



2017 MAG Household Travel Survey Report

Prepared by



with



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Executive Summary

The 2015-2017 Maricopa Association of Governments (MAG) household travel survey included 6,073 completed households. The data was collected from fall 2015 through spring 2017. The survey collected, for every household, household-level data, person-level data for each household member, and vehicle-level data for every vehicle in the household. For every household member aged sixteen and over a minimum of two days of Global Positioning System (GPS) activity-travel data was collected. A minimum of one full day of a detailed activity-travel diary was completed and verified for every household member aged five and over for the same travel day.

The household-level, person-level, and vehicle-level data was collected via an online survey filled out by one member of a recruited household. Household members age sixteen and over then carried around either a GPS logger or a smartphone for a minimum of two days. The MMMonitor mobile sensing software is downloaded as an application on a smartphone or loaded on to a GPS logger. This software processes GPS data into a series of trips and stops and infers modes and activities using highly refined intelligent algorithms. Once travel was complete, survey participants viewed their activity diary featuring a timeline and a map on their smartphone or online and answered supplemental questions concerning their travel or activity. Children age five to fifteen recorded travel via an online child activity-travel diary.

The survey effort involved an agile approach to data collection. The survey began with a pilot study, utilizing best-practices in traditional household survey design. This included recruiting household into the study via an address-based sample following a sampling plan and attracting and retaining households through a multi-level incentive structure. For the first part of the main survey, the survey was altered to provide a simplified incentive structure and assigning household members to a GPS logger or smartphone rather than giving households an option of device type. In the second part of the main survey, only households who all own smartphones were recruited into the study. In addition, traditional recruitment efforts were abandoned in favor of a convenience sampling approach. The convenience sampling permitted anyone in the MAG region to participate in the study, allowing for advertisement and promotion of the study to a much larger population via social media and e-mail.

Once data was collected, a series of QA/QC checks were performed and demographic characteristics of the unweighted dataset were analyzed to ensure that the population of MAG was aptly represented. Finally, a rigorous weighting process was undertaken to expand the data to the population of the region. The overall result of the analysis indicates that the data collected is appropriate and applicable for use in transportation planning, travel demand modeling and travel demand forecasting purposes.

1.0 Introduction

1.1 Background

The Maricopa Association of Governments (MAG), the regional transportation planning agency for the Phoenix region, conducted region-wide household travel surveys in 2001 and in 2008 using traditional phone interviews and paper-based survey methods. The 2008-2009 survey effort for the region was an Add-On to the 2009 National Household Travel Survey (NHTS) effort executed within the NHTS program by Federal Highway Administration. The survey was scoped for 4,286 household samples and exceeded its targets by collecting 4,707 samples. However, the completion criteria of the survey allowed for partial answers to the survey instrument questions and certain inconsistencies in the collected data. The nature of the traditional phone and paper-based methods also imposed some well-known limitations on the quality of the data, such as trip underreporting, oversampling of retirees, and under sampling of minorities, young adults and other population groups. As a result, estimation of advanced travel demand models, even though possible, was hindered by the data deficiencies associated with traditional methods of data collection. These limitations prompted MAG to look at alternative methods of collecting household travel survey data. MAG planned and advertised for an innovative 100 percent Global Positioning System (GPS) survey in 2014. The survey scope was based on the latest advances in the household survey methodologies and practice, as described in the next section. The survey area includes entirety of Maricopa and Pinal Counties with small portions of Gila and Yavapai Counties as well.

1.2 Purpose

MAG develops and maintains a set of travel forecasting tools and procedures that ensure adequate support of the regional planning efforts, air quality conformity analysis, and compliance with relevant federal regulations and requirements. In order to support development and maintenance of these advanced regional models MAG collects a variety of transportation data sets. These data form a foundation for the regional models' update, improvement of the regional travel forecast and ultimately better planning decisions.

Household travel surveys are a necessary part of data collection for transportation planning, travel demand modeling and travel demand forecasting purposes. Most of the large regional, provincial and state transportation planning agencies and departments in North America and in many metropolitan areas around the world conduct such surveys every 5-10 years. The surveys capture behavior, patterns and attitudes of the traveling public. This information is later used to estimate travel forecasting models, which are used to analyze and plan regional transportation systems. Recent advances in passive data collection and big data analysis allow substituting some of the data collected through household surveys with alternative data collection and analysis methods. Nevertheless, at the present time, there is no a reliable alternative to household travel surveys. Household travel surveys continue to be the only source of detailed information on travel behavior and patterns, sufficient for estimation of advanced travel demand models and state-of-the-practice travel demand forecasting, system analysis and planning.

1.3 Previous Efforts

MAG conducted region-wide household travel surveys in 2001 and in 2008 using traditional phone interviews and paper-based survey methods. The National Household Travel Survey (NHTS) 2008-2009 sample included 4,707 households for the MAG region (consisting of samples from National Survey and Add-on

Survey).¹ The survey has data on households, persons, vehicles and trips by all modes of transportation. Most of the data for MAG region was collected in the fall of 2008. MAG received the data in early 2010 for use in estimation, recalibration, and validation of the MAG travel demand models. MAG conducted extensive analysis for the purposes of analyzing the data's applicability for estimation of MAG activity-based model and trip based four step modeling procedures maintained by MAG. Main direction of the performed analyses included:

- Analysis of the geocoding results and quality control checks for reasonableness and consistency.
- Analysis of spatial and temporal data consistency on both tour and trip levels.
- Analysis of value ranges and distributional characteristics of the data values.
- Cross tabulations and multi-field comparisons.
- Comparisons and trend analysis with 2001 MAG household survey, other regional surveys, census data, American Community Survey (ACS) and Census Transportation Planning Products (CTPP) data.
- Imputation of school and work locations where applicable.
- Other tasks as were required for the purposes of data application.

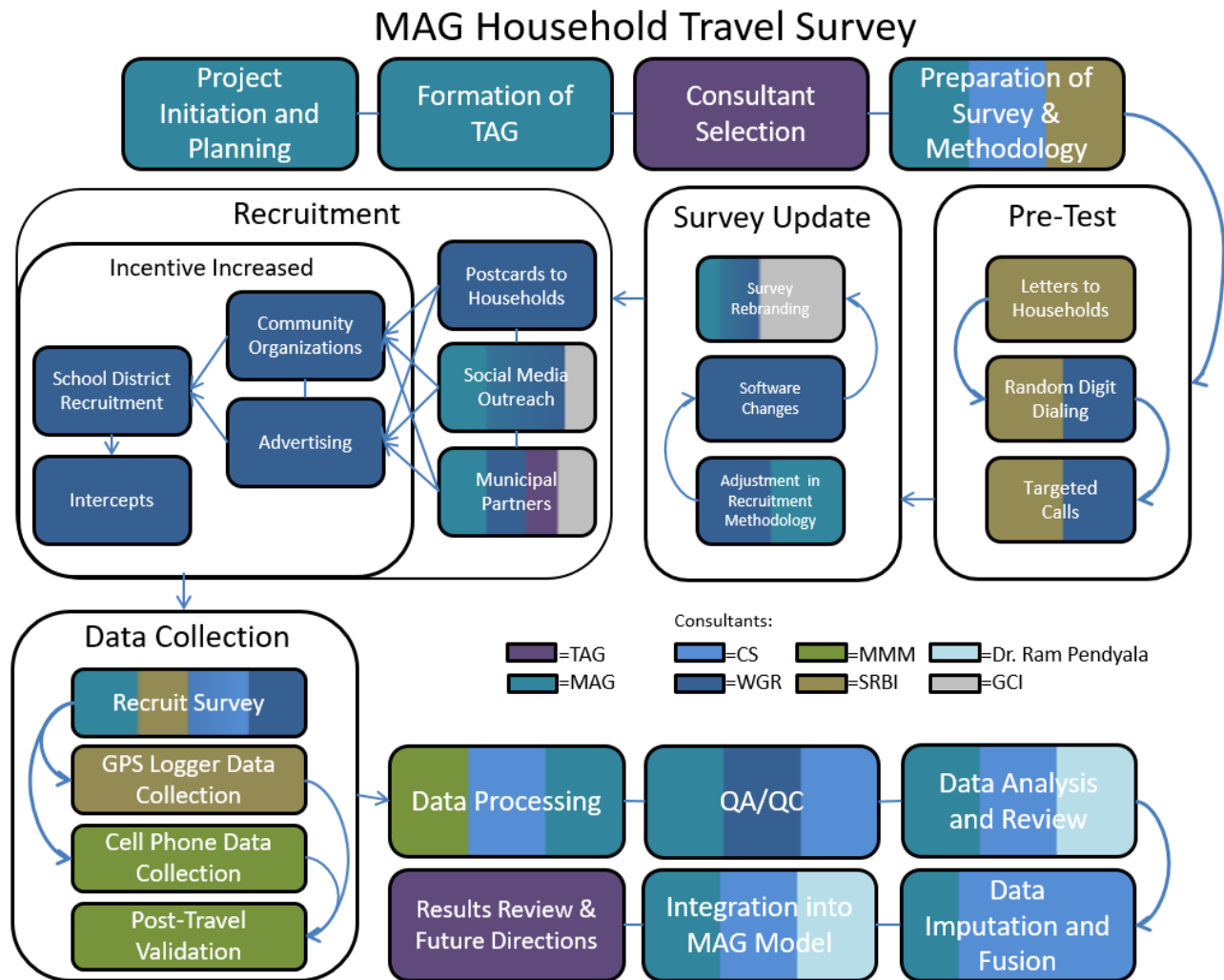
Some of the identified deficiencies included insufficient representation of transit users and certain biases in the raw data sample in terms of spatial data distribution. Overall, the performed analysis demonstrated general applicability of the survey data for analytical purposes as well as for the purposes of models estimation, calibration and validation. The applicability of the dataset for various modeling applications was analyzed and the relevant issues were investigated.

¹ http://azmag.gov/Portals/0/Documents/TRANS_2012-02-17_2008-National-Household-Travel-Survey-Dataset-for-MAG-Region.pdf?ver=2017-04-06-111941-653.

1.4 Project Team

The project team is composed of MAG, a technical advisory group (TAG), and the consultant team made up of six entities, as shown in Figure 1.1.

Figure 1.1 Project Flowchart



MAG staff was involved in every aspect of the project from initial planning to data integration into the MAG models. As shown in purple in Figure 1.1, the TAG played an important role in the beginning of the project effort by selecting the consulting firm. The TAG was then updated and consulted approximately every six months on the project's status. Members of the TAG are listed in Table 1.1. At the conclusion of the project the TAG reviewed survey results and provided future direction.

Table 1.1 Technical Advisory Group Members

TAG Member	Organization
Anubhav Bagley	Maricopa Association of Governments
Arash Mirzaei	North Central Texas Council of Governments
Darlanne Hctor Mulmat	San Diego Association of Governments
Cory Whittaker	Valley Metro
Denise Lacey	Maricopa County Department of Transportation
Keith Killough	Arizona Department of Transportation
Ratna Korepella	City of Scottsdale
Tim Strow	Maricopa Association of Governments
Vladimir Livshits	Maricopa Association of Governments
Jesse Ayers	Maricopa Association of Governments
Angela Horn	Maricopa County Department of Transportation

Cambridge Systematics (CS) led the consultant team. CS was involved throughout the project to ensure the survey was conducted in a timely manner and within budget. In addition CS played a lead role in development of the survey design and sampling plan. They were also involved after the data collection process was complete in data processing, QA/QC, and data analysis and review. Also included with the light blue color is the sub-consultant under “CS”, Ram Pendyala, who played a key role in survey design, expansion, data analysis, and integration into the MAG models.

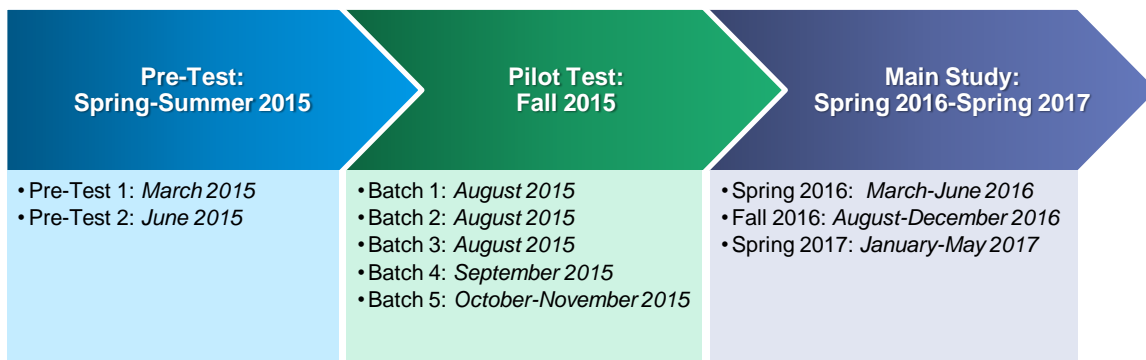
Abt Associates (SRBI) played a role in the initial survey design and implementation of the Pilot Test. They also were responsible for GPS logger deployment during the pilot and main survey effort. West Group Research (WGR) led the data collection effort for the main survey and brought on Gunn Communications (GCI) to develop marketing materials and assist in recruitment efforts. Mobile Market Monitor (MMM) was the technology firm that provided the mobile sensing software used for data collection.

2.0 Survey Methodology

2.1 Timeline of Data Collection

Data collection spanned from the spring of 2015 through spring 2017, as shown in Figure 2.1. The spring and summer of 2015 included two internal project team pre-tests. The pre-tests focused on technology testing and survey design. The pilot survey, which was broken into five separate batches, was conducted in the fall of 2015. The main survey spanned from the fall of 2016 through the spring of 2017 and was broken into three separate batches corresponding to the season of data collection. In the summer months, the MAG region experiences a significant decrease in both traffic and activity. Coupled with the lack of school activity, the decision was made to only survey during the winter, spring, and fall. For the brevity, the remaining report will refer to different batches as shown in Figure 2.1.

Figure 2.1 Timeline of Data Collection



2.2 Overview of Survey Methodology

The main phases of data collection include the following:

1. **Sampling Plan:** Determine number of households to recruit based on geographic and sociodemographic composition.
2. **Recruitment:** Method used to recruit households for participation in study.
3. **Recruitment Survey:** Household member filled out detailed questionnaire about household and household members and questions necessary for GPS data collection phase of study.
4. **GPS Device Selection:** Individuals within household choose or are assigned either a Smartphone or Logger to collect GPS data. This was applicable through the Spring 2016 data collection effort and is discussed in the 2.2.4 GPS Device Selection section.
5. **Deliver Survey Materials:** Materials needed to complete data collection are delivered to households.
6. **GPS Data Collection:** Household members carry around GPS device for 2 to 4 days.

7. **Travel Validation:** Household members answer questions and confirm the activities and travel collected by the GPS devices.
8. **Household Completion:** Based on an established definition of a completed household, households are considered Complete and are provided a monetary incentive for participation.
9. **Data Quality Assurance and Quality Control:** The data collected for each household is analyzed to ensure that the data produced is logical, complete, and suitable for modeling purposes.
10. **Data Expansion:** Households are weighted to represent the population within the MAG region across key sociodemographic and geographic characteristics.

Throughout the data collection process the implementation of each phase was adjusted to improve upon the recruitment and completion rates, the quality of data collected, and the cost of data collection. The following sections summarize the different methodologies implemented for each data collection phase.

2.2.1 Sampling Plan

The initial sampling plan was constructed by identifying block groups with the highest probability for transit use, auto deficiency and Hispanic population. It was understood at the outset that many of these block groups would overlap. Table 2.1 was created as a guide for purchasing addresses as part of the address-based sampling recruitment effort.

