success!

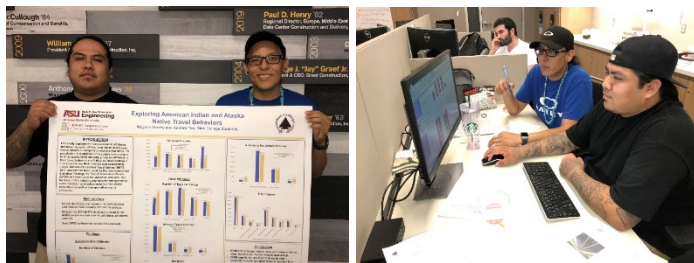


Figure 1. Images of Dine' College Students doing Summer Internship at TOMNET Center at ASU

On June 9, 2019, University of Washington PhD student Katherine Idziorek gave a presentation on “Natural Disasters and

Communities” to a FIRST LEGO League team in Seattle, WA. FIRST LEGO League is an international competition for elementary and middle school students in which teams focus on and research a scientific and real-world challenge. The competition involves designing and programming LEGO robots to complete tasks. The students develop solutions to given problems and then compete in tournaments to share knowledge, compare ideas, and display their robots. The Seattle team mentored by Katherine comprises six middle school students seeking to develop an innovative solution in response to the “Nature’s Fury” challenge theme that could help people prepare, stay safe, or rebuild their communities in the event of a natural disaster. The team members were tasked with choosing a community to work with, specifying a type of disaster they want to address, and then developing a solution to a specific problem that is likely to be caused by that disaster (Figure 2). Students were particularly interested in leveraging technology to improve communications between communities and finding creative ways to enable transportation over and around debris that might be laying in public roadways after an earthquake. The students will take these ideas forward in the development of their project for the 2019 FIRST LEGO League competition.

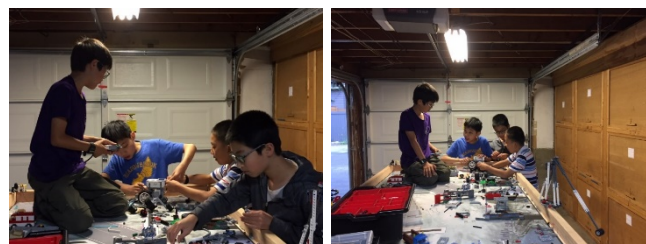


Figure 2. Images of the LEGO Fury project team working on their challenge project

In another highlight of TOMNET achievements, five USF students (Brian Staes, Divyamitra Mishra, Nazmus Sakib, Eren Yuksel and Rakesh Rangaswamy) traveled to the ITE 2019 Annual Meeting in Austin

to compete in the Transportation Technology Tournament – a national competition on ITS and TSMO solutions. Their project, *Improving pedestrian safety through ITS solutions*, was chosen as a finalist in the competition (Figure 3). The students worked with Dr. Pei-Sung Lin, Dr. Nikhil Menon and Pete Yauch from Albeck Gerken Inc. to learn about potential ITS and TSMO solutions. TOMNET provided a travel scholarship to Divyamitra Mishra to participate in the competition. The students were required to submit proposals prior to the conference and were one of five teams chosen as finalists.



Figure 3. USF students compete in the Transportation Technology Tournament in Austin (2019)

TOMNET faculty and students administered a workforce development workshop (developed last year by the same team) entitled *Future Careers in Transportation* for high-school students in 12th grade. The workshop included an introduction about transportation systems and potential careers in transportation followed by an entertaining transportation-related quiz competition between groups of students. These workshops are included in the K-12 summer camp programs at the consortium institutions so that students participating in the camps are exposed to transportation concepts and research projects. These outreach efforts have been very successful with participating high school students getting exposed to transportation career information. Sara Khoeini (TOMNET Assistant Director) presented *Future Careers in Transportation* workshop to about 140 high school students on June 27 and July 11. TOMNET PhD students, Shivam Sharda, Taehooie Kim, Tassio Magassy, Denise Silva, and Irfan Batur assisted Sara Khoeini during the workshop activities.

