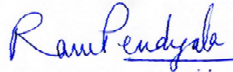


QUARTERLY PROGRESS PERFORMANCE REPORT (QPPR #3)



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INTRODUCTION

This document constitutes the Program Progress Performance Report (PPPR) 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, 2018. This PPPR covers work accomplished and performance metrics for the period of April 1, 2018 to September 30, 2018.

1. ACCOMPLISHMENTS

The TOMNET University Transportation Center 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 mail-based and email-based surveys regarding users attitudes, perceptions, and behaviors in the present and in the future, considering all 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. TOMNET is undertaking a number of inter-related research projects that involve survey design and data collection, data fusion and machine learning, modeling and forecasting, and policy simulation and analysis. Through a portfolio of well-coordinated research projects, TOMNET researchers are deriving new and deep insights about traveler behavior and values under alternative futures, and developing new methods, models, tools, and algorithms for forecasting travel demand in regional planning processes.

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. These individuals will be equipped to design transportation solutions of the future while taking advantage of emerging technologies and paradigms *and* addressing the occasionally competing challenges of economic growth, quality of life, community resiliency, equity and environmental justice, affordability, health, and energy and environmental sustainability. 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, policy-makers, and the broader public. TOMNET recognizes that transportation plays an important part in affecting the quality of life, health, and resilience of communities; therefore, TOMNET is undertaking activities to transfer knowledge and communicate accurate information about traveler behavior and values to various stakeholders who are affected by and/or make decisions that may affect future mobility options. By developing and disseminating open source software tools and methods, new algorithms and modeling approaches, and research reports and policy briefs, TOMNET will inform decision-makers and empower communities. TOMNET will enhance the capabilities of the workforce of today and tomorrow by providing new and rich data about behaviors, choices, and attitudes; conducting hands-on training workshops and boot camps; and organizing specialized executive courses and information sessions specifically aimed at decision-makers.

What was accomplished under these goals?

Within the reporting period, TOMNET researchers made considerable progress on research projects that were initiated October 1, 2017. The 2017-2018 list of projects is provided in Table 1.

Table 1. Year 1 (2017-2018) TOMNET Research Projects

Project Topic/Title	Lead Institution	Institution PI
Quantifying the Relative Contribution of Various Factors to Household Vehicle Miles of Travel*	ASU	Ram Pendyala
Modeling Level of Interest in Autonomous Mobility Services and Vehicles*	ASU	Ram Pendyala
An Exploration of Feelings of Subjective Well-Being During Travel Episodes*	ASU	Ram Pendyala
Attitudes Towards Mobility Options/Technologies – A Multi-region Survey Design and Data Collection Effort*	ASU	Sara Khoeini
Comprehensive Review of Attitudes-Travel Behavior Literature	ASU	Deborah Salon
Assembling Integrated Data Sets for Analyzing Connections between Travel Behavior, Attitudes, and the Built Environment	ASU	Deborah Salon
Attitudes Towards Mobility Options/Technologies – A Multi-region Survey Design and Data Collection Effort	GT	Giovanni Circella
An Investigation of the Contribution of Targeted Marketing Data to the Prediction of Attitudes	GT	Patricia Mokhtarian
Attitudes Towards Mobility Options/Technologies – A Multi-region Survey Design and Data Collection Effort	USF	Michael Maness
Investigation of the Role of Attitudinal Factors on Adoption of Emerging Automated Vehicle and Vehicle Safety Technologies	USF	Fred Mannering
Understanding Community Behaviors and Attitudes for Resilience: Developing a Scalable Survey Methodology	UW	Cynthia Chen

Note: ASU = Arizona State University; GT = Georgia Institute of Technology; USF = University of South Florida; UW = University of Washington. *These projects are joint efforts of TOMNET UTC and D-STOP UTC (led by the University of Texas at Austin).

During the reporting period covered by this PPPR, TOMNET held its annual meeting on May 9-10, 2018 at Arizona State University. About 20 faculty members, research scientists, and graduate students delivered presentations reporting on progress made on various research projects during the past year. In addition, the meeting included extended sessions during which the team developed the portfolio of projects that would be undertaken commencing October 1, 2018 (while continuing to work on projects that commenced in 2017). During this TOMNET annual meeting, a rigorous review of project proposals submitted for 2018-2019 funding was undertaken. The 2018-2019 list of selected projects is provided in Table 2. It should be noted that five of the selected 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. A number of projects commenced in 2017 and will continue into a Phase 2 effort in 2018-2019.

Table 2. 2018-2019 TOMNET Research Projects

Project Topic/Title	Lead Institution	Institution PI
Development of an Integrated Model of Daily Activity-Travel Behavior and subjective Well-Being	ASU	Ram Pendyala
Data Fusion to Model Residential and Transport Energy Footprint of Households While Considering Attitudinal Variables	ASU	Sara Khoeini
Attitudes Towards Mobility Options/Technologies – A Multi-region Survey Design and Data Collection Effort - Phase II	ASU	Sara Khoeini
Comprehensive Review of Attitudes-Travel Behavior Literature - Phase II	ASU	Deborah Salon
Assembling Integrated Data Sets for Analyzing Connections between Travel Behavior, Attitudes, and the Built Environment - Phase II	ASU	Deborah Salon
Consumer Attitudes and Behavioral Implications in the New Era of Shared Mobility	ASU	Zhongju Zhang
Emerging Approaches to Autonomous Vehicles in Transportation Policy and Planning	ASU	Thaddeus Miller
Consistency Guarantee of Transportation Modeling Calibration and Validation Using Multi-source Data in a Computational Graph Approach	ASU	Xuesong Zhou
Attitudes Towards Mobility Options/Technologies – A Multi-region Survey Design and Data Collection Effort - Phase II	GT	Giovanni Circella
An Investigation of the Contribution of Targeted Marketing Data to the Prediction of Attitudes - Phase II	GT	Patricia Mokhtarian
Attitudes Towards Mobility Options/Technologies – A Multi-region Survey Design and Data Collection Effort - Phase II	USF	Michael Maness
Investigation of the Role of Attitudinal Factors on Adoption of Emerging Automated Vehicle and Vehicle Safety Technologies - Phase II	USF	Fred Mannering
Understanding community behaviors and attitudes for resilience: developing and implementing a scalable survey methodology - Phase II	UW	Cynthia Chen

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

The following is a summary of progress made on various projects, with descriptions, accomplishments, and plans for the next year if applicable. Due to page limitations, detailed descriptions of progress cannot be furnished here for all projects.

Project Title: Attitudes towards Transformative Mobility Options/Technologies – A Multi-region Survey Design and Data Collection Effort (Phase I &2)

Institution and Investigators: Arizona State University – Sara Khoeini; Georgia Tech – Giovanni Circella; University of South Florida – Michael Maness

Description: To enhance transportation forecasting models such 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 1000 individuals across Phoenix metro area. During Phase 1 (2017-2018) of this project, a comprehensive literature review of survey design and methodology was performed. A survey questionnaire was designed in accordance with the findings from the review. During the second phase of the project (2018-2019), data collection will happen in two phases: pilot and full deployment. Pilot phase of data collection is planned for October-November 2018 with the goal of having a sample size of 150 respondents. The goals of

the pilot survey are to evaluate response rates between two survey methods (mail vs e-mail), and test the survey content and sampling plan.