Table 2.1 Initial Sampling Plan

Area/Size	Sampling Rate	1	2	3	4+	Total
Transit Intense	0.92%	349	283	138	229	1,000
Zero Vehicle and Auto Deficient	0.42%	224	228	106	183	740
Hispanic	0.42%	414	473	265	535	1,687
Rest	0.42%	877	1,548	463	684	3,573
Total	0.45%	1,863	2,533	973	1,631	7,000
Sampling Rate		0.47%	0.45%	0.45%	0.45%	

Starting with transit intense demographic, ten thousand addresses were purchased. Completed surveys were monitored for transit trips and for the city in which it originates. MAG developed flexible “ideal situation” targets for the cities involved. In the case of transit intense, three cities were expected to have a share of the transit ridership: Mesa, Phoenix and Tempe. After 75% of the first sample purchase was exhausted, the distribution of collected surveys was evaluated before purchasing the second half of the sampling frame for transit intense block groups in order to adjust for better or worse than expected sampling rates (i.e. if 65% of returned surveys have come from Tempe then the second data purchase would reduce the number of samples purchased in Tempe to more accurately reflect transit use in the region.) Using an identical process as described above, the next step was to target zero vehicle/auto deficient and Hispanic households using a two-part data purchase and tracking by key variables. MAG envisioned half of the proposed advance letters (70,000) be used on these three targets under the assumption that even returned surveys that don’t meet the

targeted group will still be used toward the rest of region target. The remaining samples were to be distributed equally across all cities in the region after taking into account the previously collected surveys.

This methodology was used for the initial mailings at the start of the project. Unfortunately, it was extremely ineffective. A very low response rate and a lower than expected sample of the desired targets led to a re-thinking of the sampling plan. Instead of targeting block groups, hard targets were established using the American Community Survey as a guide. Each recruitment method used thereafter provided an opportunity to fine-tune the approach. When school districts were approached, special attention was given to schools in neighborhoods meeting the sampling criteria.

In an effort to collect Hispanic households the team reached out to the Hispanic Chamber of Commerce and received their assistance in recruiting households for the survey. Finally, to collect transit riders interceptors were sent to transit stations in two cities to recruit households. The team also partnered with the local transit agency who helped promote the survey on their social media accounts.

2.2.2 Household Recruitment

Households were recruited into the study by a combination of probability and non-probability sampling. Probability sampling relied on mail and phone-based recruitment whereas non-probability sampling was based on social media platforms, email lists, in-person interceptors, and paid advertisements.

Mail Recruitment

For households recruited via mail, an Address-Based Sample (ABS) was purchased based on the sampling plan. Since a significant portion of the population belongs to cell-phone only households, an ABS approach was initially used². The ABS was based on the United States Postal System Delivery Sequencing File. It is updated frequently and has better than 95 percent coverage rate of residential addresses. The file was provided by sample vendor MSG and contained all addresses (including individual apartments within a building) where the post office delivers mail. Using the delivery sequencing file as the sampling frame, samples were drawn precisely at the census block group level.

One to two mailings, two weeks to one month apart, were sent to each ABS household. These mailings were in the form of a postcard or letter and were provided in both English and Spanish. They contained information on the purpose of the study, details of participation, how to sign-up, and the monetary compensation that would be provided for completion of the study. An example of the advanced letter mailed to households is shown in Figure 2.2 and an example of the follow-up postcard is shown in Figure 2.3. Mail recruitment was used for pilot test batches 1, 2, 4, and 5, the Spring 2016 survey, and a negligible portion of the Fall 2016 survey.

² Blumberg, Stephen and Julian Luke. 2017. "Wireless Substitution: Early Release of Estimates from the National Health Interview Survey, July-December 2016". Division of Health Interview Statistics, National Center for Health Statistics.

Figure 2.2 Advanced Letter Used for Spring 2016 Survey
English Version



**MARICOPA
ASSOCIATION of
GOVERNMENTS**

March 1, 2016

[Redacted]
Greater Phoenix Area Resident
[Redacted]

Dear Greater Phoenix Area Resident:

I am writing to ask for your help in improving our understanding of residents' travel habits in the greater Phoenix area. The Maricopa Association of Governments (MAG) believes the best way to do this is by asking local residents where they travel, how often they travel, and about other aspects of their travel experiences. Your household is among those randomly chosen to help us evaluate the current and future transportation needs of your area.

To enroll in this travel study:

1. Go to MAGTravelSurvey.org
2. Click on the "Household Registration" button
3. Enter the PIN: [Redacted]
4. Complete the online survey by March 11, 2016

After you complete the online survey, we will send materials to help your household log travel and related activities for two days. As a token of our appreciation for participating in this important travel study, we will send **\$10** for **each member** of your household who logs and verifies travel. To be eligible for participation, all members of your household age 6 and up must participate.

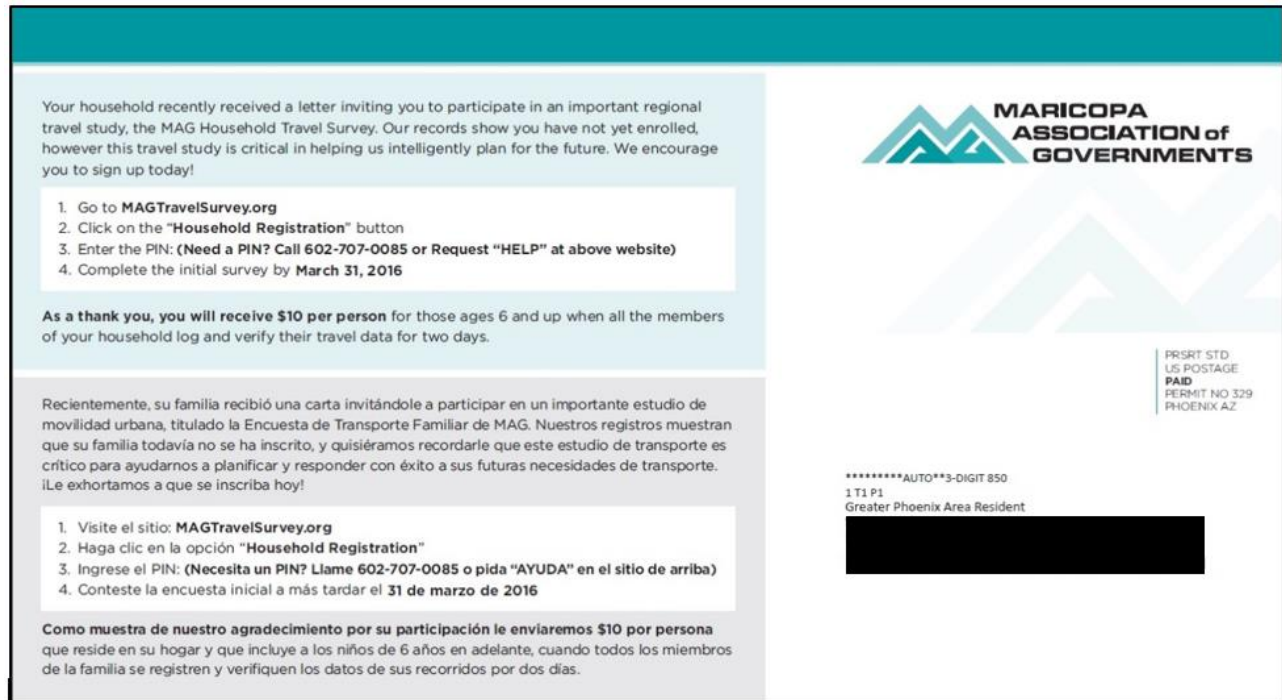
Participation in this travel study is voluntary. Your information will be confidential and used only for the purpose of determining travel patterns and habits of area residents. If you have any questions about this travel study, you can call us at 602-707-0085 or visit our website www.MAGTravelSurvey.org. I want to personally thank you for your time and consideration. I hope you will choose to participate.

Sincerely,



Dennis Smith
Executive Director

Questions or comments? Call our helpline: 602-707-0085

Figure 2.3 Follow-up Postcard Used for Spring 2016 Survey

Phone Recruitment

Phone recruitment was implemented for pilot test batches 3, 4, and 5. Phone numbers were obtained via Random Digit Dialing (RDD) or by matching phone numbers to the already purchased ABS sample. Those contacted via phone were provided information on the study and were encouraged to complete the recruit survey over the phone via computer-assisted telephone interviewing (CATI).

Non-probability Sampling

The convenience sample is composed of households recruited from the general population of the MAG region that meet the study requirements. For the Fall 2016 survey and Spring 2017 survey, a variety of convenience sample recruitment methods were used including: multiple social media platforms, e-mails, in-person interceptors, and a small sample was recruited via paid advertisement. Social media and e-mail recruitment was implemented by both city and county governments, the Hispanic chamber of commerce, and other non-profit groups. In addition, school districts were provided an incentive to send survey information to families in their e-mail databases and to post on their social media pages. An e-mail list was also purchased and correspondence was sent directly to those addresses. Advertisements were purchased on Facebook, Valpak, and ASU's State Press student newspaper. Finally, in person interceptor recruitment was conducted at transit stations and on ASU's main campus.

Using these methods required a rethinking of the sampling plan. The number of households by key demographics or geographic distribution recruited into the study needed to be controlled via a pre-qualification survey. The pre-survey allowed for screening out of households that did not meet certain qualifications. However, except for ensuring household zip codes were within the MAG region and ensuring a household had the proper technology (i.e. owned a smartphone), all households were allowed to participate.

2.2.3 *Recruit Survey*

In order to participate in the study, households were required to fill out a recruitment survey. For all survey batches, the household could fill out an online survey. The online version of the survey took approximately 15 minutes to complete. When phone based recruitment was piloted, many of the households completed the survey over the phone via CATI. For pilot test batch 5, half of the households were provided a paper survey containing the recruitment questions that required the households to mail back the completed paper survey in order to confirm their desire to participate in the study. This was done to test the efficacy of paper surveys versus online recruitment methods.

The recruitment survey questions included verifying or providing home address, detailed questions on each household vehicle, household demographics including number of household members and household income, and detailed questions on each household member including their relationship to survey taker. Age, employment status, student status, employment industry, completed education level, and disability status were also included. The survey taker was also asked about their work flexibility status. The recruitment survey also asked some questions important for the travel portion of the study which focused on determining if each household member over a certain age, owned an eligible Smartphone, and collected contact information for each household member. Finally, the household was assigned or provided a choice of travel dates.

2.2.4 *GPS Device Selection*

For all pilot tests, household members thirteen years and older had the choice of either collecting their GPS travel data via a GPS logger or by downloading an application onto their personal smartphone. Children younger than twelve did not collect GPS travel data and their parents were instead given a paper diary to record their travel. Given the much higher cost of GPS loggers, the Spring 2016 survey assigned GPS loggers only to household members aged thirteen and older who did not own a qualifying smartphone. To further decrease costs, the Fall 2016 and Spring 2017 survey eliminated the use of loggers altogether and only allowed participation by households where all household members aged sixteen and older owned a smartphone. Children younger than fifteen were not required to collect GPS travel data and were provided a paper or an online option for collecting child diaries instead.

2.2.5 *Survey Materials Delivery*

For all pilot survey batches, once households were recruited into the study, they were mailed instructions on how to collect travel data. Household members collecting GPS data via GPS logger were mailed the logger and instructions on how to use the logger and validate the travel data they collected. A prepaid envelope to return the logger after data collection was also mailed to them. Household members collecting data via smartphone were mailed instructions on how to download the application and how to validate travel after GPS data collection. When the materials were mailed to participants, there was a two-week gap between the day a household filled out the recruitment survey and the day the household was assigned to travel.

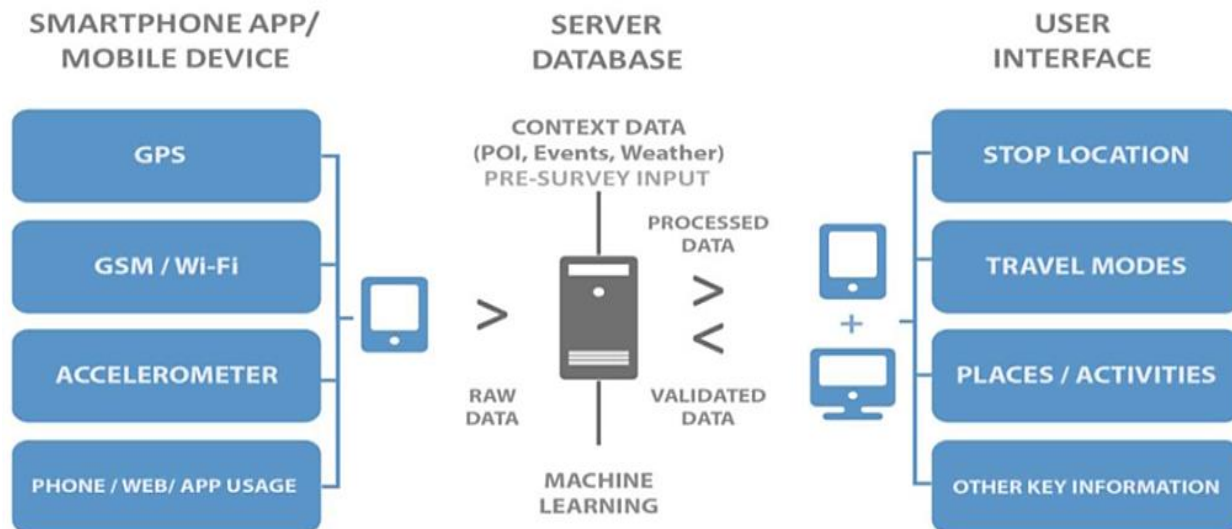
For the Spring 2016 survey, household members were only mailed materials if a household member participated via GPS logger. These households were assigned to travel two weeks after recruitment. For the Spring 2016 survey, Fall 2016 survey, and Spring 2017 survey smartphone-only households all instructions and reminders were delivered via e-mail and text message. With the increased efficiency of digital messaging, households were given the choice of travel dates starting as early as two days after recruitment.

2.2.6 GPS Data Collection

Before their assigned travel date, household members were asked to either download a smartphone application or were sent a GPS logger. The smartphone application was available in the Google Play Store and Apple App Store. For pilot survey batches 1-4, all members of the household who were assigned a GPS logger or smartphone application were instructed to carry around their GPS device for four consecutive days starting on their assigned travel day. For pilot survey batch 5, and all main survey batches, household members were instructed to carry around their GPS device for two consecutive days. The change was made in an effort to reduce the burden on survey participants.

Respondents used the MMMonitor system to collect and validate their travel data. The MMMonitor system is a prompted recall survey system and platform designed to collect detailed multiday data on travel and activity patterns for use in urban and transportation planning, modeling, and analysis. The MMMonitor system is comprised of three interconnected components, as shown in Figure 2.4, 1) a mobile application, available for both Android and iOS smartphones; 2) an analytics backend; and 3) a front-end web interface. The back-end analytics of the MMM system converts the raw GPS traces into a series of stops and activity patterns that are then displayed to the traveler in real-time on their smartphone or via a website³. The GPS data loggers have real-time data transfer capabilities, and integrate seamlessly with the MMM prompted recall system (i.e. analytical back-end and front-end web interface) in the same manner as the “MMMonitor” app. This approach allowed for the capture of both GPS and smartphone app data using the same system.