On September 30, 2019, Sara Khoeini presented a guest lecture in a Freshman course entitled Grand Challenges for Engineering. Dr. Khoeini discussed the challenges that autonomous vehicles might produce for an urban area and she had an interactive discussion with the students to explore potential solutions and mitigation strategies. Other highlights of activities to achieve research, education and technology transfer goals of TOMNET include:

- Georgia Tech engaged a high school junior as a research intern during Summer 2019.
- TOMNET research was reported and cited in a [Mobility Lab blog](#) on April 2, 2019.
- Madisen Kerr who is a senior civil and environmental engineering undergraduate student involved in the TOMNET project designed an in-person interview to explore the attitudes and preferences of electric vehicle owners for public charging infrastructure.

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. Moreover, TOMNET team members will meet during the next reporting period at Georgia Tech to talk about various TOMNET plans including the selected projects in the upcoming year.

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 new 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 completion of their studies and appropriate career pathways.

In the technology transfer domain, TOMNET will continue to organize webinars/seminars/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.

Discussions are underway to organize a symposium, called the A4 Symposium. This symposium

will focus on Attitudes, Automation, Autonomy, and Access (hence, A4) and bring together the many key themes addressed by TOMNET. TOMNET will be launching a data science challenge, inviting students from around the world to participate in a data challenge and student paper competition. Students will be required to submit entries that aim to enhance the profession's understanding of the relationships between traveler attitudes, behaviors, perceptions, and preferences, while clearly explaining how their submissions can be translated into real-world tools and models that can be implemented in planning agencies to advance the state-of-the-practice. This data challenge and student paper competition will be launched in Spring 2020, potentially in conjunction with A4 symposium. TOMNET scholars will continue engage in considerable K-12 outreach activities.

The multi-city TOMNET survey is currently in final phases of data collection. It is envisioned that, during the next reporting period, the results of the survey will be disseminated widely through different channels such as presentations at local agencies, national and international conferences, webinars, research briefs, project reports, and academic journal papers. Moreover, advanced modeling and analysis of the cleaned/weighted data will commence during the next reported period, thus leading to the production of numerous impactful products during and beyond the life of TOMNET.

TOMNET team will be at the 2020 Annual Meeting of the Transportation Research Board, with numerous papers based on TOMNET-funded research projects accepted for presentation. Needless to say, TOMNET researchers and scholars will continue to engage in many traditional technology transfer activities that involve presenting research results at conferences and symposia around the country and world, writing papers for publication in journals and conference proceedings, preparing manuscripts for publication in edited books and volumes, and guest editing special issues of journals dedicated to topics of interest to TOMNET. All of these products will be disseminated through the TOMNET website.

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. In addition to establishing an External Advisory Board (EAB), whose details will be furnished on the TOMNET website (once all biographical sketches and photographs are obtained), 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. As mentioned in the previous SAPR, TOMNET has a very significant ongoing partnership with the Maricopa Association of Governments (MAG), the regional metropolitan planning organization (MPO) for the Greater Phoenix Metropolitan Area. This partnership continues to provide many opportunities for students to engage in real-world planning and modeling research, and for testing TOMNET products in an agency setting. More recently, TOMNET researchers have been engaged in assisting MAG with developing a smart region plan.

What organizations have been involved as partners?

- Maricopa Association of Governments, Phoenix, Arizona: in-kind support, data sets, collaboration
- University of Texas at Austin: collaborative research
- Oak Ridge National Laboratory: models, data sets, collaborative research
- City of Seattle Office of Emergency Management: collaborative research, supplied facilities
- City of Westport, Westport, WA and Westport Tsunami Safety Committee: collaborative research, supplied facilities
- 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, supplied facilities
- University of Leeds and University of Warsaw: collaborative research

Have other collaborators or contacts been involved?