The full phase of data collection is planned for December 2018 through February 2019. During the full deployment, the research team will finalize the survey instrument, content and sampling plan based on the results from pilot survey. During the remaining period of Phase 2, the research team will compile and clean the data, analyze it using advanced statistical methods, estimate econometric models, and produce the reports, papers, presentations, and data documentation. The same data collection effort, using the same questionnaire, will be undertaken across multiple jurisdictions of Atlanta, GA, Tampa, FL, and Austin, TX. The data collected across multiple jurisdictions will eventually be aggregated to produce a single dataset with sample size of about 4,000 responses. This dataset will be 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 across metro areas.

Project Title: Comprehensive Review of Attitudes-Travel Behavior Literature (Phase I &2)

Institution and Investigators: Arizona State University – Deborah Salon

Description: The original objective of this project was to write a comprehensive review of the literature on the role of attitudes in explaining travel behavior. As part of this review, the TOMNET team noticed that there are many studies dedicated to this topic, but that many/most of them use different attitudinal questions and statements - often to get at rather similar concepts and constructs. Unfortunately, this makes the study results less comparable than they would be if researchers had employed more standardized questions to represent concepts when they collected attitudinal survey data. The team subsequently embarked on a project to catalog not only the methods and results of many studies, but also the actual questions used. The idea is to create an online “question bank” of attitudinal questions that have been used in prior travel behavior studies. The question bank will include the actual questions organized by attitudinal construct, identify the study or studies that used them, and describe how they appeared to influence travel behavior. Senior TOMNET researchers developed a prototype of this question bank in Spring 2018, using Google Sheets to organize the information. In the next TOMNET reporting period, talented undergraduate students at ASU will be hired to help with the question bank project, and expose undergraduate students to transportation literature and research.

Project Title: Assembling Integrated Data Sets for Analyzing Connections between Travel Behavior, Attitudes, and the Built Environment (Phase I &2)

Institution and Investigators: Arizona State University – Deborah Salon

Description: Important travel behavior outcomes include distance, mode, route, and time of day for a particular trip, as well as number of trips made overall by an individual or a household. Observed travel behavior depends on some combination of attitudes and preferences about these factors; attitudes and preferences about vehicle ownership, vehicle type, and residential location; and physical (both individual capability and the built environment) and budget constraints. The objective of this project is to fuse existing datasets that are rich in attitudinal information with vehicle ownership and use, home neighborhood, and individual property characteristics datasets. These combined datasets will allow us to investigate questions about how attitudes influence residential location choice, and how the combination of attitudes and location choice influences travel behavior. In the past six months, the team accomplished the data integration goals for two existing transportation attitudinal surveys: one initially collected in Arizona in 2012 (the ASU Travel Survey), and the other originally collected in California in 2015 (the California Millennials Dataset). In the next reporting period, the team will begin analyzing these data sets, specifically to investigate how attitudes affect residential location choices or travel behavior, or both of these choices. The next reporting period will be focused on conducting this data analysis.

Project Title: An Investigation of the Contribution of Targeted Marketing Data to the Prediction of Attitudes (Phase I &2)

Institution and Investigators: Georgia Tech – Patricia Mokhtarian; Giovanni Circella; Kari Watkins

Description: 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 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 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.

During this reporting period, collection and preliminary cleaning of the GDOT data was largely completed. Because of the size of the order, there were delays in acquiring the TM variables. These issues have now been resolved, and the data should be delivered prior to the end of the calendar year 2018. In the meantime, the team has been setting up file structures and scripts for the analyses to come, so that the team will be able to quickly begin the desired analyses once the data arrive.

Project Title: Investigation of the Role of Attitudinal Factors on Adoption of Emerging Automated Vehicle and Vehicle Safety Technologies (Phase I &2)

Institutions & Investigators: University of South Florida – Fred Mannering; Michael Maness

Description: During the last year, the team studied factors affecting people’s likelihood of sharing autonomous vehicles. The team’s models found statistically significant influences on adoption from ethnicity, household size, daily travel times, and vehicle crash history. Regarding sharing concerns, the statistical analysis identified key characteristics of respondents who were more or less likely to be concerned with safety, privacy, reliability, and travel time/cost. In other work, the study team has closely analyzed factors relating consumers’ perceptions towards automated vehicles and their intended adoption. Using cluster analysis techniques and discrete choice models, substantial and statistically significant differences were found across each automated-vehicle consumer market segment. This underscores the potentially large impact that different consumer demographics may have on autonomous vehicle adoption and the need for targeted marketing to improve market-penetration outcomes.

To explore the practical benefits of incorporating attitudinal variables in models of automated vehicle adoption, the study team compared the spatial transferability for two model structures: multinomial logit (MNL) and integrated choice and latent variable (ICLV) models. A transferability analysis of intended AV usage data from Florida and Michigan was performed. The study yielded mixed results in finding improvements from using transferred ICLV models versus locally estimated MNL models. The ICLV models tended to predict as well as a corresponding MNL model. The team plans to continue to refine their analysis and to possibly explore other datasets with transferability possibilities.

Project Title: Understanding Community Behaviors and Attitudes for Resilience: Developing a Scalable Survey Methodology (Phase 1 & 2)

Institutions & Investigators: University of Washington – Cynthia Chen; Daniel Abramson

Description: Specific goals for the first phase of the project are: to understand, via a thorough literature review, the state of the field in survey methodology with a focus on intersections between the transportation, resilience, and appreciative inquiry literatures; to identify and address issues relevant to creating a scalable methodology; to develop a scalable survey methodology focused on identifying and characterizing community resources as well as attitudes about those resources, including their current and future use; to potentially implement a small pilot project and collect preliminary data.

The team has expanded its engagement with community partners to include a low-income and relatively isolated rural coastal community to complement initial partners in a high socio-economic status, well-connected urban residential neighborhood, enhancing the regional applicability of the research. The two communities also span different dominant vulnerabilities: earthquakes in one; tsunamis (and also earthquakes) in the other.

The team has continued to meet with research partners in other academic departments and local agencies, including UW Medicine Telehealth and Seattle's Office of Emergency Management, as well as the UW Department of Global Health, Seattle's Community Emergency Hubs organization, Seattle-King County Public Health, the Northwest Healthcare Response Network, and the Washington State Emergency Management Division. The team has been invited to prepare presentations on community resilience and multi-method data-gathering (qualitative and quantitative; questionnaire- and map-based), to be shared with municipal agencies on November 15, 2018. The community self-assessment survey is nearly ready for implementation. The above-mentioned urban and regional community and agency partners have all provided feedback on the questionnaire, and a color booklet for mail distribution is being designed. A method for sampling respondents has been determined. The team is scheduled to conduct an asset-mapping workshop with the urban partner community on November 7, and to implement the survey.