Figure 2.4 MMMonitor System



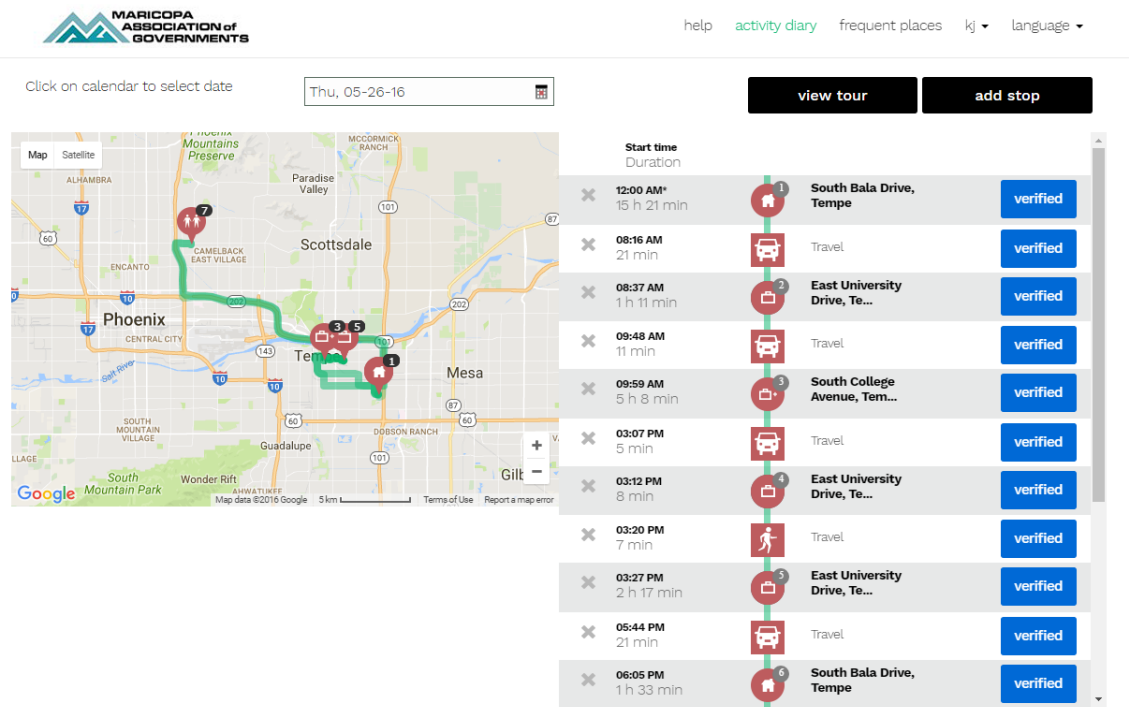
2.2.7 Travel Validation

After the travel on the assigned date is complete, households were asked to verify the activity and travel patterns recorded by the MMMonitor system and to answer a few supplemental questions. The user interface

³ Zhao, Fang, Ajinkya Ghorpade, Francisco Câmara Pereira, Christopher Zegras, and Moshe Ben-Akiva. "Stop Detection in Smartphone-based Travel Surveys." *Transportation Research Procedia* 11 (2015): 218-26.

displayed a travel diary and a corresponding map detailing the travel times and stops made throughout the individual's day, as shown in Figure 2.5.

Figure 2.5 Example of MMSMonitor Daily Activity and Travel Diary and Map



For each travel segment, the supplemental information asked includes how many people were in the travel party, which specific household members traveled with the individual, and the mode of travel. Depending on the mode additional questions are asked such as household vehicle used, driver status, parking location, fare paid, or sub-mode. An example of the travel segment sub-mode questions are shown in Figure 2.6. Respondents were asked to provide the activity they engaged in at each stop. If dropping off or accompanying someone, respondents were further asked for the activity the transported passenger was engaging in at that stop.

Figure 2.6 Supplementary Travel Segment Questions for Taxi/Car Service Mode

6 AM : 47 of Current day

Number of other people in your traveling party

☒ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5+

Please tell us how you travelled

☐ Foot

☐ Vehicle

☐ Bus

☐ Light Rail

☐ Bicycle

☒ Taxi/Car Service

☐ Air

☐ Other

Was your fare reimbursable?

☐ Yes

☐ No

☐ Not applicable

Fare Paid

Which of the following services did you use?

☐ Taxi

☐ Uber

☐ Lyft

☐ ExecuCar

☐ Other

While users were encouraged to complete the online prompted recall activity diary in a self-administered fashion (i.e. via computer or smartphone), the system was configured to enable a Travel Survey Coordinator (TSC) to either complete the activity diary for an individual user, or provide guidance with the activity diary validation process. The TSC's role could be as small as answering a quick question, or as large as validating all of a household member's travel. The travel validation methodology remained consistent throughout data collection.

For children over the age of five who did not collect data via GPS devices, households were required to complete a paper or online diary. Paper diaries were used for all pilot test batches and online diaries were available for all subsequent batches. Travel was not collected for children up to the age of five.

2.2.8 Household Completion

A household was considered complete if they met the following criteria:

1. Minimum of two days of GPS data for each household member over the age of 12 (for pilot study batches 1-5 and Spring 2016) or over the age of 15 (for Fall 2016 and Spring 2017 surveys).
2. Minimum of one weekday of validated travel data for each household member over the age of five. All household members must have validated travel data for the same weekday. Children who did not collect travel data via a GPS device were required to have a completed travel diary for that day.
3. 100 percent completed survey data for the following questions:
 - a. Household-level: Household size, number of household vehicles available, primary home address in the MAG region
 - b. Person-level: Age category, gender, employment status, student status.

c. Stop-level: Activity/purpose.

d. Trip-level: Main mode, sub-mode, how many people were traveling with the respondent

Once a household was marked as complete and had returned their GPS loggers, if applicable, they were sent an incentive check or an Amazon gift card. The incentive amount varied for the different batches as follows:

- **Pilot Batch 1-5:** \$20 per households plus an additional \$10 per person in household aged twelve and up.
- **Spring 2016 and Fall 2016:** \$10 per person in household aged six and up.
- **Spring 2017:** \$100 per household.

Amazon gift cards sent via e-mail were given as an option for the Spring 2016, Fall 2016, and Spring 2017 surveys.

2.2.9 Data Quality Assurance and Quality Control (QA/QC)

Once all data was collected, the household-level data (from recruit survey), person-level data (from recruit-survey), child stop diary (from child diary), and stops files (from MMMonitor validation) were compiled and linked together. These files were analyzed to ensure that the data produced was logical, complete, and suitable for modeling purposes. An automated procedure was developed to read, process, and evaluate each household's survey responses. Manual analysis of flagged results and periodic spot checks supplemented this effort, on an as-needed basis.

The QA/QC process tested the database for several types of potential issues:

- The most obvious issue checked is missing information or entries in the databases that do not have responses for questions. This is not relevant to all questions since some questions do not apply to certain individuals or trips. For instance, it is acceptable and expected that a non-worker would not answer a question about employment industry. These issues are exceedingly rare since the online recruit survey simply does not allow one to skip questions or leave blanks.
- The second issue checked is illogical or incorrect data, such as the start time for a trip (or activity) appearing to be earlier than the end time for that same trip (or activity). This effort helps identify cases in which the survey respondent made a mistake or misinterpreted the survey questions.
- The third issue checked is data transcription concerns. This can take the form of offset columns or mislabeled data. Such concerns can be fixed by going back to the raw responses and reprocessing to produce new output. A related issue is incorrect geocoding for trip starts and trip ends. Changes made by the respondent were tracked by the MMM system allowing one to turn back the clock and review records at all stages of cleaning.
- The last issue checked is misinterpretation of data variable formats. The coding of variables could either be misunderstood or read in the wrong format. It can be as simple as a time stamp being read as 24 hour format rather than 12 hour format or the expectation of an answer for an inapplicable question. This does not require correction, but it is important as it affects the use of the data in the future.

The QA/QC assessments are divided into three groups – household, person, and stop (activity) – and are consistent with the databases received from the survey administrators. Household-level checks include assessments of household-level data, such as income, and a summing of checks at the trip and person level. Person-level checks verify information specific to persons. One such check identifies individuals who are missing employment status, as each person has their own employment status. Stop-level checks include information about arrival times, activity purposes, departure times, party size, and travel mode. For the person stating that they traveled via transit checks were conducted to ensure that the boarding and alighting locations were within reasonable distance from transit stops. Those checks were conducted for both light rail and bus travel modes.

Three tiers of checks were established based on the relative importance of the check. There are exclusion checks which indicate conditions for acceptance of the data into a final dataset. Critical checks indicate important concerns that did not necessarily exclude records from being kept. The lowest tier of checks flag records which have either issues of milder concern, or information which is questionable but not necessarily wrong. The latter could include issues such as unusual ages for a spouse or workers who do not make work trips. These lower level checks are generally not serious individually, but can indicate an issue if a high number of records are flagged.

Types of Checks

The potential issues from the previous section apply to elements of the data in different ways based on the characteristics of the survey questions. Generally, the QA/QC checks fit into the following types:

- **Formatting:** All IDs should follow a format that is consistent and relevant to the questions at hand.
- **Geocoding:** The locations must have reasonable location coordinates relative to the MAG region. Respondents can have a trip destination out of the model area, , but their primary homes have to be in the modeling area
- **Counts:** The number of people, workers, and vehicles in a household must be consistent with the information given in the different files.
- **Dataset consistency:** All households and people of relevant age should be represented in one of the stops files, and vice-versa.
- **Age, Gender, License:** This information must be given and must be consistent with activities, modes, and relationships.
- **Employment and Education:** Status and related details should be given and consistent with other information.
- **Origin/destination:** Trip origin and trip destination should be at difference locations and consistent with previous and next trips.
- **Time:** Time must be provided and chronologically correct, and the durations of travel and activities must be logical.
- **Activities:** Trip activities should be consistent with person's characteristics. Days should start and end at home or work for the most part and activities must be recorded for the entire day of travel.

- **Mode:** The mode should be recorded properly and details, like driver vs. passenger, should be logical.

2.2.10 Data Expansion

The objectives of the data expansion procedure are two-fold. First, as in any household travel survey, the respondent sample may not be perfectly representative of the true population due to biases that may arise during the sampling process or due to selective non-response where certain demographic groups are more (or less) likely to respond to the survey. Thus, the weights are computed to correct for sample biases. Second, the weights constitute expansion factors that can be used to obtain population-wide statistics on various travel activities or socio-economic measures of interest. The weights essentially expand the sample to be representative of the population – not only in terms of distributions or proportions of various characteristics, but also in terms of the total values for various attributes that describe population behavior.

The sample expansion and weighting process aims to compute weights such that the weighted sample has the same distributions as the regional population on a number of variables of interest that are considered important from a transportation modeling and analysis perspective. Geographic control totals were established at county and Super PUMA level (Public Use Microdata Areas), Super PUMs being grouping of PUMA polygons. An iterative process was executed to settle on the final set of control variables and categories at each of the SuperPUMA and county levels of geography. At the household level, the household Income variable is controlled at the SuperPUMA level. All other household variables, including Child Presence (Maricopa County only), household race, household size, and number of vehicles were controlled at the county level. Three person variables were used in the sample weighting procedure to match person control distributions at the County or SuperPUMA level. Person employment status was added at the level of SuperPUMA while gender and age were included as controls at the county level.

The algorithms embedded in the PopGen synthetic population generator were used to derive sample expansion weights for the HTS. Synthetic population generation algorithms can be used to weight survey samples because one of the key steps in the population synthesis process involves estimating weights for sample households. The weights on the sample households are then used in subsequent steps to draw households (repeatedly) and form a synthetic population. The step that involves computation of weights for the sample households is essentially similar to weighting a household survey sample such that marginal control distributions are matched to replicate known population-wide characteristics.

The results of the expansion indicate that the HTS weight estimation process yielded a weighted survey sample whose characteristics closely replicate marginal control distributions across all control variables for both Maricopa and Pinal Counties and compare closely with the latest ACS (American Community Survey) data across non-controlled variables. Survey expansion will be discussed in detail in Section 3.3 Expansion and Data Analysis.

2.3 Pre-Test Methodology and Findings

2.3.1 MAG Internal Pretest 1 – March 2015

The first pretest for the project was conducted by MAG's System Analysis Group. The pretest was limited to testing the MMMonitor GPS data collection and validation via smartphone as the full recruit survey was not yet complete. GPS Loggers had been ordered but were not received in time for this pretest. Testers were asked to provide feedback on smartphone battery life, GPS accuracy, and usability.

Twelve staff members tested the smartphone application and validation website. Android and iOS phones were both included in the pretest. Following the pretest MAG staff concluded that the GPS accuracy was acceptable and with the exception of an older iPhone device no significant issues with battery life were encountered. Minor tweaks to the validation website were recommended, accepted and implemented for subsequent tests.

2.3.2 MAG Internal Pretest 2 – June 2015

A larger pretest consisting of thirty MAG staff members and members of the project team was conducted in June 2015. Participants were split evenly between smartphones and GPS logger users. The objective of the second internal pretest was to obtain feedback on the look and feel of the survey app and website, length of the survey, ease of completion and readability. Additionally, survey participants were asked to report on technological malfunctions and data validation errors.

Participants were instructed to fill out the recruit survey, carry around their GPS device, and validate their travel. Numerous participants encountered various errors with the GPS logging devices. The Sanav MU-201 tracking devices chosen for this project have two indicator lights on the front of the device. A clear explanation of the lights and their function during proper operation was not provided which caused confusion as to whether they were collecting data and correctly charged. The GPS loggers also suffered from data transmission errors. A conscious decision was made to only transmit data when the device was charging in an attempt to preserve battery life. Implementing this function on the devices required updates to the internal software. This was not done correctly for several devices causing the error. Once identified the issue was easily corrected.

Smartphone application testers reported significantly fewer issues with data collection. It was noted that devices with an operating system more than two years old had a difficult time with precise data collection. This applied to both Android and iOS devices. It was noted that the newer devices provided more precise information. In response to this finding, the recruitment materials were updated to ask about the age of the device and its operating system.

Both the GPS logger and the smartphone application presented similar GPS data collection issues when it came to stop detection and walking trips. The backend stops detection algorithm used by the consultant often placed additional “phantom stops” when testers stopped for long traffic lights or created multiple stops during walking trips.⁴ The issue was discussed at length with the consultant who argued that each metropolitan area was slightly unique and required slight alterations to the algorithm to increase accuracy. The consultant also added a tracking mechanism to their output which allowed for analysis of the number of respondents who deleted, moved or otherwise altered stops during validation. In subsequent tests MAG noted a reduction in “phantom stops” although the problem was not entirely resolved during the project.

Finally, testers provided feedback on the MMSMonitor validation website used by both smartphone and logger users. They found the website difficult to maneuver, particularly when it came to adding missing stops. While the website did allow for adding stops, the times associated with travel to and from the – added stopes were difficult to adjust. Smartphone testers noted the inconvenience of having to switch from their mobile device to their computer to validate the day’s travel. No option for validation was provided within the application and the website was not mobile friendly. In addressing these concerns the consultant re-examined the

⁴ Zhao, Fang, Ajinkya Ghorpade, Francisco Câmara Pereira, Christopher Zegras, and Moshe Ben-Akiva. “Stop Detection in Smartphone-based Travel Surveys.” *Transportation Research Procedia* 11 (2015): 218-26.

methodology for adding a stop and streamlined the process. They also began development of validation within the smartphone application.

2.4 Pilot Test Methodology and Findings

2.4.1 Pilot Test Batch 1 – August 2015

Following procedural improvements to the survey, the first pilot test involving the public began in August 2015. Seven thousand advance letters were mailed to households selected as part of the ABS. Reminder postcards were mailed to the households seven to ten days after the advance letters. Based on previously completed household travel surveys the consultant team expected a recruitment rate of approximately five percent or three-hundred and fifty households.