Other collaborators that have been involved include, but are not limited to:

- Professor Chandra Bhat, University of Texas at Austin, TX
- Professor Thad Miller, Arizona State University, Tempe, AZ
- Dr. Farzad Alemi, Institute of Transportation Studies, University of California, Davis
- Dr. Francisco Bahamonde-Birke, Researcher at Utrecht University, the Netherlands
- Dr. Sungtaek Choi, a visiting postdoc from Hongik University, South Korea
- Grays Harbor County Emergency Management
- Jia Tang, a PhD student from Nanjing University
- Northwest Healthcare Response Network
- Ocosta Public School District
- Professor Laurie Garrow (Civil & Environmental Engineering) of Georgia Tech
- Professor Brian German (Aerospace Engineering) of Georgia Tech
- Professor Joseph Saleh (Aerospace Engineering) of Georgia Tech
- Professor Patrick Singleton, an Assistant Professor at Utah State University
- Rolf Moeckel of the Technical University of Munich (TUM)
- Shoalwater Bay Tribe
- South Beach Regional Fire Authority
- South Park Information and Resource Center
- Washington Emergency Management Division
- Washington State Parks
- Westport Police Department

TOMNET work closely with members of the D-STOP University Transportation Center led by the Center for Transportation Research 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 survey on attitudes towards and adoption of transformative transportation technologies. The University of Texas at Austin D-STOP researchers participated in the development of the survey and administered the same survey in Austin, Texas, thus enabling the addition of another city to the overall project effort. 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.

TOMNET has played a critical role in the formation of new collaborative partnerships. TOMNET has facilitated meetings with a number of industry and research stakeholders including Harley Davidson, Nuro, ON semiconductor, AAA Foundation, Uber, and National Renewable Energy Laboratory (NREL). These conversations are ongoing, and areas of collaboration are being identified. TOMNET is also collaborating with staff at Maricopa County Department of Transportation and Arizona Department of Transportation on data fusion, data analysis, and experimental testing of new models and methods developed by TOMNET.

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. Long, K., Silva, D.C., Dias, F.F., Khoeini, S., Bhat, A., Pendyala, R.M., & Bhat, C.R. (2019). Role of childhood context and experience in shaping activity-travel choices in adulthood. *Transportation Research Record, Journal of the Transportation Research Board*, 2673, 575-585.
2. Dias, F.F., Lavieri, P.S., Kim, T., Bhat, C.R., & Pendyala, R.M. (2019). Fusing multiple sources of data to understand ride-hailing use. *Transportation Research Record, Journal of the Transportation Research Board*, 2673, 214-224.
3. Nair, G.S., Bhat, C.R., Pendyala, R.M., PY Loo, B., & Lam, W.H.K. (2019). On the use of probit-based models for ranking data analysis. *Transportation Research Record, Journal of the Transportation Research Board*, 2673, 229-240.
4. Sharda, S., Kim, T., Khoeini, S., Batur, I., Silva, D.C., & Pendyala, R.M. (2019). Development of an integrated model system of transport and residential energy consumption. *Proceedings of the 15th World Conference on Transport Research*, World Conference on Transport Research Society, Leeds, UK.
5. Zmud, J., Dias, F., Lavieri, P., Bhat, C., Pendyala, R.M., Shiftan, Y., Outwater, M., & Lenz, B. (2019). Research to examine behavioral responses to automated vehicles. In G. Meyer and S. Beiker (Ed.) *Road Vehicle Automation 5* (pp. 53-67). Lecture Notes in Mobility: Springer, Cham.
6. Salon, D., & Gulyani, S. (2019). Commuting in Urban Kenya: Unpacking Travel Demand in Large and Small Kenyan Cities. *Sustainability*, 11(14), 3823.