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

Institution and Investigators: Arizona State University – Ram Pendyala; Sara Khoeini

Description: The notion that people's activity-travel patterns are important determinants of well-being and overall quality of life is well recognized. Despite the close linkage between quality of transportation and quality of life, activity-travel demand models do not output explicit measures of well-being that can be used to assess the impacts of alternative policies, investments, and technologies. In addition, because activity-travel demand models provide no information about how in-home time is allocated to various activities, it is virtually impossible to assess feelings of well-being resulting from in-home activity and time allocation. This project is an effort to develop a model of well-being that explicitly accounts for in-home time allocation to different activities. The research team will use the well-being modules of the American Time Use Survey (ATUS) and impute well-being information into the 2017 National Household Travel Survey (NHTS) data. The project will provide a robust behavioral approach to assess the quality of life implications across different groups of population and can be used as an add-on module to activity-based models to evaluate the impact of different policy and planning decisions on overall user well-being.

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

Institution and Investigators: Arizona State University – Sara Khoeini; Ram Pendyala

Description: 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. Integrated models of activity-travel demand and transport energy consumption often do not consider the mix of vehicle types owned and used by households, thus making it difficult to assess the energy implications of shifting vehicle/fuel type choices – particularly in a rapidly evolving marketplace. More importantly, integrated models of activity-travel demand and transport energy consumption do not consider the residential energy consumption implications of travel. 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. This project will develop an integrated transport – residential energy model system that connects these three entities by fusing information between two survey data sets, namely, the National Household Travel Survey (NHTS) data set and the Residential Energy Consumption Survey (RECS) data set. The integrated model system will be applied to a synthetic population of one or more metro areas to illustrate the efficacy of the model system.

In addition to research activities described above, TOMNET has been involved in other related research activities. For example, Dr. Mokhtarian and her group at Georgia Tech have fused multiple attitudinal data sets collected by Dr. Mokhtarian over the course of her 28-year faculty career, and are initially using it to investigate spatio-temporal variations in respondent-reported Satisfaction with Life. This study is yielding some unexpected and useful insights into some hidden characteristics of online opinion panelists in contrast to more randomly-recruited respondents. Moreover, the mode choice model in which the travel time *coefficient* is expressed as a function of demographic and attitudinal variables (described in the previous PPPR) was written up, submitted, and accepted for presentation at the 2019 TRB Annual Meeting.

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 2018 (that spans the reporting period covered by this PPPR). 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

Semester	Course Level	Course Number	Course Title	No.	Instructor	Unit
Arizona State University						
Fall 18	Undergrad	CEE 372	Transportation Engineering	126	Pendyala	SSEBE
Fall 18	Graduate	CEE 591	Transportation Engineering Seminar	3	Pendyala	SSEBE
Fall 18	Graduate	PUP642	Urban and Regional Economic Analysis	14	Salon	SGSUP
Fall 18	Graduate	CEE 598	Traffic Simulation and Model Application	10	Zhou	SSEBE
Fall 18	Undergrad	PUP301	Introduction to Urban Planning	180	Kelley	SGSUP
Fall 18	Graduate	CEE 573	Transportation Operations	10	Basha	SSEBE
Fall 18	Grad/UG	GCU 494	Campus Transportation Planning	14	Nelson/Thigpen	SSEBE
Fall 18	Grad/UG	GCU 442	Geographical Analysis of Transportation	22	Kuby	SGSUP
Georgia Institute of Technology						
Fall 18	Graduate	CEE 6623	Transportation Survey Methods	14	Mokhtarian	CEE
University of South Florida						
Fall 18	Undergrad	TTE4003	Transportation and Society	38	Kourtellis	CUTR
Fall 18	Undergrad	TTE4004	Transportation Engineering I	105	Bertini	CEE
Fall 18	Graduate	TTE6507	Travel Demand Modeling	6	Maness	CEE
Fall 18	Graduate	TTE6307	Statistical and Econometric Methods I	29	Mannering	CEE
Fall 18	Graduate	TTE5501	Transportation Planning & Economics	29	Menon	CUTR
Fall 18	Undergrad	TTE4006	Transportation and Society	32	Kourtellis/Islam	CUTR
Fall 18	Graduate	TTE6930	Graduate Transportation Seminar	9	Zhang	CEE
University of Washington						
Sum 18	Grad	URBDP	China Village Studio	6	Abramson	UrbPlng
Fall 18	Grad	URB508B	Advanced Urban Planning Studio	7	Abramson	UrbPlng
Fall 18	Grad/UG	CEE 416	Urban transportation planning	70	Bassock	CEE

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 Washington; CEE = Department of Civil and Environmental Engineering; University of South Florida; CEE = Department of Civil and Environmental Engineering

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 PPPR 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 Masters and PhD degrees, the TOMNET consortium is involving 12 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. Moreover, TOMNET is hosting Jimmy Armoogum who is a senior researcher at the Laboratory Economic and Social Dynamics of Transport (DEST) of the French Institute of Science and Technology for Transport, Development and Networks (IFSTTAR) as a visiting TOMNET Senior Scholar at Arizona State University.

Table 3. Students and Post-Doctoral Scholars Engaged in TOMNET Research and Education and Activities

Inst	Name of Scholar	Level	Major/ Unit	Supervisor/ Advisor
Arizona State University	Calvin Thigpen	Post-doc	SGSUP	Nelson
	Denise Capasso da Silva	PhD Student	SSEBE	Pendyala/Khoeini
	Shivam Sharda	PhD Student	SSEBE	Pendyala
	Taehooie Kim	PhD Student	SSEBE	Pendyala
	Tassio Bezerra Magassy	PhD Student	SSEBE	Pendyala
	Irfan Batur	PhD Student	SSEBE	Pendyala
	Jimmy Armoogum	Visiting Scholar	SSEBE	Pendyala
	Matthew Wigginton Conway	PhD Student	SGSUP	Salon
	Sumit Kumar	MS Student	CIDSE	Pendyala
	Sarah Moran	Undergrad	CIDSE	Pendyala
	Amy Santilli	Undergrad	SSEBE	Pendyala
	Eileen Imbus	Undergrad	SSEBE	Pendyala
	Allison Charles	Undergrad	SSEBE	Pendyala
	Elyse Kats	Undergrad	Sustainability	Salon
Georgia Institute of Technology	Gwen Kash	Postdoc	CEE	Mokhtarian
	Yongsung Lee	PhD/Post-doc	SCaRP/CEE	Circella/Mokhtarian
	Ali Etezady	PhD Student	CEE	Circella/Mokhtarian
	Alyas Widita	PhD Student	SCaRP	Circella
	Xinyi Wang	PhD Student	CEE	Mokhtarian
	Faaika (Atiyya) Shaw	PhD Student	CEE	Mokhtarian
	Aliaksandr Malokin	PhD Student	CEE	Mokhtarian
	Richard Sinz	MS Student	CEE	Mokhtarian
	Sung Hoo Kim	PhD Student	CEE	Mokhtarian
	Zahra Khan	Undergrad	CEE	Mokhtarian
	Robert Brown	Undergrad	CEE	Mokhtarian
	Cynthia Bledsoe	Undergrad	CEE	Mokhtarian
	Sanghyun Park	Undergrad	ME	Mokhtarian
	Oluwasanmi Toyobo	Undergrad	CEE	Mokhtarian
University of South Florida	Dr. Michael Maness	Post-doc	CEE	Pinjari/Mannering
	Parvathy Vinod Sheela	Graduate	CEE	Pinjari/Mannering
	Suryaprasanna Balusu	PhD student	CEE	Pinjari/Mannering
	Divyakant Tahlyan	MS Student	CEE	Pinjari/Mannering
	Natalia Barbour	PhD student	CEE	Zhang/Mannering
	Nawaf Alnawmasi	PhD student	CEE	Fred Mannering
	Dr. Nikhil Menon	Post-doc	CEE	Robert Bertini

University of Washington	Katie Idziorek	PhD student	UrbDP	Chen/ Abramson
	Xi Zhu	PhD Student	CEE	Chen
	Feilong Wang	PhD Student	CEE	Chen
	Jenny Phan	Undergrad	UrbDP	Chen/Abramson
	Sophia Nelson	Undergrad	UrbDP	Abramson/Chen
	Tan Chou	Undergrad	Geography	Chebn

Notes: Please use the information below table 2.