In the first week of recruitment sixty-four households completed the recruit survey. The second week saw an additional thirty-five households. The recruitment slowly trailed off for the next few weeks and in total approximately one hundred households signed up through this initial effort. The final recruitment rate of one and a half percent was well below expectations and led to several changes in the ensuing pilot tests.

In addition to the recruitment rate, the split between households using smartphones and GPS loggers was different than expected. Initially it was believed that sixty percent of households would choose the smartphone application. However, sixty percent of respondents preferred the GPS loggers. No definitive reason can be given for this development but anecdotally it is believed that participants preferred the privacy and perceived ease of the GPS loggers. It was also expected that roughly fifty percent of the households who began the survey would complete it. At the end of the pretest batch fifty-five percent of recruited households completed the survey.

2.4.2 Pilot Test Batch 2 – August 2015

The second pretest batch consisted of a small sample of five hundred households drawn from the previously purchased ABS. Given the low response to batch one of the pilot test a number of recommendations were suggested. The envelope containing the advance letter was redesigned to include the incentive amount, the phoenix skyline image and a due date. The title line of the return address was changed from the name of the consultant's firm to MAG. The advance letter itself was slightly re-written for clarity and the signature of the executive director was changed from black to blue ink.

The five hundred letters were mailed two weeks after the pretest batch one to a fresh sample of addresses. In the following two weeks ten households were recruited with the materials. The two percent recruitment rate was an improvement over pretest batch one but still fell short of the initial goal of five percent.

2.4.3 Pilot Test Batch 3 – August 2015

The low recruitment rates through ABS led the consultant team to recommend another traditional recruitment method, Random Digit Dialing (RDD). A sample of both landline and cell phone numbers was compiled and two nights of calling the targeted households were scheduled. Four call centers with Florida numbers were used for the pretest. Nearly eleven thousand numbers were dialed. A brief disposition of the calls made is shown in Table 2.2. Despite the large volume of calls seventeen households were recruited during pretest batch three. Well below the expected rate of return.

Table 2.2 Pilot Test Batch 3 RDD Results

	Dial Numbers	Bad Numbers	Voicemail Left	Completes
Landline	10,331	7,362	1,011	12
Cell Phone	517	96	248	5

Debriefing call center employees provided a few avenues for improvement. It was noticed that the long introduction to the survey was a strong deterrent for participants. Many call center employees stated the respondent often hung up on them before hearing even a sentence or two. When they did find willing participants the length and intrusive nature of the survey provided further obstacles to completing recruitment. The feedback received from pretest batch three resulted in a shorter introduction to the survey for pilot test batch four.

2.4.4 Pilot Test Batch 4 – September 2015

In addition to a streamlined introduction, the fourth pilot test batch also utilized a local call center as well as the call centers at the previous locations. Given the proliferation of caller ID for landlines and area code identification/notification features on cell phones the consultant team suggested a local number would provide better results. Both call centers were given sample numbers and two nights for phone calls were scheduled.

The revised introduction provided only a slight increase in the responses. The local call center did have a slightly better production rates but overall neither change led to a viable long-term recruitment strategy.

2.4.5 Pilot Test Batch 5 – October 2015

The final pilot test batch was an amalgamation of previous efforts and the inclusion of a paper recruitment survey. The households from pilot test batch one that were not recruited would be matched against a telephone/cell phone number database. Attempts was made to re-recruit any household where a match was found. Half of these households received a letter containing a paper recruitment survey. The other half received a revised version of the advance letter directing them to a recruitment survey specifically formulated to be brief. . All households received a phone call from a trained interviewer approximately two weeks after the letters were mailed.

Forty-five hundred addresses from pretest batch one were matched with a number from the telephone/cell phone database. The enhanced recruitment efforts resulted in the recruitment of one hundred and thirty-three households, or three percent. The three methods of recruitment: paper, online and phone were utilized equally by the respondents. Pilot test batch five was the most successful effort with a three percent recruitment rate. Unfortunately, this was still significantly below the five percent goal established before the pretesting began.

2.4.6 Overall Pilot Test Findings

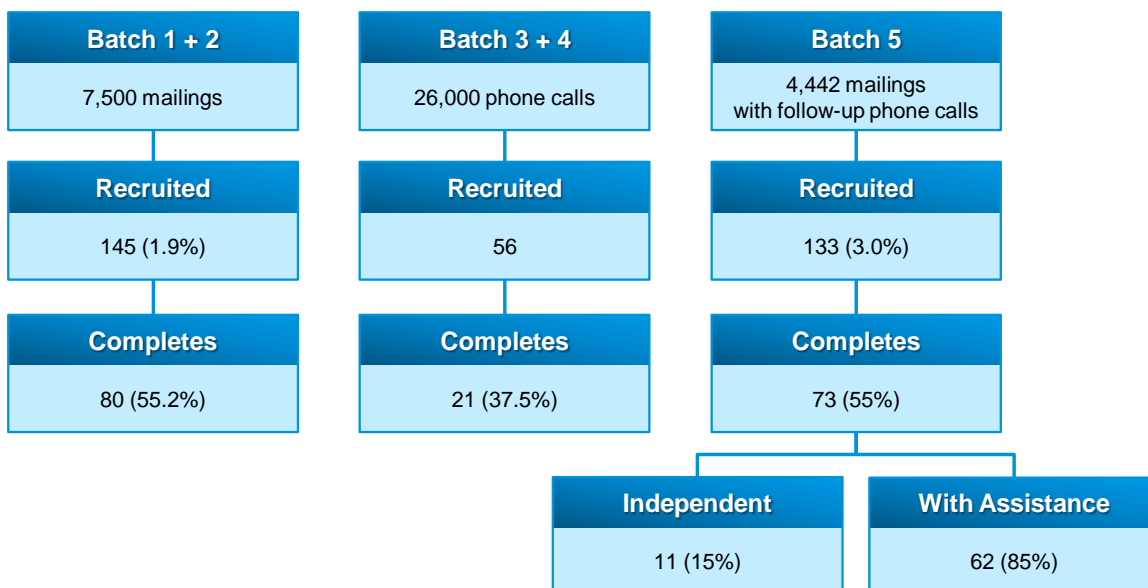
No recruitment method met the five percent recruitment goal but many improvements were made as a result of the pretests which resulted in a steady improvement of the recruitment rate. The length and complexity of the survey were reduced as initial pretests revealed those were a major source of frustration and

apprehension for respondents. The materials accompanying the GPS logger were amended for clarity. The phrasing of the advance letter was revised numerous times for brevity. With regards to providing information to respondents, our initial approach was to give complete and thorough information about all aspects of the survey at each stage. The feedback we received changed this philosophy. Moving forward we provided only the most straightforward questions to the participants while simultaneously directing them to links with additional materials for those who were interested.

Making changes to the look and language of the advance letter alone resulted in a one percent increase in the recruitment rate. It was noted that the vast majority of households were recruited via the advance letter and that the reminder postcard resulted in a smaller than anticipated increase. As a result of this finding, the production cost of the postcard was reduced. RDD was found to be an unsuccessful method of recruitment for the survey. It was extremely difficult to recruit through landlines. Cell phone calls did result in more completes but the advantage was lost when factoring in the increased cost of cell phone sample and the additional staff time to manually dial the numbers.

The most successful pretest, Batch 5, resulted from a combination of mail and phone efforts as shown in Figure 2.7. While the recruitment rate in Batch 5 was the closest to the desired rate, it did so at an unsustainable cost and level of effort. RDD and address-to-phone number matching proved to be too costly to implement at full scale.

Figure 2.7 Summary of Pilot Test Results



The most important finding of the pilot test was the amount of work required to bring recruited households to complete status. In Batch 5 only fifteen percent of the households were able to complete the survey from start to finish without the assistance of the consultant's staff. We anticipated some level of troubleshooting, especially given the complexity of validating travel but were surprised that eighty-five percent of household required partial or full assistance with their travel records. This finding led us to once again examine the data collection systems and to adjust the project budget accordingly.

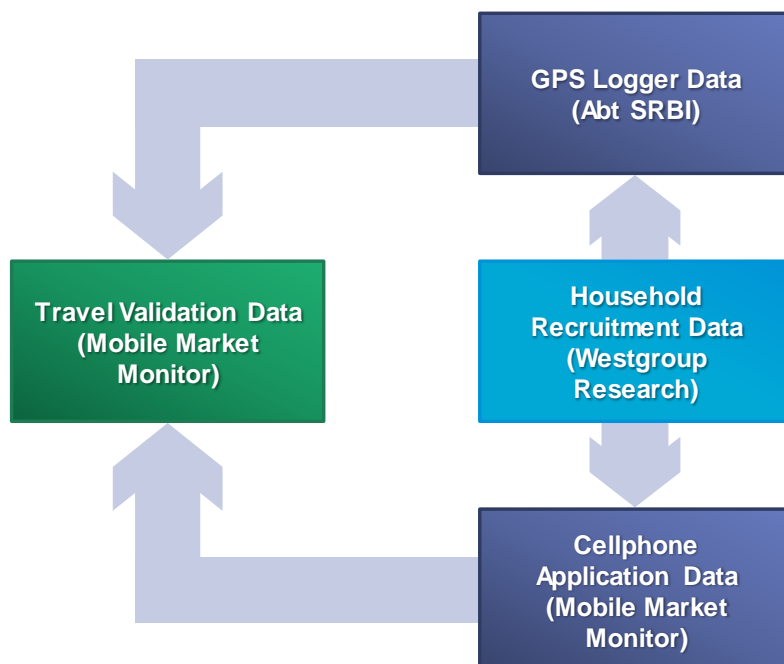
2.5 Main Survey Methodology and Findings

2.5.1 Spring 2016

Following the completion of the pilot tests and taking budget restraints into consideration the decision was made to send an advance letter and postcard to ninety-six thousand households during the Spring 2016 collection period. No RDD was completed for the main data collection period. During the spring data collection both GPS loggers and the cellphone application were offered. The costs associated with sending loggers to households led to a change in the recruit survey that automatically assigned recruited households the smartphone application if they were eligible. Households that did not qualify for the smartphone application were sent GPS loggers instead.

In preparation for the main data collection period the consultant team improved the transmission of the survey data through the creation of custom application program interfaces (APIs). Three firms were involved in the collection of recruitment and travel data. Figure 2.8 shows the flow of data between the firms. New software to recruit, track and monitor household was also implemented before the spring launch. The software was an instrumental tool for tracking households as they progressed through the survey process. Participant travel dates were no longer assigned and instead participants could choose from dates when they were recruited. It also allowed for the automation of sending reminder e-mails and text message to survey participants.

Figure 2.8 Data Flow between Firms



The public-facing survey website, which included instructions, FAQs, the privacy policy and acted as the gateway into the survey was completely overhauled. The site was changed to make it consistent with the spring data collection methodology and the questions and instructions were shortened one more time for

clarity. In addition to being updated the entire survey and website were translated into Spanish before the spring data collection began.

Due to the overwhelming assistance statistics from the pretest the consultant began hiring and training Travel Survey Coordinators (TSCs) to help the households move to a complete status. They were responsible for technology support, correcting validation errors and troubleshooting any additional issues experienced by participants.

The 96,000 households were contacted in five separate mailings via an advanced letter followed by a postcard two weeks later as shown in Figure 2.9. The recruitment rate across all five mailings hovered around 1.7%. The slight decrease in recruitment rate between the pilot and Spring 2016 effort may have been due to the restructuring of the incentive from \$20/household + \$10/person (aged 12 and over) to \$10/person in household (aged 5 and over). As noted, the recruitment rate is the percentage of households who received an advanced letter divided by those who then fully completed the recruit survey. In the Spring 2016 survey, 2.6% of households who received an advanced letter began the recruit survey, of which 65% of those households completed it, as shown in Table 2.3.

Figure 2.9 Spring 2016 Data Collection Statistics

1 st Mailing	2 nd Mailing	3 rd Mailing	4 th Mailing	5 th Mailing
Sample Size: 10,000	Sample Size: 14,000	Sample Size: 24,000	Sample Size: 24,000	Sample Size: 24,000
Final Recruitment Rate: 1.79%	Final Recruitment Rate: 1.89%	Final Recruitment Rate: 1.77%	Final Recruitment Rate: 1.62%	Final Recruitment Rate: 1.70%
Final Completion Rate: 64.25%	Final Completion Rate: 62.88%	Final Completion Rate: 65.33%	Final Completion Rate: 60.26%	Final Completion Rate: 59.56%
Completed Households: 113	Completed Households: 166	Completed Households: 277	Completed Households: 235	Completed Households: 243

Table 2.3 Recruit Survey Participants by Location of Survey Drop-Out

	Percent of All Households Who Log into Website	Percent of Drop-outs
Fully completed survey and were recruited for study	65%	
Dropped-Out		
• Dropped-out during Survey Introduction or Address Confirmation	9%	24%
• Provided some household and person details, but...		
– Began filling out Vehicle Information, but did not finish	4%	10%
– Filled out all Vehicle information, but...		

» Did not complete any Person information	7%	19%
» Dropped-out before completing Person Information	2%	7%
» Provided all detailed Person Information, but...		
○ Refused Contact Information/No Assigned Travel Date	10%	30%
○ Dropped out after assignment of travel date	3%	9%

The completion rate once they were recruited ranged between 60-65%, which increased from the Pilot study due to the formal process put in place for reminding households to complete each phase of data collection as well as the availability of TSCs to help with every aspect of data collection. Understandably single and two person households quickly reached complete status while larger households struggled. Once this was identified, the consultant team began tracking more closely large households. Along with the larger households the team also started actively pursuing households that were close to completing their recruit surveys through phone calls and reminder e-mails or texts as appropriate. This procedural shift was necessitated by the continued dropping off of recruits for the project.

About a third of recruited households were unable to be contacted after initial recruitment. Phone numbers and e-mail addresses were collected as final questions in the recruit survey but re-contacting these households was still unsuccessful. Another third of recruits were completing the recruitment survey but not completing the travel portion of the survey. Many had already downloaded the application or received the GPS loggers. These households were quickly identified and contacted when possible. Approximately 50% of them completed the travel portion of the survey as a result of this effort.

Throughout the Spring 2016 survey, the use of the GPS loggers for data collection continued to be a costly endeavor. Given the need to purchase GPS loggers and pay for their shipment to the households and then back the GPS loggers were significantly more expensive to deploy compared to downloading an application on the participants' smartphones. In addition, households requiring a GPS logger could not be assigned a travel date until a minimum of two weeks after filling out the recruit survey, so it took them longer to go from the recruitment to the completion phase.. Households using the GPS loggers were more frequent users of the project's manned helpline. A review of the materials and settings of the GPS loggers was conducted but no changes were made.

2.5.2 Fall 2016

For the Fall 2016 survey, the decision was made to move from ABS recruitment to a convenience based sample, inviting residents through various outreach efforts to participate in the survey. The other major change to the survey methodology was that GPS loggers were no longer offered to the survey participants, and thus only households with smartphones qualified for the study.

A key difference between traditional random sample and a convenience sample is the need for a pre-qualification survey to screen out households that do not meet certain requirements. A pre-qualification survey ensuring that the households' zip codes were within the MAG region and that the household had the proper technology (i.e. owned a smartphone) was administered. If they qualified for the study participants were then instructed to complete the recruitment survey.

To assist in creating awareness and recruiting residents, Gunn Communications, Inc. (GCI) was added to the project team. GCI was responsible for developing and implementing a strategic communications plan designed to increase the number of people participating in the HTS survey. The first step in the

communications plan was the development of key messaging and materials. In order to promote participation in the survey it was essential to develop key messages that were catchy and simple. The purpose of the messaging was to:

- Generate excitement about the survey.
- Compel recipients to act.
- Instill a sense of data/personal security.