Presentations Within Reporting Period

1. Silva, D.C., Khoeini, S., & Pendyala, R.M. (2019, September). The effect of attitudes on women's willingness to share autonomous vehicles. Presented at the 6th International Conference on Women's Issues in Transportation, Irvine, CA.
2. Silva, D.C. (2019, July). User perceptions and potential adoption of autonomous vehicles: an in-depth attitudinal survey based study. Presented at the 2019 Automated Vehicles Symposium, Orlando, FL.
3. Sharda, S., Kim, T., Khoeini, S., Batur, I., Silva, D.C., & Pendyala, R.M. (2019, May). Development of an integrated model system of transport and residential energy consumption. Presented at the 15th World Conference on Transport Research, Mumbai, India.
4. Salon, D. (2019). How do we choose where to live? Presented at American Association of Geographers Annual Meeting, Washington, DC.
5. Pendyala, R.M. (2019) Transportation research and education at ASU: an overview. Presented at Arizona Department of Transportation, Multimodal Planning Division Staff Meeting, Phoenix.
6. Pendyala, R.M. (2019) Behavioral considerations for integrated modeling in an era of disruptive emerging transportation technologies. NSF Workshop on Control for Networked Transportation Systems, Philadelphia.
7. Bhat, C.R. and R.M. Pendyala (2019) Public transit, MaaS, and EVs in car-dominated cities: research findings and an agenda. Workshop on Pathways for Synergies Among Mobility as a Service (MaaS), Electric Vehicles (EVs), and Multimodal Public Transit Systems. Indian Institute of Science, Bangalore

Georgia Tech

Book Chapters

1. Lee, Y., & Circella, G. (2019). ICT, millennials' lifestyles, and travel choices. In E. Ben-Elia (Ed.), *Advances in Transport Policy and Planning: The Evolving Impact of Information and Communication Technology on Activities and Travel Behaviour* (Vol. 3, pp. 107-141). Oxford, UK: Elsevier.

Papers Published within Reporting Period

1. Lee, Y., Circella, G., Mokhtarian, P. L., & Guhathakurta, S. (2019). Are millennials more multimodal? A latent-class cluster analysis with attitudes and preferences among millennial and generation x commuters in California. *Transportation*. <https://doi.org/10.1007/s11116-019-10026-6>
2. Kim, S.H., Circella, G. & Mokhtarian, P.L. (2019). Identifying latent mode-use propensity segments in an all-AV era. *Transportation Research A*, 130, 192-207.
3. Shaw, F.A., Malokin, A., Mokhtarian, P.L., & Circella, G. (2019). It's not all fun and games: An investigation of the reported benefits and disadvantages of conducting activities while commuting. *Travel Behaviour and Society*, 17, 8-25.

Presentations Within Reporting Period

1. Mokhtarian, P.L. (2019, April). How can we model the impact of automated vehicles on time use and value of travel time? Presented at AV Modeling Expert Group Meeting, University of California, Davis, CA.
2. Lee, Y., Alemi, F., & Circella, G. (2019, August). Investigating the relationships between use of ridehailing and car ownership in the 2017 National Household Travel Survey. Presented at the 6th International Choice Modelling Conference, Kobe, Japan.
3. Kim, S.H., Circella, G., & Mokhtarian, P.L. (2019, August). Do people expect autonomous vehicles to change their residential

location and vehicle ownership? Early glimpses from the state of Georgia. Presented at the 6th International Choice Modelling Conference, Kobe, Japan.

4. Kash, G. & Mokhtarian, P.L. (2019, September). How much and what for? The interrelated effects of gender and age on mobility and trip purpose. Presented at 6th International Conference on Women's Issues in Transportation, Irvine, CA.
5. Wang, X., Shaw, F.A., & Mokhtarian, P.L. (2019, September). Latent vehicle type propensity segments: Considering the influence of household vehicle fleet structure. Presented at 6th International Conference on Women's Issues in Transportation, Irvine, CA.
6. Clark, C., Watkins, K.E., & Mokhtarian, P.L. (2019, September). The role of attitudes in perceptions of bicycle facilities: A latent class regression approach. Presented at TU Delft TRAIL (Research School for Transport, Infrastructure and Logistics) Seminar, Delft, Netherlands.