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 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 more than 50 participating high school students getting exposed to transportation career information. Sara Khoeini (TOMNET Assistant Director) presented *Future Careers in Transportation* workshop to 60 high school students on July 12, 2018. TOMNET PhD students, Shivam Sharda, Taehooie Kim, Denise Silva, and Irfan Batur, assisted Sara Khoeini during the workshop activities.

Additionally, Sara Khoeini (TOMNET Assistant Director) developed and conducted a workshop for preschoolers (Age 3 to 5) at Summit School of Ahwatukee. A group of a dozen preschoolers gathered to build a mini-city on a large cardboard, including a house for each student, one school, trees, and roads to connect their houses to the school. They became introduced to the concept of transportation, local and main roads, intersections, and traffic control signs and signals. The students greatly enjoyed the activity.

TOMNET presented a display at the Arizona Council for Transportation Innovation (ACTI) Innovation Day 2018. On September 25, 2018, senior transportation leaders from public and private sectors as well as academia gathered to talk about how to advance and deploy innovation in transportation planning and decision making. Speakers from the USDOT and FHWA were also present and delivered keynote lectures. Event participants visited the TOMNET exhibit table and discussed the cutting-edge projects that are underway at TOMNET. In particular, the recent survey on new transportation technologies such as autonomous vehicles and ridehailing services captured a lot of attention.

On April 19-20, 2018, the University of Washington (UW) TOMNET team hosted an interactive exhibit at the University of Washington’s Annual Engineering Discovery Days event. This event brings 4th to 8th graders from the Puget Sound region to the UW campus to learn about engineering disciplines via hands-on activities. The TOMNET team developed two activities that engaged participants in resource matching for disaster scenarios. Participants considered how to creatively use different kinds of resources (e.g., transportation, communication, skills and supplies) to solve a variety of challenges. They also considered the role of social connections in being able to access and leverage a wider pool of potential resources when “everyday conveniences” are not available. Participants shared with researchers the qualities of a transportation system that they felt contributed to resilient communities.

During the summer of 2018, the University of Washington research team participated in several community outreach activities with coastal partner communities to learn more about the strengths and values of those communities as well as the unique challenges they face due to natural hazard risk. On a visit to Shoalwater Bay Tribe in Tokeland, WA in June of 2018, Daniel Abramson, Katherine Idziorek and two undergraduate research assistants were invited to visit and “fire up” Shoalwater Bay Tribe’s Mobile Command Center with Shoalwater Bay Police Chief Robin Souvenir. This provided an opportunity to learn about how local emergency responders approach transportation and communication issues in preparing for potential disaster scenarios.

In September 2018, PhD students Atiyya Shaw and Xinyi Wang, together with Dr. Patricia Mokhtarian of Georgia Tech, participated in a two-day international workshop hosted at the University of New South Wales (Sydney, Australia), and funded by the Global Initiative Fund of the Technical University of Munich

(Germany). The purpose of the project is to explore the use of machine learning methods to improve the estimation of population parameters used to generate and evolve synthetic populations in an activity-based model. At the workshop, the partners exchanged information on their related activities, brainstormed possible approaches to the challenge of estimating population parameters, and proposed a series of explorations to pursue in preparation for the second (final) workshop in June 2019 – that one to be hosted by Georgia Tech. The partners plan to meet during the 2019 TRB conference to update each other on the progress being made.

In the *technology transfer* domain, Arizona State University launched the **weekly TOMNET webinar/seminar series** that is presented to a worldwide audience through the webinar arrangement on TOMNET website. The recorded webinars are available on TOMNET’s website for further reference (www.tomnet-utc.org/seminars-and-webinars.html). Table 4 presents a list of TOMNET-sponsored seminars for the period covered by this PPPR. Speakers met with TOMNET faculty and students, thus enabling the development of collaborative ties.

Additionally, all of the 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 participating 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.

Table 4. Key TOMNET-Sponsored Technology Transfer Events

Title of Seminar/ Webinar	Speaker Name and Affiliation	Date of Event
Arizona State University		
Stochastic Modeling of Traffic Breakdown for Freeway Merge Bottlenecks	Soyoung (Sue) Ahn, PhD Associate Professor, University of Wisconsin-Madison	April 5, 2018
Local Motors - Autonomous Vehicle Development and Advanced Manufacturing	Phillip Rayer Phoenix General Manager, Local Motors	April 12, 2018
On the Path to Autonomous Vehicles	Dr. Bill Sowell, MBA, PhD Vice President-Business Development, Eberle Design	April 19, 2018
Valley Metro Update	Wulf Grote, PE, Director Capital & Service Development, Valley Metro	April 26, 2018
One “Road” to Success	Jenny Grote, PE Principal, GroTrans Engineering, LLC	April 26, 2018
Non-Commute Long Distance Travel in the California Household Travel Survey	Konstadinos G. Goulias, PhD Professor, Department of Geography University of California at Santa Barbara	May 11, 2018
Measurement and Analysis of Mobility	Jimmy Armoogum, PhD Senior Researcher, IFSTTAR-DEST, France	Aug 31, 2018
The Influence of Personal Experiences and Media Coverage of Bicyclist and Pedestrian Crashes on Perceptions and Behavior	Calvin Thigpen, PhD Post-doctoral Research Scholar, SGSUP, ASU	Sep 7, 2018
Tempe Streetcar - The Making of a New Transit System	Tom Wolf, PE Transit Program Manager, Stantec Thomas (Tom) Wilhite, PE MPA StreetCar Project Engineer, City of Tempe	Sep 14, 2018
How Small Can Headways Be in Platoons of Connected Autonomous Vehicles?	Yingyan Lou, PhD Associate Professor, SSEBE, ASU	Sep 21, 2018
Georgia Institute of Technology		
Travel Behavior Implication of Automated Vehicles	Yoram Shiftan, The Technion, Israel Institute of Technology	April 12, 2018

It should be noted that seminars at partner institutions (University of Washington, Georgia Tech, and University of South Florida) are largely omitted from the listing in Table 4 because the seminars are listed in the PPPR documents of other University Transportation Centers (UTCs) for which these institutions serve as either a lead or a consortium partner. In an effort to avoid double-counting seminars across UTC PPPR documents, only those seminars that can be truly counted as TOMNET seminars are listed in Table 4. The Georgia Tech transportation seminars are video-recorded and available on YouTube at <https://www.youtube.com/user/gatechtranspo>. TOMNET faculty and students at these institutions actively participate in and help organize those seminar series.