To create relevant messaging that would generate large-scale involvement, the project team met with a group of project “champions” to discuss the status of the project, potential issues, stakeholder groups and ideas for increasing survey participation. After identifying the target demographics, a logo and tagline were developed that had wide appeal and created a sense of fun. The logo features a dog riding in a car, to appeal to the many Valley residents who enjoy the company of animals. Figure 2.10 shows the logo with a tagline and a banner that was created for use on the project website and printed materials.

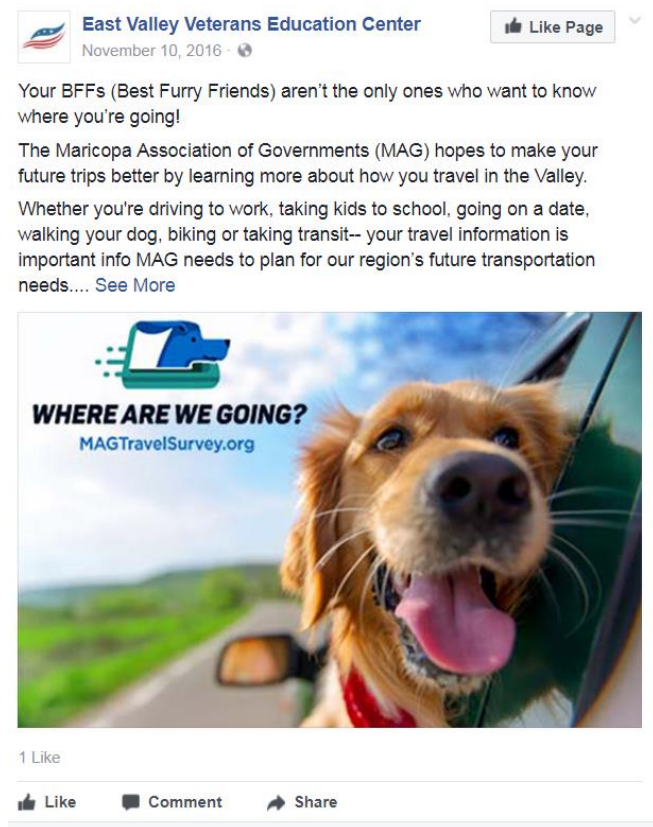
Figure 2.10 Survey Logo, Tagline, and Advertising Banner



Messages were developed for use via a variety of channels. Each message featured the project brand, a call to action, and a sign-up link to participate. Unique links were used for each channel to facilitate tracking by channel. Messages were customized for the following channels:

- Facebook.
- Twitter.
- NextDoor.
- Printed newsletter article.
- Online newsletter article.
- Email Graphic/Electronic flyer.
- Website.

Figure 2.11 shows an example of a Facebook post that was developed to promote the survey.

Figure 2.11 Example of a Facebook Post for Advertising the Survey

The next step in the communications plan was to identify project champions and ask them to distribute information through their existing communication channels. A "champion" is a person who has access to a significant network of electronic and social media communications enabling the messages to reach the broadest audience possible. Municipal Public Information Officers (PIOs), who are typically involved with MAG already as member agency liaisons, were listed as champions in addition to community advocacy groups, such as chambers of commerce and downtown development organizations. The champion list was developed with a variety of members so survey messages would be seen in diverse communities (see List of Champions in Appendix A.2).

GCI reached out to each champion to inquire whether they would help publicize the survey. Additionally, the message was spread through three of MAG's committees. The Intergovernmental Committee, Bicycle and Pedestrian Committee and Transit Committee provided platforms for a representative of the survey to provide information on the survey and contact information to committee members. A few additional organizations that do not fall into any of the above categories also participated in spreading the word about opt-in recruitment. These included motoring and bicycle related businesses. They were recruited through both word of mouth and by their attendance/participation in public meetings.

Once an agency agreed to help promote the project the key messages and presentation materials were sent via email and follow up calls were made to encourage the agency to post messages as widely as possible and to answer questions. Many agencies shared the messages and were active in promoting the study, however, others either only promoted once or opted not to provide assistance. It became apparent by the postings that agencies who had been emailed and received a follow-up call were more likely to share

messages. The public relations firm attempted to keep the champions engaged through repeated contacts and by changing the messages from month to month.

Not all outreach approaches were “equal” in their efficacy. Facebook and NextDoor posts along with emails from the agencies were more likely to garner survey respondents than were other approaches such as promotion in newsletters, posters, and twitter. Signatures in the links tracked responses based on invitations to participate and revealed the direct response to an outreach effort. Overall, promotion via known agencies was a very low-cost and successful recruitment methodology. The primary cost of recruitment was the hours spent by the public relations firm to develop marketing materials and contact agencies, plus the support hours provided by the survey firm staff. Note, that support hours were necessary regardless of the recruitment method. Over a one month period 520 households were recruited into the study. For an equivalent ABS mailing, approximately 24,000 letters would have had to be mailed at a significantly more substantial cost.

Since emails seemed to be effective, MAG requested the purchase of a mailing list of 48,000 verified email addresses. The email addresses were used for a series of email blasts using the established email graphics. Blasts were sent in batches ranging in size between 200 and 400 individual email addresses. Unfortunately, it was determined that emails were only effective coming from a known entity rather than from an unknown source, such as the public relations company.

Facebook and Instagram advertisements were also tested, but proved to be an inefficient recruitment method. A cost was incurred each time the link was clicked, and so while the link was clicked a fair number of times, very few of these “clicks” converted into recruited households. Thus, while the ads proved a successful means to advertise the study they were not very helpful in recruiting households, with a total of only one complete coming from this recruitment method.

We also tested a coupon-style ad that involved a mailing to two geographic “zones” selected by MAG. Each zone contained 10,000 household for a total of 20,000 coupons delivered to unique households. The special offer, which had the appearance of a coupon, was the opportunity to use a special link to earn double the incentive. The results were disappointing with only 8 households completing the full recruit survey and only 5 households successfully completing the study.

The third recruitment method undertaken was via advertisement by school districts. Seventy Maricopa and Pima County public school districts identified by zip code as being within the MAG region were approached with the opportunity to promote the MAG Household Travel Survey as a fundraiser. To incentivize the school districts to promote the project to their constituencies (staff and parents) the study would donate \$10 per completed household to an education fund within the district.

Districts were primarily contacted via email, but letters were physically mailed to 17 districts that did not have readily available email addresses. Districts were asked to promote the Survey via social media posts and email blasts in exchange for a donation to the district. Districts were paid the \$10 per household that used their unique link or selected the district as their source of study awareness and successfully completed the travel survey. Two school districts participated during the Fall 2016 survey effort. This method of recruitment was deemed successful and worthwhile to continue into the next phase of the survey.

2.5.3 *Spring 2017*

For the Spring 2017 effort, the incentive payment was changed from \$10/person in household to a flat \$100/household regardless of household size. The recruitment focused on targeting three specific population

segments: 1) Households with children via school district recruitment; 2) ASU faculty, staff, and students via e-mail and in-person intercept recruitment; and 3) Transit users via in-person intercept recruitment.

A total of 11 school districts participated in the Fall 2016 and Spring 2017 survey effort. The \$100/household incentive resulted in high recruitment rates for the participating school districts for a total of close to 1,800 completed households recruited from school districts in Spring 2017 alone.

ASU faculty and staff were recruited via an e-mail from the Provost's office promoting the survey. This recruitment method coupled with the \$100/household incentive proved so successful that it resulted in having to turn away interested participants. Since it was not feasible to allow all ASU faculty and staff who were interested to participate, coupled with technical troubles that occurred due to the large survey response, the Provost office was unwilling to promote the survey to ASU students. Thus, to recruit ASU students the survey team focused on in-person intercept surveys and an advertisement via ASU State Press social media. The paid advertisement was not a successful recruitment method and the vast majority of recruits came from in-person intercept surveys.

In-person interceptor recruitment was the final recruitment methodology used on the project. Interceptors were sent out to transit stations and to the ASU main campus to recruit the targeted populations of transit riders and university students. Interceptors approached people at these locations to ask them to fill out the full recruit survey. It proved unsuccessful to fill out the entire recruitment survey with the passerby, but it was more feasible to have the respondents fill out the short pre-recruit survey on the spot and finish the full recruit survey online on their own time. The interceptors completed the short pre-recruit survey with interested parties to ensure they met study qualifications; an email was then automatically sent to the individuals so they could then go online and complete the full recruit survey at their convenience. Approximately four people were pre-recruited into the survey per hour, and 60% of those who completed the pre-recruit survey went on to complete the full recruit survey. Since the interceptors were paid per hour, this recruit methodology is more expensive than the other methods; however it still proved cheaper than the traditional ABS recruitment methodology. It was a successful methodology to recruit targeted population groups.

3.0 Data Analysis⁵

3.1 QA/QC Checks

The results of the QA/QC are summarized in Table 3.1, Table 3.2, and Table 3.3. The tables display the number of households, persons, or stops flagged for each issue. The percentages in the tables give the share of the records in that dataset which have been flagged.

Table 3.1 Household File Checks

Description	Exclusion	Frequency	Percent
Household Passed Acceptance Criteria	Yes	6,073	95%
Missing TAZ, Home	Yes	3	0%
TAZ out of the Region, home	No	952	15%
Multiple TAZs Reported for Home Activities.	No	0	0%
Length of HHID is not 7.	No	2	0%
Number of Workers > HH Members 16+	No	0	0%
Number of Workers not equal to workers in person file	No	548	9%
Household Missing Income	Yes	0	0%
HHID in Household File Not in Person file	No	0	0%
Number of People in Person File Must Equal HH size	Yes	0	0%
Households in the Household File Not in Trip File	No	2	0%
Number of Spouses > 1	Yes	0	0%

Table 3.2 Person File Checks

Description	Exclusion	Frequency	Percent
Person ID Formatting Error	No	0	0%
HH ID in Person File Not in Household file	Yes	0	0%
Adult Not Represented in Stops File	Yes	125	1%
Child Not Represented in Stops File (Child Diary)	No	22	0%
Unusually High Number of Stops (>10)	No	1,214	7%
Very High Number of Stops (>20)	No	74	0%
Unusual Age for Spouse	No	9	0%
Unusual Age for Children of Head of Household	No	17	0%
Unusual Age for (Grand)Parents of Householder	No	0	0%

⁵ This chapter reflects ongoing data analysis and application work. Further update to the report might be issued to reflect changes if any.

Description	Exclusion	Frequency	Percent
Child Under 16 has Driver's License	No	6	0%
Missing Educational Attainment	No	233	1%
School Type and Education Attainment Must Match	No	0	0%
Unusual Age for School Type	No	0	0%
School Type Missing From Student	No	0	0%
School Type Present in Non-Student	No	0	0%
Work Status Missing	No	183	1%
Child Under 16 is Listed as Working	No	8	0%
Work Responses Missing from Worker	No	1,204	7%
Worker Did Not Make a Work Trip	No	1,905	11%
Worker Did Not Report Work Location Status	No	30	0%
Missing School Status	No	564	3%
Missing Gender	No	100	1%
Missing Age	No	248	1%
Missing License	No	52	0%
Missing Relation to Household Head	No	65	0%

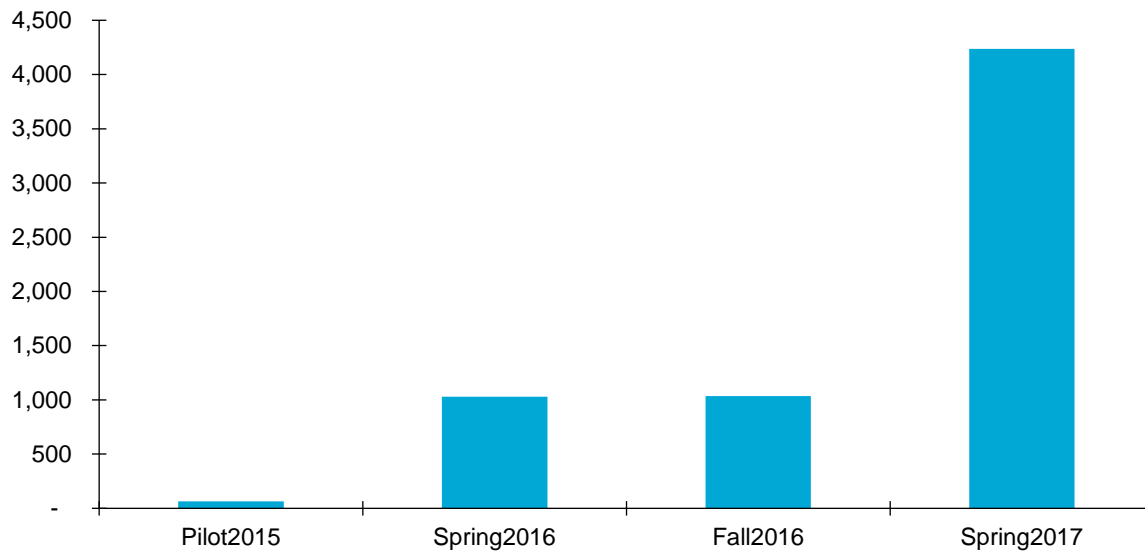
Table 3.3 Stop File Checks

Description	Exclusion	Frequency	Percent
Missing Geocode, Stop	No	1,445	2%
Sign Inconsistency in Geocode, Origin	No	3	0%
Geocode Out of the Region	No	1,003	1%
Household (in the Stop File) Not in Household File	Yes	0	0%
Duplicate Stop ID	No	0	0%
Non-Traveler Not at Home	No	185	0%
This and Previous Stops are Both Home Activity	No	2,691	3%
Day Does Not Start at Home or Work	No	1,568	2%
Day Does Not End at Home or Work	No	1,543	2%
Missing Time Information	No	0	0%
Arrival Time is After Departure Time	No	1	0%
Arrival Time is Before Previous Departure Time	No	264	0%
Unusual Activity Durations	No	96	0%
Entry for Other Activities but Not Main	No	0	0%
Non-Auto Trip Time Greater than 90 Minutes	No	4,850	6%
Auto Trip is Missing Passenger/Driver Info	No	648	1%
Child is Listed as Driving	No	16	0%

Description	Exclusion	Frequency	Percent
Auto Passenger in Single Person Party	No	515	1%
Household Vehicle Not Specified in Auto Trip	No	0	0%
Missing Party Size in Auto Trip	No	655	1%
Missing/Invalid Household Members in Party in Auto Trip	No	3,544	4%
Household Members List Does Not Match Party Size	No	4,516	6%
Manifest Has Duplicate Entries	No	55	0%
Work Trip by Non-Worker	No	8,273	10%
Auto Trip Driver Unlicensed	No	304	0%
Drive Alone Trip in Zero-Vehicle Household	No	100	0%
Work Trip in Zero-Worker Household	No	669	1%
Stop Matches Previous by Lat/Long	No	542	1%
Missing Primary Activity	Yes	615	1%
Missing Accompanying Family Member, 0-5 Years Old	No	0	0%
Missing Accompanying Family Member, 6-12 Years Old	No	0	0%
Missing Accompanying Family Member, 13+ Years Old	No	0	0%
Mode is Different from Family Member's Matched Trip	No	0	0%
No Drivers in Joint Vehicle Travel	No	0	0%
2+ Drivers in Joint Vehicle Travel	No	0	0%
Child Diary Missing Street Address	No	5,998	7%
Child Diary Missing Zip Code and Town	No	6,994	9%
Missing Zone/Not in Region, 'Adults'	No	1,056	1%
Missing Zone/Not in Region, Child Diary	No	1,108	1%
Home Activity Not in Home Zone	No	2,079	3%
Missing Zone & Geocode	No	1,084	1%

3.2 Overall Results

Overall the survey effort gathered completed surveys from 6,073 households in the MAG region that sufficiently met the 'completion' criterion as described under section 2.2.8 and passed the QA/QC checks described in section 3.1. Figure 3.1 presents the number of completed surveys from each of the four survey phases. The following sections provide more details on household and person attributes from the completed surveys.