University of South Florida

Papers Published Within Reporting Period

1. Barbour, N., Zhang, Y., & Mannering, F. (2019). A statistical analysis of bikesharing use and its potential as an auto-trip substitute. *Journal of Transport and Health* 12, 253-262
2. Menon, N., Barbour, N., Zhang, Y., Pinjari, A., & Mannering, F. (2019). Shared autonomous vehicles and their potential impacts on household vehicle ownership: An exploratory empirical assessment. *International Journal of Sustainable Transportation* 13(2), 111-122.
3. Alnawmasi, N. & Mannering, F. (2019). A statistical assessment of temporal instability in the factors determining motorcyclist injury severities. *Analytic Methods in Accident Research* 22, 100090, 1-20.
4. Barbour, N., Menon, N., Zhang, Y., & Mannering, F. (2019). Shared automated vehicles: A statistical analysis of consumer use likelihoods and concerns. *Transport Policy* 80, 86-93.
5. Behnood, A. & Mannering, F. (2019). Time-of-day variations and temporal instability of factors affecting injury severities in large-truck crashes. *Analytic Methods in Accident Research* 23, 100102, 1-17.

Presentations Within Reporting Period

1. Luong, T. & Maness, M. (2019, July). Using social capital data to account for heterogeneity in activity behavior within and between genders. Presented at the 6th International Conference on Women's Issues in Transportation, Irvine, CA.
2. Tahlyan, D., Maness, M., & Stathopoulos, A. (2019, August). The value of free electric vehicle charging infrastructure: An exploratory analysis. Presented at the International Choice Modelling Conference, Kobe, Japan.
3. Maness, M. (2019, August). Leveraging social capital questions for travel and activity surveys. Presented at the Conference on Current Trends in Survey Statistics, Singapore, Singapore.

University of Washington

Papers Published Within Reporting Period

1. Zhu, X., Wang, F., Chen, C., & Reed, D.D. (2019). Personalized incentives for promoting sustainable travel behaviors. *Transportation Research Part C: Emerging Technologies*. <https://doi.org/10.1016/j.trc.2019.05.015>
2. Wang, F., Wang, J., Cao, J., Chen, C., & Ban, X. (2019). Extracting trips from multi-sourced data for mobility pattern analysis: An app-based data example. *Transportation Research Part C: Emerging Technologies*. 105, 183–202. <https://doi.org/10.1016/j.trc.2019.05.028>
3. Abramson, D. (2019). Ancient and current resilience in the Chengdu Plain: Agropolitan development re-'revisited'. *Urban Studies*. <https://doi.org/10.1177/0042098019843020>
4. Whiting, S., Abramson, D., Yuan S., & Harrell, S. (2019). A long view of resilience in the Chengdu Plain, China. *Journal of Asian Studies* 78(2), 257-284. <https://doi.org/10.1017/S0021911819000111>
5. Smith, N., Abramson, D., & Shih, M. (2019). Planning China's communities: Between people and place. *International Development Planning Review* 41(3), 247-267. <https://doi.org/10.3828/idpr.2019.20>
6. Abramson, D. (2019). The insurmountable opportunities of explosive growth: Urban design in China. Tridib Banerjee and Anastasia Loukaitou-Sideris (Ed.), *The New Companion to Urban Design*, Routledge, Chapter 15.

In summary, TOMNET core faculty generated 21 publications in well-respected journals within the reporting period covered by this SAPR. These publications are directly attributable to funding provided by the TOMNET UTC. During the reporting period of this SAPR, the TOMNET researchers prepared numerous conference and journal papers for the 99th Annual Meeting of the Transportation Research Board which will take place in Washington, DC during January 2020. The outputs corresponding to TOMNET papers and presentations at TRB2020 will be covered in detail in the next SAPR.