Information about the seminars is disseminated widely through distribution channels and e-mail lists maintained by the respective institutions. At Arizona State University, for example, announcements about the seminars and other transportation-related events on campus are sent out via e-mail to a list of 100 faculty members (who, in turn, distribute the announcements to all of their students) and 135 professionals. Similar lists are maintained by partner institutions, thus enabling effective technology transfer as well as the engagement of the professional community and trans-disciplinary faculty and students in TOMNET activities.

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 are currently finalizing their annual research reports for 2017-2018 cycle. These reports will be posted to the TOMNET website by the end of the calendar year following a rigorous peer review process. These reports will be disseminated widely through various channels. Moreover, research activities on recently selected proposals for the 2018-2019 cycle (Table 2) have commenced for TOMNET core group members.

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 towards appropriate career pathways in transportation.

Several additional activities are being planned to further advance the educational component of the TOMNET portfolio of accomplishments. First, 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 2019. Second, TOMNET scholars will continue engage in considerable K-12 outreach activities.

In the *technology transfer* domain, the TOMNET team will continue to organize and conduct webinars/seminars such as those listed previously in Table 4. TOMNET will expand the portfolio of outreach activities to include a **TOMNET Monthly Leadership Webinar Series**, to be delivered by TOMNET core faculty members as well as specially invited guest speakers on topics related to the projects funded by TOMNET and/or very close to the TOMNET theme. These webinars will be recorded and archived at the TOMNET website for the benefit of those who could not attend the webinars live and in-person. The seminars and webinars will be publicized via various distribution lists and e-mail listservs.

The Center will conduct a four-day workshop on "Travel Survey Methods for Behavioral Analysis" during December 10-14, 2018 to be taught by Professor Peter R. Stopher, Professor Ram Pendyala (TOMNET Director) and several invited speakers. The primary workshop instructor is Emeritus Professor Peter R. Stopher, an internationally renowned authority in the design and administration of travel surveys, including the application of new technologies to collect travel data. The workshop will be held in a state-of-the-art learning facility on the main Tempe campus of Arizona State University. Thanks to UTC funding, TOMNET

offers reduced registration fees to public agencies and university faculty and students. Moreover, TOMNET partners and sponsors receive a large discount on the workshop registration fee. A complete description, including a workshop agenda, is available at the workshop website: <https://www.tomnet-utc.org/training--technology-transfer.html/#Description>.

Discussions are underway to organize an annual 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. The first symposium will likely be held in Summer 2019, with a view to bring together a diverse worldwide audience working in these domains and discuss methods, tools, and models that can help leverage data about attitudes and behaviors to understand how the future of transportation may evolve in an era of automation and autonomy (as well as *sharing*). TOMNET will expand the reach of its newsletter and launch a blog within the next reporting period to greatly enhance the impact and reach of its technology transfer activities. The newsletter will be sent to an e-mail list of more than 1,500 professionals that TOMNET partners have carefully assembled through their respective networks; recipients will, of course, have the ability to unsubscribe and manage their subscription to the TOMNET communications (as TOMNET will be using a professional service such as Constant Contact to handle all communications and newsletter production). TOMNET also plans on participating in social networks to communicate its research and education achievements via social media platforms. In addition, TOMNET will present its accomplishments in USDOT's April 2019 newsletter.

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. PRODUCTS

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

Arizona State University

1. Astroza, S., Bhat, P. C., Bhat, C. R., Pendyala, R. M., Garikapati, V. M. (2018). Understanding activity engagement across weekdays and weekend days: A multivariate multiple discrete-continuous modeling approach. *Journal of Choice Modelling*, 28, 56-70.
2. Singh, A. C., Astroza, S., Garikapati, V. M., Pendyala, R. M., Bhat, C. R., Mokhtarian, P. L. (2018). Quantifying the relative contribution of factors to household vehicle miles of travel. *Transportation Research Part D: Transport and Environment*, 63, 23-36.
3. Zhang, W., Robinson, C., Guhathakurta, S., Garikapati, V. M., Dilkina, B., Brown, M. A., Pendyala, R. M. (2018). Estimating residential energy consumption in metropolitan areas: A microsimulation approach. *Energy*, 155, 162-173.
4. Zmud, J., Dias, F., Lavieri, P., Bhat, C., Pendyala, R., Shiftan, Y., Outwater, M., Lenz, B. (2018). Research to Examine Behavioral Responses to Automated Vehicles. In *Automated Vehicles Symposium 2018* (pp. 53-67). Springer, Cham.
5. Conway, M., Salon, D., King, D. (2018). Trends in Taxi Use and the Advent of Ridehailing, 1995–2017: Evidence from the US National Household Travel Survey. *Urban Science*, DOI: 10.3390/urbansci2030079.
6. Breetz, H., Salon, D. (2018). Do electric vehicles need subsidies? Ownership costs for conventional, hybrid, and electric vehicles in 14 US cities. *Energy Policy*, DOI: 10.1016/j.enpol.2018.05.038.

Georgia Institute of Technology

7. Alemi, F., Circella, G., Mokhtarian, P.L., Handy, S. (2018). Exploring the Latent Constructs behind the Use of Ridehailing in California. *Journal of Choice Modelling* 29, 47-62.
8. Delbosc, A., Mokhtarian, P.L. (2018). Face to Facebook: The Relationship between Social Media and Social Travel. *Transport Policy* 68, 2018, 20-27.

9. Alemi, F., Circella, G., Mokhtarian, P.L., Handy, S. (2018). What Influences Travelers to Use Uber? Exploring the Factors Affecting the Adoption of On-Demand Ride Services. *Travel Behaviour and Society* 13, 88-104.
10. Kim, S. H., Mokhtarian, P.L. (2018). Taste Heterogeneity as an Alternative Form of Endogeneity Bias: Investigating the Attitude-Moderated Effects of Built Environment and Socio-demographics on Vehicle Ownership using Latent Class Modeling. *Transportation Research Part A* 116, 130-150.
11. Mokhtarian, P. L. Subjective Well-Being and Travel: Retrospect and Prospect. In press, *Transportation*. <https://doi.org/10.1007/s11116-018-9935-y>.
12. Watkins, K. (2018). Using Value Sensitive Design to Understand Transportation Choices and Envision a Future Transportation System. In press, *Ethics and Information Technology*.

University of South Florida

13. Balusu, S., Pinjari, A., Mannering, F., Eluru, N. (2018). Non-decreasing threshold variances in mixed generalized ordered response models: A negative correlations correction approach to variance reduction. *Analytic Methods in Accident Research* 20, 46-67.
14. Fountas, G., Anastasopoulos, P., Mannering, F. (2018). Analysis of vehicle accident-injury severities: A comparison of segment- versus accident-based latent-class ordered probit models with class-probability functions. *Analytic Methods in Accident Research* 18, 15-32.
15. Menon, N., Barbour, N., Zhang, Y., Pinjari, A., Mannering, F. (2018). Shared autonomous vehicles and their potential impacts on household vehicle ownership: An exploratory empirical assessment. Forthcoming in *International Journal of Sustainable Transportation*, <https://doi.org/10.1080/15568318.2018.1443178>.