Figure 3.1 Completed Surveys by Phase

3.2.1 Household Attributes

The following summaries compare the distribution of key household attributes to the 2008-2009 NHTS Add-On and the 2009 and 2015 ACS data for the MAG region. Figure 3.2 presents household size distribution by survey effort. The 2008-2009 NHTS over-sampled 2-person households and under-sampled large households. In contrast the 2015-2017 HTS under-sampled 2-person households and slightly over-sampled 1-person and large households.

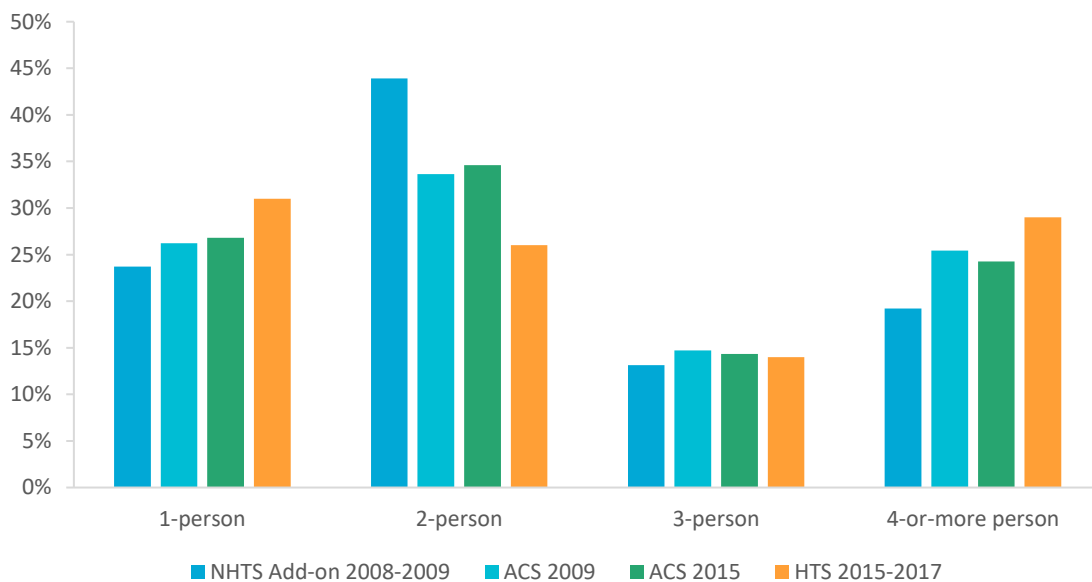
Figure 3.2 Household Size Distribution by Survey Effort

Figure 3.3 compares household income distribution across the different surveys. The 2015-2017 HTS slightly over-samples high income households and slightly under-samples lower income households.

Figure 3.3 Household Income Distribution by Survey Effort

Figure 3.4 compares number of household vehicles across the different survey efforts. The 2008-2009 NHTS slightly over-sampled three or more vehicle households and under-sampled zero and one vehicle households, while the 2015-2017 HTS household vehicle distribution matches closely to the ACS.

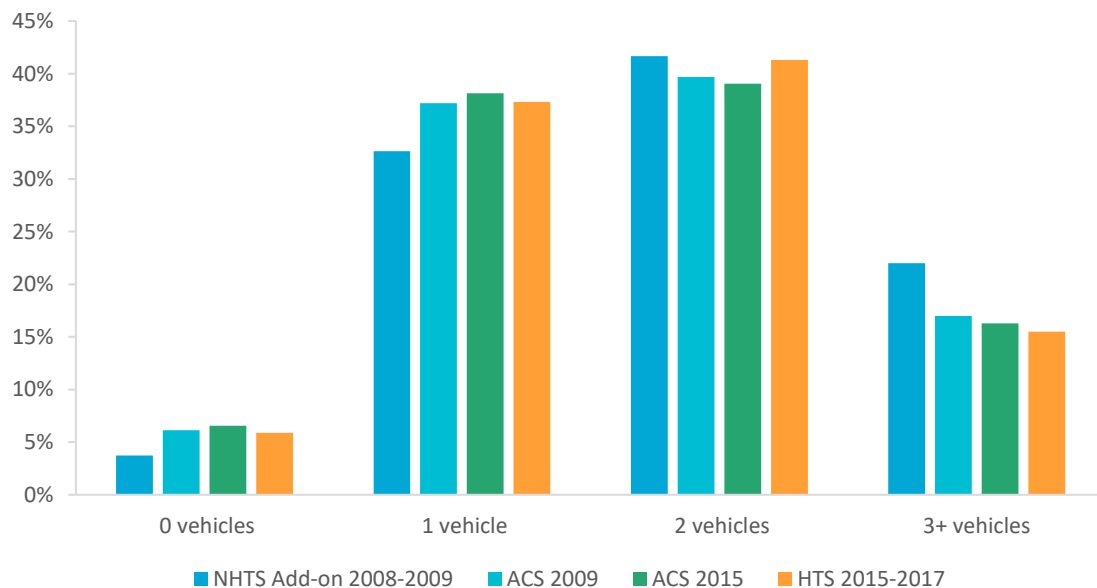
Figure 3.4 Household Vehicle Distribution by Survey Effort

Figure 3.5 compares household Hispanic status across the different surveys. While still under-sampling the Hispanic population, the 2015-2017 HTS did succeed in recruiting a higher share of Hispanic households and receiving complete surveys from them compared to the 2008-2009 NHTS.

Figure 3.5 Hispanic Status by Survey Effort

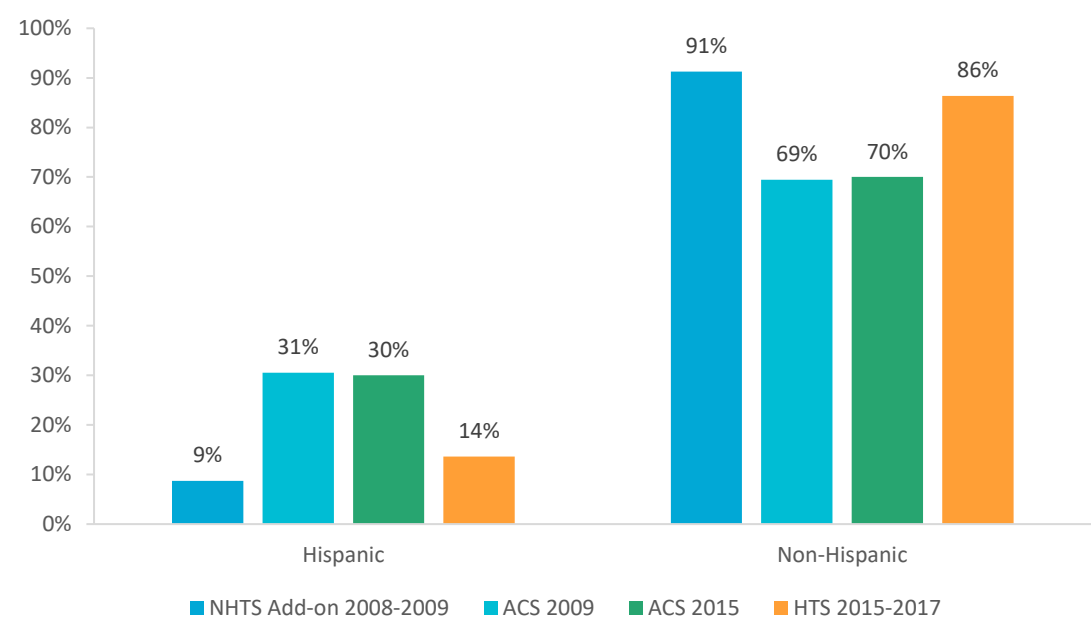
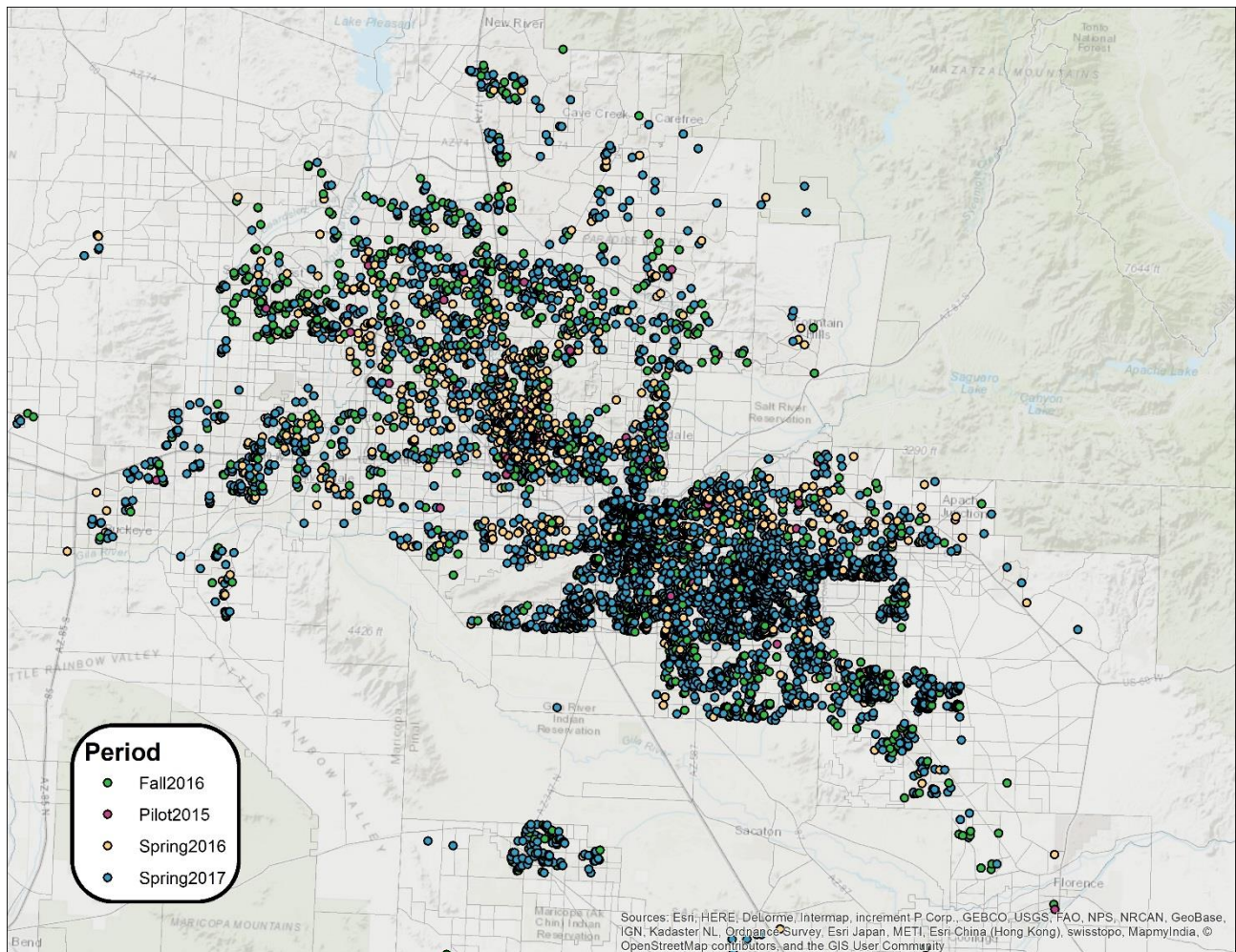


Figure 3.6 maps the residential location of households with complete surveys. There is a good representation of households across the MAG region. There is an over-sampling of households in some areas, such as East Valley due to the Spring 2017 survey’s focus on school districts and ASU.

Figure 3.6 Geographic Distribution of Households

3.2.2 Person Attributes

The following summaries compare the distribution of key person attributes in the current survey to the 2008-2009 NHTS Add-On and the 2009 and 2015 ACS data for the MAG region. Figure 3.7 compares the age distribution of surveyed individuals across survey efforts. The 2008-2009 NHTS over-sampled older individuals and under-sampled children and young adults. In contrast, the 2015-2017 HTS over-sampled children and under-sampled older individuals. The 2015-2017 HTS matched closely the ACS for young adults.

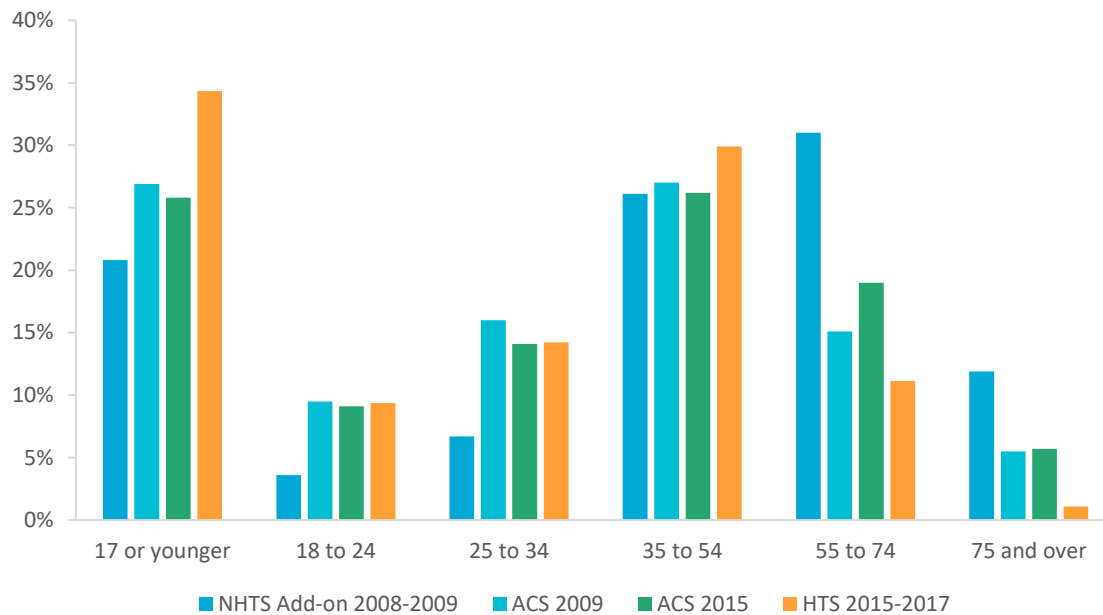
Figure 3.7 Age Distribution by Survey Effort

Figure 3.8 compares the highest level of completed education of surveyed individuals across surveys. Due to the over-sampling of ASU students and faculty the 2015-2017 HTS has very high representation of individuals with high level of educational attainment

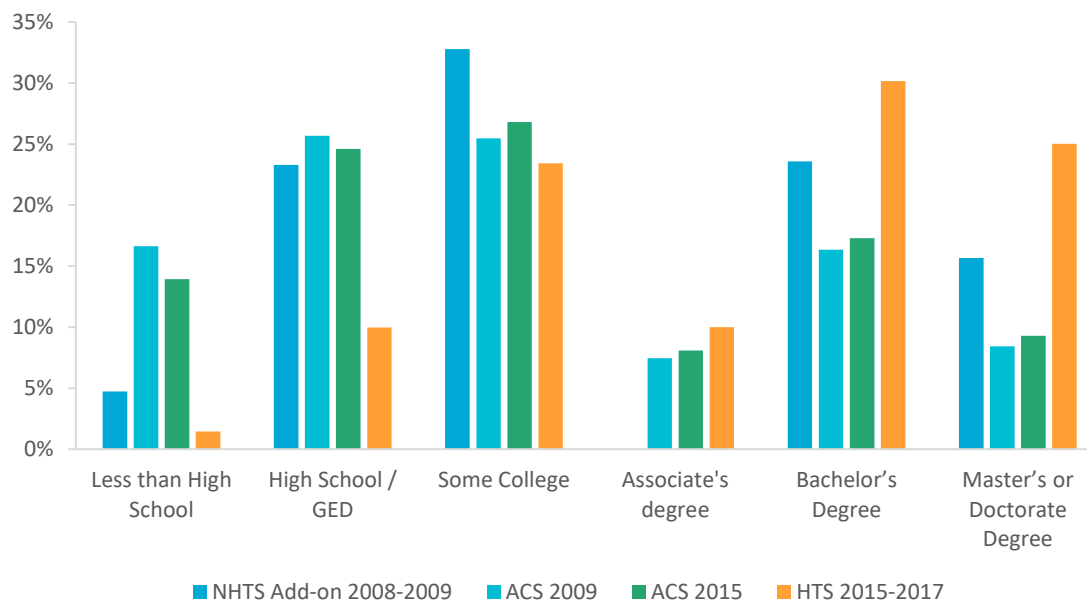
Figure 3.8 Educational Attainment by Survey Effort

Figure 3.9 compares the employment status of surveyed individuals across survey efforts. The 2008-2009 NHTS over-sampled non-workers and under-sampled full-time workers. Most of the over-sampling of non-

workers is due to a high representation of retired individuals in the sample. The 2015-2017 HTS matches closely the ACS data with regard to employment status.