Website(s) or other Internet site(s)

One major product of the center is the TOMNET website that is being continuously enhanced to support the mission of the center. The [website](#) is a portal with comprehensive information about activities of the Center. The website includes information about TOMNET mission, organization, core team, faculty and student affiliates, partners, sponsors, ongoing research projects, proposal submission portal, online seminar and webinar announcements and recorded files, related events around the world, short course registration portal, and TOMNET semi-annual progress reports. The website has a member-only link that facilitates communication between the core TOMNET team. Other websites of relevance are not listed here because they have been listed in detail in prior semi-annual progress reports. No new websites were developed during this reporting period; however, the websites listed in the prior progress report were enhanced and updated with additional content during the reporting period.

Software Programs, Codes, and Products

During the reporting period covered by this SAPR, the TOMNET team has worked diligently towards developing a few key products that would be of value to the transportation planning and modeling community. As noted in prior progress reports, the TOMNET team at ASU has been heavily involved in the development and application of a **synthetic population generator called PopGen** (please see www.mobilityanalytics.org/popgen.html). Progress was made during the reporting period in moving the software system into the cloud so that any entity around the world can apply PopGen without having to install the software locally. An initial alpha-version has been released and is under testing. The business model that would allow the cloud version to be a self-sustaining enterprise is under development.

Over the past year, TOMNET has developed comprehensive **survey instruments** that can be used to measure behaviors, attitudes, perceptions, and preferences in the domain of future transportation technologies and mobility options. Georgia Tech, ASU, and USF collaborated with the D-STOP UTC at the University of Texas at Austin and conducted a multicity survey of attitudes and perceptions towards transformative transportation technologies; this survey includes a number of sections and provides a comprehensive platform for any agency or research entity to conduct a similar behaviorally rich survey. Data from the survey is being weighted, cleaned, and analyzed in the next year; after that, data sets will be released for public use as well. The University of Washington team has developed a standardized **survey instrument** that can be used to collect data on how communities access information and respond to disaster situations and crises. As part of this effort, the TOMNET team at the University of Washington is meeting with stakeholders, reviewing the literature in different disciplines, and compiling a comprehensive list of disaster and crises scenarios for which transportation professionals would benefit from understanding how people in different types of communities respond, obtain information, interact, use services, and adapt. This survey is a product that the TOMNET team envisions making available to any community that may wish to collect such data.

The TOMNET team continues to make progress on the development of R and Python codes for transportation model estimation and implementation. These codes are undergoing further testing and will be posted to the TOMNET website shortly. In particular, the programs 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. Moreover, an integrated Household Energy Analysis Tool (iHEAT) is under development. The alpha version of this calculator is already implemented online and the researchers are working to improve the modeling method as well as the application and visualization features of the tool. This integrated model system provides a methodology to estimate total household and transportation energy expenditure and can be used for planning and policy making in the context of reducing household energy consumption.

In addition, TOMNET is developing the Wellbeing Estimator for Activities and Travel (WBEAT). This special model is intended to serve as an add-on module for any activity-based travel demand model

system. The methodology embedded in the module calculates a wellbeing index for each person in the simulation based on the activities (predicted to be) undertaken by that individual (including “travel” episodes) over the course of a day. Given the critical role that transportation plays in shaping wellbeing of communities, this tool will prove valuable in assessing and comparing the potential impacts of alternative transportation investments, policies, and mobility options on societal wellbeing. The model system has been developed and the results will be presented at TRB2020. The journal paper based on this study is also under review for possible publication in *Transportation Letters*.

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](#).

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 study 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. Some of these efforts are described in Section 2 of this report. All data sets assembled by TOMNET will be made available (without personally identifiable information) via the TOMNET website for the broader community.