University of Washington

16. Guan, X., Chen, C. (2018). General methodology for inferring failure-spreading dynamics in networks. *Proceedings of the National Academy of Sciences*. DOI: <https://doi.org/10.1073/pnas.1722313115>
17. Wang, F., Chen, C. (2018). On data processing required to derive mobility patterns from passively-generated mobile phone data. *Transportation Research Part C*, 87, 58-74. DOI: 10.1016/j.trc.2017.12.003
18. Whiting, S., Abramson, D., Yuan, S., Harrell, S. (2018) A Long View of Sustainable Development in the Chengdu Plain, China. *Journal of Asian Studies*. Accepted for publication September 11, 2018.

During the reporting period of this PPPR, the 7th International Conference on Innovations in Travel Modeling (ITM) took place during June 24-27, 2018 in Atlanta, GA. The Transportation Research Board (TRB) Innovations in Travel Modeling (ITM) conference series has become the leading venue for researchers and practitioners to come together to discuss, debate, and share information about advances in travel analysis and modeling methods. TOMNET was very actively involved in this important transportation event. Dr. Ram Pendyala (TOMNET Director) served as the conference committee co-chair, and Drs. Giovanni Circella and Patricia Mokhtarian served as planning committee members and co-hosts. Moreover, TOMNET was among the conference sponsors. Lastly, TOMNET researchers presented their cutting-edge work at the conference in multiple sessions.

Similarly during the reporting period of this PPPR, the 15th International Conference on Travel Behavior Research (IATBR) took place during July 15-20, 2018 in Santa Barbara, CA. The International Association for Travel Behavior Research (IATBR) is an international organization of scholars, researchers, practitioners, consultants, and public agency professionals dedicated to the advancement of travel behavior research. TOMNET was very actively involved in the organization of this event. Dr. Ram Pendyala (TOMNET Director) served as a member of the conference steering committee. Moreover, TOMNET served as a major sponsor, providing funding that enabled the conference to offer discounted registration fees to students. TOMNET researchers presented their cutting-edge work at the conference in multiple sessions. Pendyala and Mokhtarian served as co-chairs for one of the conference workshops.

In summary, TOMNET core faculty generated 18 publications in well-respected journals and conference venues within the reporting period covered by this PPPR. These publications are directly attributable to funding provided by the TOMNET UTC. There are many other publications and presentations, made possible through several complementary and collaborative initiatives, including student theses and dissertations, that address and advance the discourse on TOMNET topics and themes. However, they are not listed here for the sake of brevity.

In addition to the 22 presentations delivered at ITM and IATBR conferences in Summer 2018, TOMNET researchers delivered presentations at other conferences, symposia, seminars, and events around the world. In the interest of brevity, the full list of presentations delivered by TOMNET researchers and students is not provided here. In summary, TOMNET core faculty, post-docs, and students delivered a total of 43 presentations during the reporting period covered by this PPPR. Among the 43 presentations, 10 were delivered by ASU faculty and students, 7 were delivered by Georgia Tech faculty and students, 19 were delivered by University of Washington faculty and students, and 7 were delivered by University of South Florida faculty and students. Many of these presentations are directly attributable to work being undertaken under the auspices of TOMNET, and serve as a mechanism for making the broader community aware of the research and technology transfer activities of the Center. A full list of presentations is available upon request and is included as a separate attachment in the interest of completeness.

Website(s) or other Internet site(s)

The TOMNET website is being continuously enhanced to support the mission of the center. The website, <http://www.tomnet-utc.org>, is a portal with comprehensive information about activities of the Center. The website include information about TOMNET mission, organization, core team, faculty and student affiliates, partners, sponsors, ongoing research projects, proposal submission portal, online seminar and webinar portals and recorded files, related events around the world, short course registration portal, and TOMNET semi-annual performance reports. The website has a member-only link that facilitates communication between the core TOMNET team members. Research project descriptions have also been entered in the RiP (Research in Progress) database (eight projects can be seen by doing a keyword search on TOMNET, and an additional six projects will be entered prior to the end of the calendar year). In addition, individual faculty members maintain their own websites with information about their publications, presentations, research projects, professional activities, and courses. Key websites with information relevant to TOMNET include:

1. <http://www.mobilityanalytics.org>: This is the website of the research group of Professor Ram Pendyala, the Director of TOMNET.
2. <https://sustainability.asu.edu/person/deborah-salon/>: This is the website of Professor Deborah Salon, who serves as an Associate Director of TOMNET.
3. <http://mokhtarian.ce.gatech.edu/>: This is the website of Professor Patricia Mokhtarian, who serves as the Research Director of TOMNET.
4. <http://cee.eng.usf.edu/faculty/flm/>: This is the website of Professor Fred Mannering, who serves as an Associate Director of TOMNET.
5. <http://www.michaelmaness.com>: This is the website of Michael Maness, postdoctoral scholar who serves as a Senior Investigator for TOMNET
6. <http://depts.washington.edu/thinklab/>: This is the website of Professor Cynthia Chen's laboratory and research group. Professor Chen is an Associate Director of TOMNET.
7. <http://www.cvent.com/events/7th-trb-innovations-in-travel-modeling-conference/>: This is the website for 7th TRB Innovations in Travel Modeling Conference held on June 24-27, 2018 at Atlanta, GA.
8. <http://www.iatbr2018.org/>: This is the website for 15th International Conference on Travel Behavior Research held on July 15-20, 2018 at Santa Barbara, CA.

The last two websites are furnished because TOMNET faculty members played a leadership role in organizing the conferences, and TOMNET partners served as conference sponsors that provided much needed support to subsidize student participation. Over time, the TOMNET website will be enhanced further to serve as a major resource to the broader community of scholars and practitioners in the transportation industry.

Software Programs, Codes, and Products

During the reporting period covered by this PPPR, the TOMNET team has worked diligently towards developing a few key products that would be of value to the transportation planning and modeling community. 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). This synthetic population generator has been adopted by a number of agencies around the country for microsimulation modeling of activity-travel demand. This product has been further refined and enhanced recently to improve the capabilities, functionality, and user-friendliness of the software. Considerable 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 prototype has been developed and tested, and the full beta-version will be released to the user community during the next TOMNET reporting period. The TOMNET team is developing a basic business model that would allow the cloud version to be a self-sustaining enterprise.

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 are collaborating with the D-STOP UTC at the University of Texas at Austin to conduct a multicity survey of attitudes and perceptions towards transformative transportation technologies; this survey includes a number of sections such as a stated preference section and separate sections dedicated to collecting data about socio-economic and demographic characteristics, current travel behavior patterns, general attitudes and preferences towards modes of transportation and lifestyles, attitudes towards and potential adoption of mobility-on-demand services, and attitudes towards and potential adoption of automated vehicle systems. Data collection is underway and a report on the data collection activities will be furnished in the next PPPR.

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 survey has reached an almost-final state during the reporting period of this PPPR, with revisions from TOMNET members integrated into the survey instrument. Data collection will occur in the next reporting period.

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 Transportation and Residential Energy Analysis Tool (iTREAT) is under development. 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 codes developed by TOMNET team can be found at <https://www.mobilityanalytics.org/r-codes-for-travel-modeling.html>.