Figure 3.9 Employment Status by Survey Effort



3.2.3 Trip and Activity Attributes

Trip departure time and activity duration by purpose were analyzed in the unweighted data to assess its reasonableness. Figure 3.10 shows plots of the hour of the trip departure time for all purposes. As expected there is a peak in departure time during the 7 a.m. hour and another uptick in trip making during the evening peak periods between 3-6 p.m.

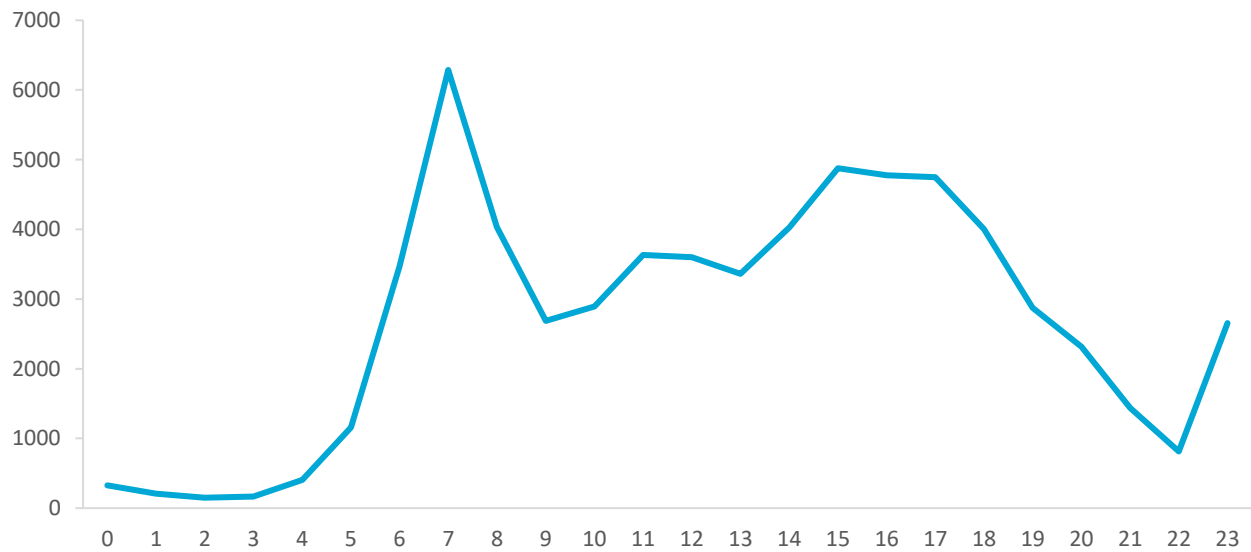
Figure 3.10 Count of Trip Departure Time by Time-of-Day

Figure 3.11 shows the average activity duration by purpose. Note, this is a plot of the average continuous duration of activities and not the total 24 hour time period. As expected, the home activities (primary home and secondary home) have the longest duration. The work and school activities have the second longest durations. The average of 3.6 hours for work suggests that most individuals do make work-based trips throughout the work day.

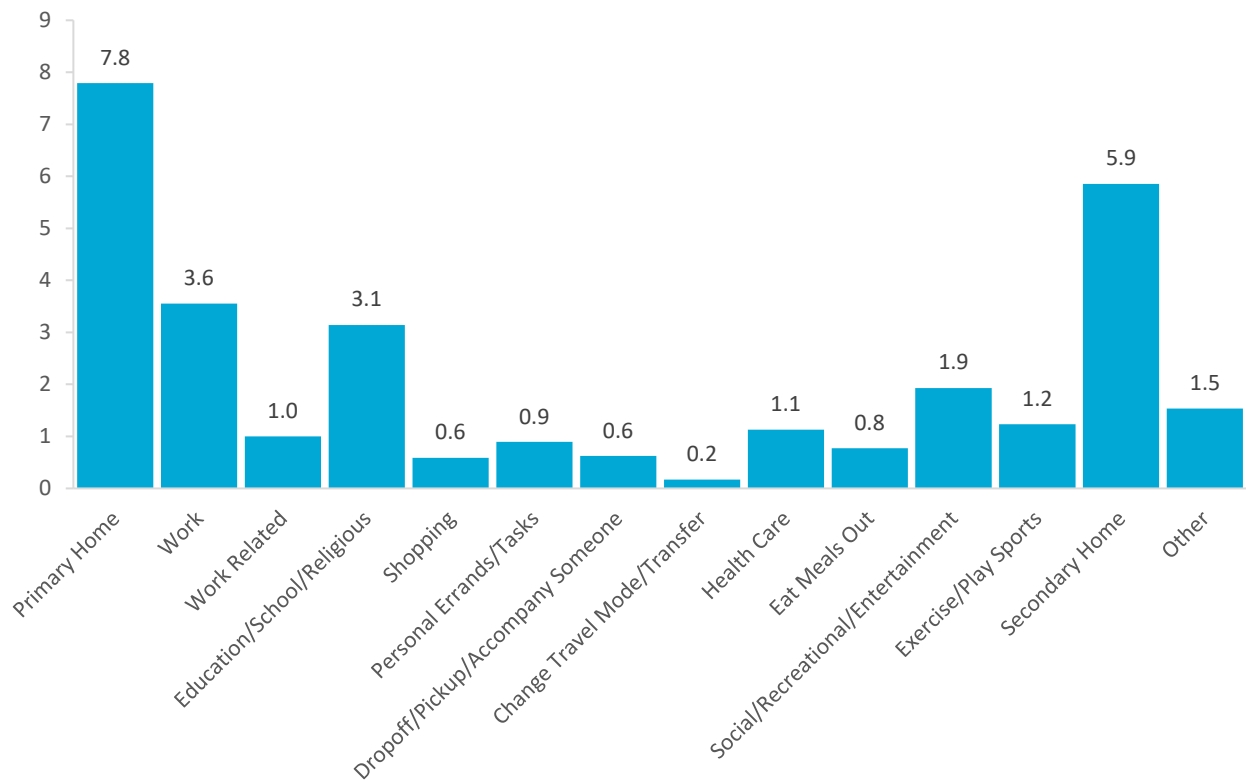
Figure 3.11 Average Activity Duration in Hours by Activity Purpose

Figure 3.12 shows a plot of the hours of continuous time spent at home, at work and on work related purposes. The high count of activities that are less than one hour in durations suggest the prevalence of individuals who make a large number of trips as part of their job are being captured by the GPS. Similarly additional trips within the work place itself are also being recorded (i.e. walking to another room within the same building). The later will be combined/aggregated for modeling purposes. On the other hand, the high number of work related activities with a duration up to two hours is reasonable. When the duration of work and work related activities are summarized into the duration of the total daily activity, as shown in Figure 3.13, the high number of total work activities in the 8-9 hour range is as expected.

Figure 3.12 Count of Activity Duration in Hours for Work and Work Related Purposes

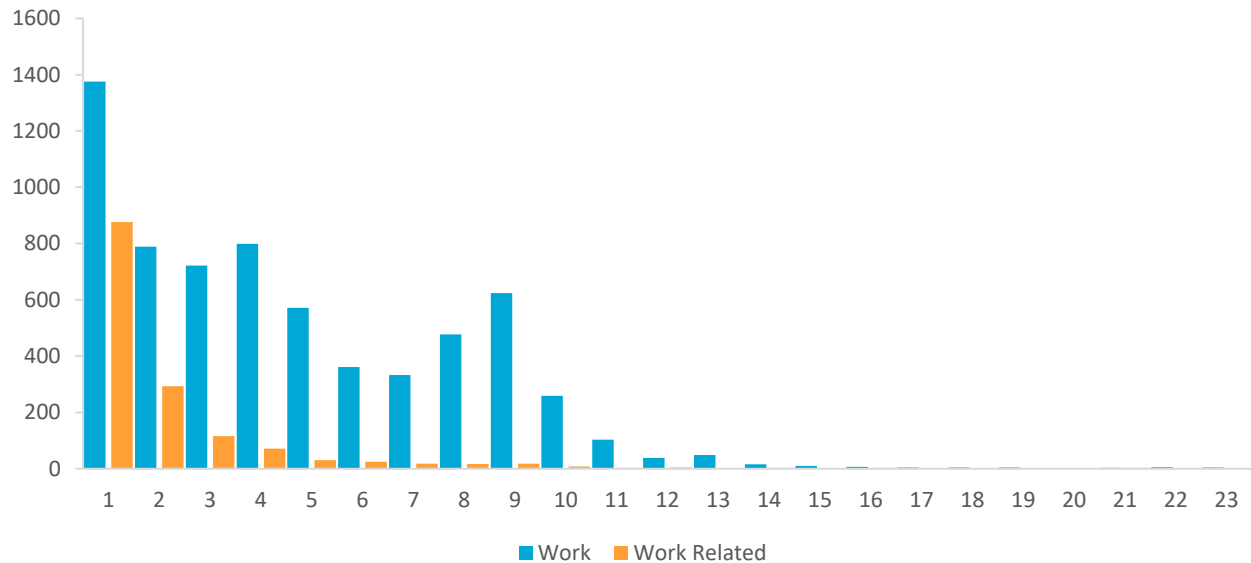
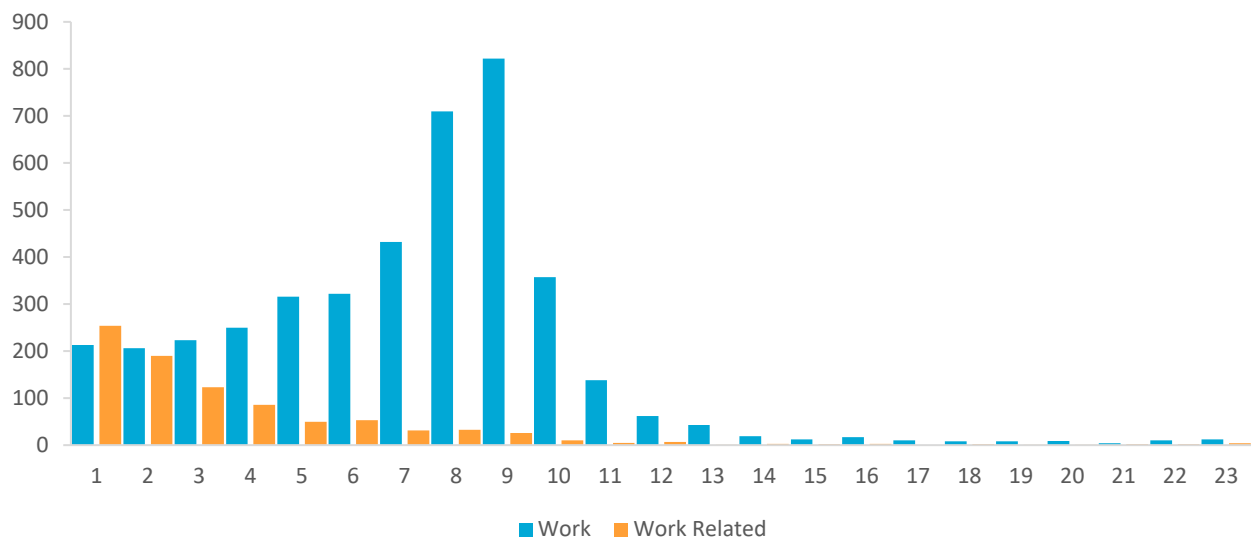


Figure 3.13 Count of Total Daily Activity Duration in Hours for Work and Work Related Purposes



3.3 Expansion and Data Analysis⁶

This section presents the procedure to compute the expansion weights for the 2017 Household Travel Survey (HTS) sample. The objectives of the weighting procedure are two-fold. First, as in any household

⁶ This section was last updated December 12, 2018.

travel survey, the respondent sample may not be perfectly representative of the true population due to biases in the sampling process or due to selective non-response where certain demographic groups are more (or less) likely to respond to the survey. Thus, the weights are computed to correct for sample biases. Second, the weights constitute expansion factors that can be used to obtain population-wide statistics on various activity-travel or socio-economic measures of interest. The weights essentially expand the sample to be representative of the population – not only in terms of distributions or proportions of various characteristics, but also in terms of the total values for various attributes that describe population behavior.

This section details the procedure and results of the sample weighting process. Throughout this section, the term weighting is used to reflect *both* the correction for sample biases and the expansion to represent population totals. The section is organized into six sub-sections. The first sub-section describes the data sources used to prepare the marginal control distributions which drive the sample weighting process. The second sub-section discusses the geographical zone system - used for sample weight computations. Because a survey sample is rather small (in comparison to the population at large), geographic-based weighting - is necessary to ensure that robust weights can be computed. The third sub-section is dedicated to describing the household and person control variables and categories - used for the household survey sample weighting and expansion process. The sample weighting algorithms, including the List Balancing and Meta-balancing methods embedded in software for generating the synthetic population (PopSyn), are described very briefly in the fourth sub-section. Finally, the fifth and sixth sub-sections offer the results of the weighting process and demonstrate that the weighted sample indeed appropriately represents the population as a whole as described by census data.

3.3.1 Data Sources for the Marginal Control Data

The estimation of the household travel survey (HTS) weights requires marginal distribution data for different variables (e.g., household income, household size, person age, and employment status) of interest which serve as controls in the expansion and weighting of the survey sample. There are three data sources that provide population-wide marginal control distributions which need to be matched through the weighting and expansion of the household travel survey (HTS) sample. These include:

- **2017 MAG Socio-economic (SE) data:** This serves as the main source for marginal control data at the TAZ (traffic analysis zone) or MAZ (micro-analysis zone) level.
- **2012-2016 American Community Survey (ACS) 5-year Estimates Summary File (SF):** This data provides marginal control distributions for a number of variables, including those that are not available in the MAG Socio-economic data. The ACS data provides marginal control distributions for household and person characteristics of interest at the County, Census Tract, and Census Block Group levels.
- **2015 On-board survey data:** For a transit trip variable, On-board survey data provides a control distribution in the desired format. That is, the weighted 2015 On-board data is used to derive the control distribution of interest, especially transit trips.