The rich set of data collected in the new transportation technology survey (4000+ responses) will be cleaned, weighted, geocoded, and documented with a data dictionary in the next reporting period. This dataset includes an extensive set of variables on socioeconomics, general attitudes, residential and vehicle ownership information, and perceptions, attitudes and potential use of new transportation options such as ridehailing services and autonomous vehicles. It is a unique database considering its comprehensiveness as well as multi-region coverage. Moreover, data is being collected by the University of Washington team about community access to information and disaster response mechanisms.

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. The following table provides a summary of performance for two metrics.

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	Still in beta-version testing. Need to release deployment ready versions.
Number of publications in refereed journals	15	18	20	38	Greatly exceeded annual target.

4. OUTCOMES

Increases in the body of knowledge:

Better information is critically needed on the transformative impacts that emerging transportation technologies and new mobility services will have on cities. This need is particularly urgent at a time of rapid socio-economic, demographic, and technological change. Planning agencies are required to make long-term evaluations of investment alternatives and important decisions on the types of infrastructure systems and services that should be funded and provided, but such decisions have proven increasingly complex in a transportation landscape characterized by large uncertainty and rapidly evolving technology. The **TOMNET multi-region Future of Mobility 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. TOMNET research has also shed deep insights on the traveler behaviors and choices of millennials, with a focus on generational differences. TOMNET research is resulting in increases in the body of knowledge related to residential location choice, driver behavior and risk-taking, and the connection between activity-travel and time use patterns on the one hand and wellbeing on the other. TOMNET research is increasing body of knowledge on the presence of market segments that follow different causal structures in terms of relationships that govern their travel choices. This body of knowledge is critical to advancing more realistic and accurate travel demand forecasting models.

Improved techniques in addressing transportation issues:

The analysis of the data collected in **TOMNET multi-region Future of Mobility Survey** will contribute to improving planning processes and informing policymakers on 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 potential analysis in travel demand forecasting exercises. These scenarios are informed by the data collected in the survey. 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 analyze such scenarios and the techniques developed by TOMNET will help fill this gap. In addition, TOMNET developed an integrated household energy analysis tool and an integrated wellbeing analysis tool, both of which incorporate techniques and algorithms that can be implemented in conjunction with existing travel demand forecasting models and planning processes. The team has also developed novel methods for fusing data from targeted marketing firms with data from traditional household travel surveys; this results in highly enriched data that can be used to advance more accurate travel forecasts.

Enlargement of the pool of trained transportation professionals:

TOMNET has been very successful and productive in engaging K-12, 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. 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 the table below for two metrics.

Metric	Annual Target	Previous Reporting Period	This Reporting Period	Annual Total	Assessment
Number of workshops, short courses, and tutorials	2	2	1	3	Need to focus on more full-scale workshops and tutorials in 2020. TOMNET is holding many seminars/webinars.
Improvement in accuracy of travel forecasts due to TOMNET research methods	10%	10%	0%	10%	Initial efforts exhibit considerable promise in improving travel forecasts. Need to do more testing in agency environment.

The TOMNET team is re-evaluating the metrics for outcomes. It would appear that these metrics are not quite ideal for tracking purposes, given that the number of workshops does not necessarily constitute an outcome and determining improvement in forecast accuracy is extremely challenging to do within the

lifetime of a UTC (because of the time it takes for MPO models to be significantly updated with new data and methods). Discussions are underway to potentially change the metrics to consider number of individuals participating in TOMNET research, education, and technology transfer activities, and the number of instances that TOMNET researchers and research results have been cited and quoted in the press or other similar public outlets.

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 transportation system and informed decision-making on transportation investments and improvements that will advance mobility for all.

UW: Community and infrastructure resilience before, during, and after crisis events is very important. The data gathered from the community outreach activities and surveys is helping to inform both transportation and emergency planners about actions people anticipate taking if they experience an extreme event. This data and community outreach activities are helping planners and emergency agencies plan various services including evacuation methods, communication channels, healthcare and medication distribution strategies, and transportation options for those who cannot evacuate themselves.