Starting in Aug 2018, 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 at <https://www.tomnet-utc.org/seminars-and-webinars.html>.

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. For example, for modeling the energy footprint of households, data from the Residential Energy Consumption Survey (RECS) data has been fused with data from the National Household Travel Survey (NHTS). Similarly, for modeling wellbeing that is derived by individuals from their daily activity-travel patterns, data from the American Time Use Survey (ATUS) is being fused with data from the NHTS. All of the data sets assembled by TOMNET will be made available (without personally identifiable information) via the TOMNET website for the broader community.

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)*

3. 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 shortly (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 PPPR, 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 tackling real-world planning problems, and for testing TOMNET products in an agency setting.

What organizations have been involved as partners?

A number of other organizations are partnering with TOMNET researchers and have provided financial or in-kind support. These include:

1. Georgia Department of Transportation, Atlanta, Georgia: In-kind support, data sets, collaborative research, funding of matching-project research
2. Arizona Council for Transportation Innovation: Free exhibit space for TOMNET materials and research
3. Arizona Department of Transportation: Data sets, advisory support, research ideas, reviews of TOMNET deliverables
4. City of Tempe, Arizona: Generate research ideas
5. Atlanta Regional Commission, Atlanta, Georgia: Data sets, model networks and files, survey data
6. Florida Department of Transportation, Tallahassee, Florida: Financial support, survey research, data sets, collaborative research
7. Puget Sound Regional Council, Seattle, Washington: Data sets, model networks and files
8. AAA Traffic Safety Foundation, Washington, DC: In-kind support, collaborative survey research, data sets
9. Cambridge Systematics, Inc., Massachusetts: Financial support, survey research, data sets, collaborative research
10. Resource Systems Group, Inc., Vermont: Survey research, data sets, collaborative research
11. D-STOP University Transportation Center, The University of Texas at Austin, Austin, Texas: In-kind support, collaborative research, data sets
12. University of California at Santa Barbara, Department of Geography, California: In-kind support, collaborative research, data sets
13. University of California at Davis, Institute of Transportation Studies, Davis, California: In-kind support, collaborative research, data sets

14. Arizona State University Engineering Summer Outreach Programs (<https://outreach.engineering.asu.edu/summer-programs/>): In-kind support and collaborative efforts for high school student outreach and workforce development
15. City of Seattle Office of Emergency Management: Policy support, collaborative research
16. Laurelhurst Earthquake Action Preparedness (LEAP): In-kind support, collaborative research, community outreach
17. UW Medicine Telehealth: Collaborative research
18. UW School of Social Work, Indigenous Wellness Research Institute: Collaborative research
19. WA State Emergency Management Division: Collaborative research
20. Northwest Healthcare Response Network: Collaborative research, stakeholder outreach
21. King County Public Health: Collaborative research
22. Seattle Public Schools: Collaborative research
23. Oak Ridge National Laboratory: Models, data sets, collaborative research
24. Maricopa Association of Governments, Phoenix, Arizona: In-kind support, data sets, collaborative research
25. City of Westport: Collaborative research
26. Shoalwater Bay Tribe: Stakeholder outreach
27. Seattle Emergency Hubs: Collaborative research
28. Technical University of Munich: TUM funded travel of TOMNET students to participate in the aforementioned workshop in Sydney, Australia. TUM is also providing data sets for further research.
29. University of New South Wales: UNSW is the third partner in the small project funded by TUM. They contributed meeting space and some meals for the two-day workshop held in Sydney in September.

Have other collaborators or contacts been involved?

TOMNET researchers have a very close working relationship with members of the D-STOP University Transportation Center led by the Center for Transportation Research at the University of Texas at Austin. TOMNET and D-STOP have elevated their level of cooperation in the past nine months, generating four jointly authored papers that were all accepted for presentation at the 98th Annual Meeting of the Transportation Research Board being held in January 2019. Moreover, the two centers had six joint presentations at the ITM 2018 and IATBR 2018 conferences during June and July 2018 (the full list of the presentations is provided in separate attachment). 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 are participating in the development of the survey and will be administering the same survey in Austin, Texas, thus enabling the addition of another city to the overall project effort (thus, the survey is going to be administered in Phoenix, Tampa, Atlanta, and Austin). TOMNET team members are pursuing close working relationships with other University Transportation Centers. Currently, there is a close working relationship with 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 stakeholders including Lyft, Intel, Uber, Waymo, Local Motors, Stantec, Office of the Governor of Arizona, and Eberle Design, Inc. TOMNET Director, Ram Pendyala, has played a key role in advancing conversations with a number of these partners. These conversations are ongoing and areas of collaboration are being identified. These conversations include the formation of an Institute for Automated Mobility (IAM) in Arizona that involves all three major public universities in Arizona, industry partners, and the Arizona Commerce Authority (ACA). TOMNET has participated in conversations with the City of Tempe on adaptive planning for automated vehicles, with Local Motors for potential deployment of an automated shuttle called Olli on the ASU campus, and with Intel to serve as the inaugural private industry partner in IAM. 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.

TOMNET-facilitated research at the University of Washington has benefited from core faculty involvement in other university-based and off-campus collaborations, including the NSF-funded project, "Magnitude 9 Earthquake Scenarios – Probabilistic Modeling, Warnings, Response and Resilience in the

Pacific Northwest (M9)”; and the Bullitt Foundation-funded Thought Leadership and Innovation in Applied Urban Sustainability Research, Scholarship and Action project, “Building Community Adaptive Capacity.” The former has provided meaningful cutting-edge scenarios and other hazard information for use in TOMNET research, and the latter has provided additional opportunities for community engagement, outreach and agency relations.

The research team has collaborated with Zhenhong Lin of the Energy and Transportation Science Division at Oak Ridge National Laboratory. This work has involved exploratory analysis of the impacts of providing free public charging infrastructure on plug-in electric vehicle ownership and usage. This work explores people’s attitudes toward free products/services and potential impacts of such free infrastructure on electric vehicle valuation. The collaboration has included the sharing of predictive vehicle market models and datasets providing current and projected market conditions nationally and at the state level. The collaboration has produced a working paper submitted for presentation/publication to the 2019 Transportation Research Board Annual Meeting.

Professor Rolf Moeckel of Technical University Munich (TUM), and Professor Taha Rashidi of University of New South Wales (UNSW) are working with TOMNET Research Director, Professor Patricia Mokhtarian, on collaborative endeavors and workshops aimed at enhancing population modeling. Dr. Mokhtarian is also collaborating with Professors Laurie Garrow and Brian German of Georgia Tech, Patrick Singleton, an Assistant Professor at Utah State University, and three visiting scholars from around the world: Jia Tang, a PhD student from Nanjing University, Prof. Sangho Choo of Hongik University, Korea, and Dr. Sungtaek Choi, a postdoc from Hongik University. All of these collaborative efforts are leading to the preparation of high impact articles for publication in refereed journals, and more importantly, in extending the global reach of TOMNET research.

4. IMPACT

What is the impact on the development of the principal discipline(s) of the program?