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 **TOMNET multi-region Future of Mobility Survey** is helping to craft realistic future scenarios and 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). The deployment of these models in agencies is just beginning to occur in the form of beta-testing and it is anticipated that these activities will be elevated in the months ahead. 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 for the next National Household Travel Survey (NHTS); this survey has substantially underestimated the actual commute distance, and this bias may disproportionately apply to women, who are more likely to trip chain on their commutes. TOMNET has offered a simple suggestion for additional information that NHTS could provide to the user community without compromising respondent confidentiality, which would enable all users to deploy the same approach in accurately computing commute distances and travel times – specifically accounting for trip chaining.

UW: This team is now helping agencies develop enhanced approaches for disaster mitigation planning that leverage community strengths over vulnerabilities. Such an approach to hazard planning has the potential to help communities develop mitigation strategies that will benefit them on an everyday basis as well as in the case of a disaster.

What is the impact on the body of scientific knowledge?

ASU/GT/USF: TOMNET research is impacting the body of knowledge along a number of dimensions. The **multi-region Future of Mobility 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*.

GT: Until now, attempts to impute attitudes into datasets that do not have them have met with abysmal results. The machine learning-based approach developed by TOMNET is showing great promise for predicting attitudes well enough for them to add meaningful value to traditional travel demand forecasting models. TOMNET has demonstrated empirically that stereotypical residential preferences for millennials only apply to a subset thereof, and conversely that those preferences are shared by many members of Generation X. In other words, residential preferences are not defined by arbitrary age thresholds, but TOMNET has transformed the conversation in generational analysis by providing a method and the data for offering a richer understanding of the nuances influencing those preferences. TOMNET research has identified a segment of people who report wanting to move *closer* to their major activity locations (e.g., work) when automated vehicles become prevalent, counter to the stereotype that AVs will increase urban sprawl (although there is a similar-size segment fitting the stereotype).

UW: The community-engaged workshop and survey protocol that is being developed through this project are helping to inform future research and action regarding region-wide resilience strategies. By engaging both urban and rural communities, TOMNET is providing new body of knowledge on differences between needs of urban and rural 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 protocols is a new development that can inform future hazard planning approaches that better take local needs, resources, knowledge, and strengths into account.

What is the impact on transportation workforce development?

ASU: TOMNET has enabled multiple undergraduate students, including Barrett Honors College students, to participate in transportation research. These students have graduated and are now in industry as transportation engineering professionals; thus TOMNET has directly impacted the workforce. Two undergraduate students from Dine’ College, an American Indian Tribal College, have engaged in TOMNET research and have decided to continue their college education in STEM fields. TOMNET is influencing high school students to consider transportation as a career option through K-12 outreach activities.

GT: In addition to all of the graduate level workforce development and undergraduate training, TOMNET faculty at GT trained a high school junior in transportation literature review and data analysis skills.

UW: To date, the project activities have engaged undergraduate and graduate students 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 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 this way, TOMNET is equipping the future workforce to use new tools and participatory approaches to address disaster planning; transportation workforce has historically not been trained in such tools and approaches.

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

Metric	Annual Target	Previous Reporting Period	This Reporting Period	Annual Total	Assessment
Number of agencies adopting TOMNET tools	2	2	1	3	TOMNET is working with multiple agencies to enhance product adoption.
Improve mobility for transportation disadvantaged populations	5%	0%	0%	0%	Difficult metric to quantify and assess. Need to consider replacing this metric with one that is more measurable.

Again, the TOMNET team is re-visiting these metrics to ensure that they are appropriate for tracking performance of the UTC. While the first metric is appropriate, the second metric tends to be harder to measure and assess. The TOMNET team is considering a change in the second metric to reflect the number of individuals educated and trained in the use of new tools developed by TOMNET (impact on workforce), or the number of instances where TOMNET research results have contributed to a change in design or policy (again, rather difficult to measure, but could be an easier metric than the existing one).

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.