TOMNET has had an impact on the principal discipline(s) through its research, education/workforce, and technology transfer activities. In the research domain, core TOMNET researchers have published 15 papers that cover critical aspects of traveler behavior and values, attitudes and perceptions, and preferences and willingness-to-pay for transportation technologies and mobility options. TOMNET research is shedding significant light on the many unknowns related to the future of transportation. How will millennials evolve in terms of their activity-travel patterns as they age and experience lifecycle events? How will automated vehicles be adopted and used by the public and by mobility service providers? What is the extent to which ride-hailing services are being used and what are the purposes for which such services are used? How can cities and metropolitan planning organizations proactively develop adaptive planning processes that can accommodate the great uncertainty associated with these emerging technologies and mobility options? These are the questions that TOMNET research is serving to answer – thus impacting the principal discipline in tangible and significant ways. TOMNET researchers have engaged in a number of studies, and produced a number of papers that shed light on the implications of emerging mobility options such as shared mobility services and autonomous vehicle systems on traveler behavior and the future of travel demand. TOMNET researchers are collecting and analyzing survey data to obtain deep insights about the future of mobility and the resilience of communities. These surveys are being developed so that they can be deployed in any context. Tools developed by TOMNET researchers (such as PopGen, iTREAT, and WBEAT) will greatly benefit agencies, practitioners, and academics around the nation for advancing transportation modeling practice.

What is the impact on other disciplines?

The work of TOMNET is highly multi-disciplinary in nature, and therefore impacts other disciplines in important ways. TOMNET is enabling cross-cutting conversations and research collaborations between engineers who design the critical infrastructure on the one hand, and planners and geographers who plan urban spaces on the other. The work of TOMNET is leading to new insights on the interactions between land

use and transportation, enabling more informed discussions on the role that built environment policies and transit oriented developments can play in shaping future mobility and communities. In particular, ongoing work of the Center aimed at understanding people's residential location choices and preferences, particularly in the context of the advent of transformative and disruptive transportation technologies, is helping to enhance the planning discipline by tightly integrating behavioral principles within its fold. One of the research projects undertaken by TOMNET faculty members shows that the influence of the built environment attributes on household vehicle miles of travel (VMT), after controlling for all other factors including self-selection, is rather modest. This is a key finding with major implications for disciplines of urban planning and public policy/affairs. If the built environment is not a significant factor in shaping household vehicle miles of travel, then policies and interventions aimed at curbing growth in household VMT need to be targeted at other factors and aspects that drive household VMT.

The work of TOMNET provides many opportunities for faculty members in a number of other disciplines to apply their methods and techniques in the transportation domain. In particular, computer scientists are working with TOMNET researchers to develop new software and tools for modeling traveler behavior in microsimulation frameworks, apply machine and deep learning algorithms to fuse and mine big data with behavioral data and derive predictive analytics, and design new algorithms for optimizing shared mobility services while considering behavioral responses to alternative service configurations and options. TOMNET researchers are working with faculty in the new ASU School for the Future of Innovation in Society to explore ways in which new transportation technologies can be deployed to enhance overall quality of life.

What is the impact on the development of transportation workforce development?

During the reporting period covered by this PPPR, TOMNET faculty members taught a number of transportation related courses at the undergraduate and graduate levels at all of the partner institutions. While teaching courses is a regular activity of the faculty members involved in TOMNET (and hence nothing new), TOMNET is beginning to significantly impact and re-shape the course content (in several courses). TOMNET faculty members are mentoring dozens of graduate students, including women and minorities, thus advancing a diverse workforce. TOMNET is directly supporting more than a dozen graduate students who are committed to careers in transportation and are actively engaged in a number of professional societies such as Institute of Transportation Engineers and Women's Transportation Seminar. TOMNET is promoting transportation as a career pathway by offering Research Experiences for Undergraduates (REU) opportunities to a dozen undergraduate students. These students are likely to pursue graduate studies in transportation and further their knowledge of the work of TOMNET and the application of that knowledge to improving transportation systems.

TOMNET is greatly enhancing its K-12 outreach activities. In the last reporting period, hands-on transportation activities were conducted as part of summer camps that seek to enhance the level of interest in STEM fields among preschool and high school students. These activities have had a significant impact as students (who participated in the summer activities) are pursuing high school projects in the field of transportation and writing to TOMNET faculty and graduate students seeking help and advice.

What is the impact on physical, institutional, and information resources at the university or other partners?

All of the information contained in previous PPPR documents still holds true for the reporting period covered by this PPPR. The special institutional resources that were impacted in this reporting period is the dedication of a fully video-recording and live webcasting enabled classroom for the TOMNET ASU Transportation Seminar series. TOMNET resources has enabled the enhancement of a classroom to be fully equipped to deliver seminars and webinars and record the events for archival purposes. The seminar series and the live webcasts have been extremely popular and TOMNET has been receiving many messages from around the world expressing gratitude for the webcast and recordings. TOMNET resources has made it possible to enhance the services of the Global Outreach and Extended Education (GOEE) team at ASU to facilitate live webcast and video recording of seminars and webinars.

What is the impact on technology transfer?

TOMNET faculty members are engaged in a number of technology transfer activities as detailed earlier in this report. TOMNET is primarily organizing seminars and webinars to help educate and inform stakeholders about TOMNET technologies and research results. More importantly, TOMNET faculty members have been able to work with agencies and stakeholders to potentially move TOMNET results and products into planning practice. The seminars/webinars bring academics and practitioners together to learn and discuss specific topics, share information about new methods and products, and develop new collaborative research ideas. TOMNET is organizing short courses and workshops to teach the latest methods and tools to practitioners. TOMNET is developing software systems and tools that are being made available to the broader community through open source software licensing arrangements. All of these technology transfer activities have been enabled by UTC funding; in the absence of TOMNET UTC funding, it would not have been possible to engage in these types of technology transfer activities.

What is the impact on society beyond science and technology?

TOMNET research aims to improve the quality of life of people by providing agencies the ability to plan future transportation investments, policies, and mobility options in a way that enhances access to destinations and opportunities in a sustainable manner. Transportation is experiencing revolutions in the form of electrification, connectivity, automation, and sharing. How can these forces of disruption be accommodated in cities such that quality of life is enhanced, and any potential unintended negative consequences are avoided. TOMNET research is providing cities and planning agencies much needed data and tools to understand how mobility services and automated technologies may be adopted and used in the future under a wide variety of scenarios; based on this information, cities and agencies are being able to proactively devise policies and plans that accommodate and integrate these technologies and mobility options without the unintended consequences that may result from a proliferation of zero-occupant autonomous vehicles and ride-hailing vehicles cruising around. Another major thrust of TOMNET research is understanding how communities access information and transportation options in the wake of disasters and extreme events. The tragic loss of life in California in the wake of the Camp Fire is a wake-up call to the profession that people rely on the transportation system to safely evacuate in the nick of time. The research being done by TOMNET faculty members will help in devising evacuation plans, educating stakeholders and the public, and designing transportation options that will help avoid tragedies of this nature in the future. TOMNET researchers will be working directly with community groups and disaster management agencies to discuss research results and findings, and help develop new and improved transportation and evacuation components of disaster management plans.

5. CHANGES/PROBLEMS

There are no changes to or problems with the scope, mission, budget, or operations of TOMNET.