The data from the U.S. Census Bureau (ACS summary file) and On-board survey are estimated for 2016 and collected in 2015, respectively, but the MAG socio-economic data is for 2017. As the HTS sample data was largely collected in 2017, it is important to weight the data to match 2017 population characteristics and transit trip trends. For this reason, the 2012-16 ACS and 2015 On-board data were adjusted to match 2017 MAG socio-economic data and 2017 Valley Metro ridership data prior to the execution of the weighting algorithm.

3.3.2 Geographic Zone System

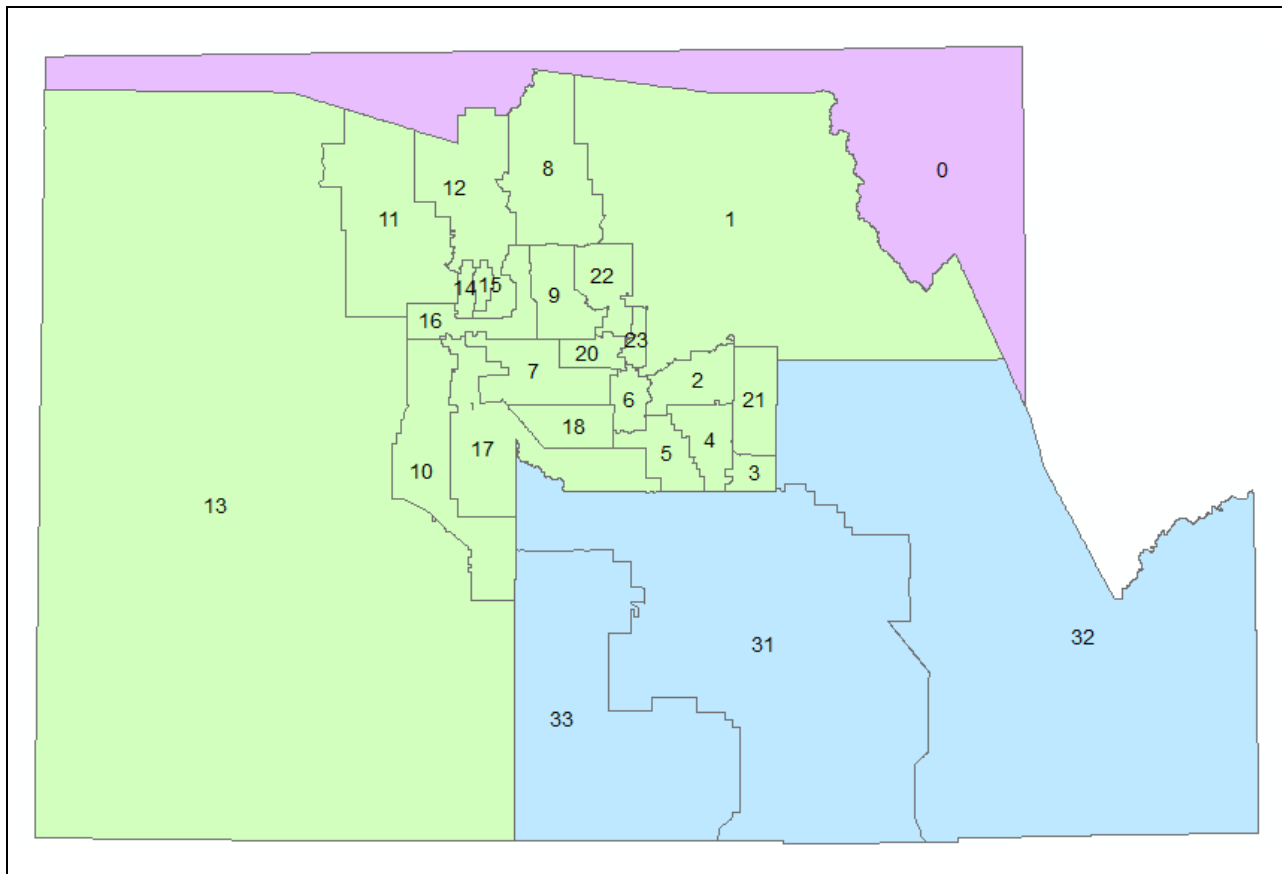
A survey sample can be weighted to match population-wide control distributions at different levels of geography. For example, the survey sample can be weighted to match county-wide population characteristics. While such an aggregate treatment of space may be convenient from a computational standpoint, it may compromise the extent to which the survey sample is representative of the true population at smaller geographical resolution such as traffic analysis zone (TAZ) or census tract or public use microdata area (PUMA). It is therefore important to choose an appropriate spatial configuration for the sample weighting process. The configuration of the geographic zone system must carefully consider the desire to weight the sample to match population characteristics in small geographies against the need to ensure that adequate sample sizes are available in the geographies of interest. For example, it may be desired to weight the sample to match population characteristics of interest at the census tract level. However, if there is only a small number of survey observations in the various census tracts, then the computation of weights becomes quite difficult, especially when trying to control (match) a number of population distributions.

Figure 3.14 shows the geographic areas used in the estimation of HTS expansion weights. Two different geographic zone systems were employed to estimate expansion weights for the HTS data. They are: 1) an aggregation of TAZs (referred to as districts in this section); and 2) Meta (Maricopa and Pinal Counties). There are 3,088 TAZs in MAG Model region. However, the 2017 HTS sample size (5,865 households) is too small to estimate expansion weights at such a fine geographic resolution. Hence, a process is essential to aggregate TAZs into Districts to be possible for an expansion weights process. Three criteria are considered in this process of TAZ aggregation. First, each District should include certain amount of household samples for successful convergence in an expansion weight process. 50 household samples is regarded as the minimum number for each district. Although one District includes less than 50 household samples, the expansion weights estimation is successfully converged. Second, a District boundary should be matched to city boundary as close as possible. Since MAG receives many requests related with household travel survey information from city-level transportation agencies in MAG model region, the expansion weight process has to provide the better household sample weight result for city transportation engineers. Third, District boundary should be closely matched to Census Tract boundary because some control variables are derived from not MAG socio-demographic data but 2012-16 ACS Summary File data. After the aggregation process, there are 22 districts in Maricopa and 3 districts in Pinal for estimation of household expansion weights (see Figure 3.14 and Table 3.4). There is one District for Counties of Yavapai and Gila. This District is not included in the expansion weight process because only one sample is available in HTS data. There is on zone for Meta level which is combined both Maricopa and Pinal County.

Table 3.4 Boundary of District and County for Expansion Weights

District IDs	County
0	Yavapai and Gila Counties
1 - 22	Maricopa County
31 - 33	Pinal County

Figure 3.14 Zonal Systems used in the Estimation of Expansion Weights



3.3.3 Mapping between MAZ and Census Tract/Block Group

Since MAG SE data and ACS SF data are based on different geographic boundary systems (TAZ/MAZ vs Census Tract/Block Group), a geographic correspondence was established between these spatial datasets. To obtain the correspondence, GIS software was used to execute the following three steps:

1. Generate the centroids of the MAZ/TAZ boundary shapefile
2. Overlay the MAZ/TAZ centroid shapefile with the Census Tract/Block Group boundary shapefile
3. Match MAZs/TAZs to the Census Tract/Block Group based on the Census Tract/Block Group in which the MAZ/TAZ centroid falls

The correspondence obtained from the steps above was used to aggregate MAG socio-economic data to the Census Tract/Block Group and Meta level of geography.

3.3.4 Control Variables

The sample expansion and weighting process aims to compute weights so that the weighted sample has the same distributions as the regional population for a number of variables of interest considered important from a transportation modeling and analysis perspective. One of the key requirements for the weighting process is that the weighted sample should replicate the population with respect to the *joint distributions* on a number of control variables. The control variables selected for the weighting process must be done with care. On one hand, there is a desire to match the sample against the population for a large number of variables. On the other hand, the use of a large number of control variables may create a problem of dimensionality wherein the joint distribution table across all variables of interest may be so large that many cells in the joint distribution matrix may simply have zero survey sample households or persons. When there are zero survey samples in the joint distribution table, it is possible to be less converged as it executes the survey weighting process (because there are no households in the cell to be weighted). In other words, the control variables and the categories should be chosen such that there is at least one survey sample in each of the cells of the joint distribution (except for infeasible cells). An iterative process was executed to settle on the final set of control variables and categories at each of the District and Meta (region or County) levels of geography.

Table 3.5 presents a list of household variables used in the HTS weighting procedure to match control data distributions at the District level. All household-level control variables are controlled at the District level. Household income is controlled as a five category variable with different income groups between Maricopa and Pinal counties. Household income categories are divided by quintile for the number of households for each County. That is, the cuts of five income groups for Maricopa County are \$25K, \$45K, \$75K and \$100K. But, \$25K, \$45K, \$60K and \$100K are used to cut income groups for Pinal County. In addition to household income, four household level variables are adopted in this estimation of expansion weights such as total number of households, number of workers in household, household size and auto-ownership in household (see Table 3.5).

Table 3.5 Household-level Control Variables

Geographical Level	Variable Name	Category	County	Data Source for Control
District	Total # of Households	1 = Resident Household	Both Counties	MAG SE 2017
	Household Income	1 = "< \$25K", 2 = "≥ \$25K & < \$45K", 3 = "≥ \$45K & < \$75K", 4 = "≥ \$75K & < \$125K", 5 = "≥ \$125K"	Maricopa Only	ACS 2012-16 5-Year
	Household Income	1 = "< \$25K", 2 = "≥ \$25K & < \$45K", 3 = "≥ \$45K & < \$60K", 4 = "≥ \$60K & < \$100K", 5 = "≥ \$100K"	Pinal Only	ACS 2012-16 5-Year
	Household Workers	0 = No workers in household, 1 = 1 worker in household , 2 = 2 or more workers in household	Both Counties	MAG SE 2017
	Household Size	1 = 1 person, 2 = 2 persons, 3 = 3 persons, 4 = 4 or more persons	Both Counties	MAG SE 2017
	# Vehicles	0 = 0 vehicle in household , 1 = 1 or more vehicles in household	Both Counties	ACS 2012-16 5-Year

Table 3.6 shows one trip level variable used in the sample weighting procedure to match an observed transit trip distribution at the Meta (region or County) level. Since any variable at the trip level had been concerned in the previous expansion weights process, the trend of trips was not properly represented for the previous weighted household travel survey data. However, in an advanced travel demand model such as Activity-based model, accurate trip patterns (especially transit trips) is important. Therefore, a transit trip variable is added in this process of HTS expansion weights. This variable is with two category values such as Bus and Light Rail that are major transit modes in MAG model region. However, no person level variables are considered in this process because of household sample limitations.

Table 3.6 Person-level Control Variables

Geographical Level	Variable Name	Category	County	Data Source for Control
Meta (Region)	Transit Trips	1 = Bus, 2 = Light Rail	Both Counties	2015 On-board Survey

3.3.5 Preparation of Marginal Control Distribution Data

The number of households are available at the MAZ level from MAG Socio-economic (MAG SE) data. Using the geographic correspondence files, the MAZ level data was aggregated to the level of the District and Meta. Thus it was possible to derive the total number of households at the District and Meta levels of geography.

The MAG socio-economic (SE) data is for 2017 while the ACS datasets are based on 2012-2016 estimates. In order to ensure consistency between the different points in time, the ACS data was adjusted to match 2017 MAG SE data. The steps followed to achieve this include:

1. Compute scale factors for all Districts. Table 3.7 shows the computation of scale factors to match ACS data to the 2017 MAG SE data.
2. Apply the factors to the ACS data for the different control variables. Note, that no specific adjustment factors are needed at the Meta level because the aggregation of the District data provides Meta-level estimates.

Table 3.8 shows an example where the household income control in the original 2012-16 ACS is adjusted using the scale factor to match the 2017 MAG SE data. In the example, the last three columns depict the final marginal control data for household income at the District level. These adjusted values are computed by multiplying actual ACS data in the first three columns of the table by scale factors. Similarly, the control data for household vehicle count at the household level, and number of transit trips at the trip level, were adjusted to match with MAG SE data and On-board data.

Table 3.7 Scale Factors for Matching ACS data to MAG Socio-economic Data

District/Meta	MAG SE Data 2017 (Column A)	ACS 2012-2016 (Column B)	Scale Factors
Households			
1	93,752	88,242	Column A / Column B = 1.0624
2	136,505	133,085	1.0257
3	12,617	11,063	1.1405
4	83,851	72,982	1.1489
5	100,481	89,380	1.1242
6	73,208	68,921	1.0622
7	75,806	76,613	0.9895
Transit Trips			
1	171,109	164,439	0.9610

Table 3.8 Example Showing the Adjustment of the 2012-16 ACS Data on Household Income Distribution to Match the 2017 MAG SE data

District	2012-16 ACS Data Income 1	2012-16 ACS Data Income 2	2012-16 ACS Data Income 3	Scale factors	Adjusted ACS Data Income 1	Adjusted ACS Data Income 2	Adjusted ACS Data Income 3
1	10,335	12,008	14,994	1.0624	10,980	12,758	15,930
2	34,405	31,872	31,459	1.0257	35,289	32,691	32,267
3	1,150	1,356	1,845	1.1405	1,312	1,546	2,104
4	6,015	8,723	15,521	1.1489	6,911	10,022	17,832
5	11,380	13,486	20,466	1.1242	12,793	15,161	23,008
6	18,156	13,499	15,482	1.0622	19,285	14,339	16,445
7	27,625	21,070	17,341	0.9895	27,334	20,848	17,158

3.3.6 Algorithms to Estimate the Expansion Weight

PopSyn developed by Vovsha et al (2014) is used to compute expansion weights for the HTS samples. It consists of two main algorithms such as: List Balancing and Meta-balancing procedures. The List Balancing procedure can handle any number of household-level and trip-level controls at different levels of geography. It is also flexible to specify differential importance weights reflecting relative importance and reliability of controls. The List Balancing procedure can be written as a convex entropy-maximization problem where household weights $\{X[n]\}$ are optimized in the following way:

$$\min_{\{x_n\}} \sum_n X[n] \times \ln \frac{X[n]}{w[n]} + \sum_t \mu[i] \times z[i] \times \ln z[i]$$

Subject to constraints:

- (1) $\sum_n a[i][n] \times X[n] = A[i] \times z[i]$,
- (2) $X[n] \geq 0$,
- (3) $z[i] \geq 0$,

where:

- $n \in N$ = seed set of households in the HTS in District level
- $i = 1, \dots, I$ = Household and Trip controls
- $a[n][i]$ = household attributes, i.e. coefficients of contribution to each control
- $z[i]$ = relaxation factors
- $A[i]$ = values of controls to be met
- $\mu[i]$ = control importance weights
- $w[n]$ = initial weights
- $X[n]$ = final weights

The second algorithm is called Meta-balancing procedure. The initial weights for regional variables (i.e. Meta level such as county or entire model area) are not close to the marginal data at the lower geographical level

(i.e. Districts). Therefore, PopSyn needs a step to match the weights to the marginal data at District level. The procedure of Meta-balancing is the follows:

- 1) Balancing for each District without meta-controls to obtain a fractional balancing solution if $X[n][t] \geq 0$
- 2) Calculate current values for region-level controls by District using an equation: $(z[i][t] = \sum_n X[n][t] \times a[n][i])$
- 3) Calculate current totals for meta-control variables at District level using an equation: $(Z[i] = \sum_t z[i][t])$
- 4) Distribute regional Meta controls by District using an equation: $(w[i][t] = z[i][t] \times A[i]/Z[i])$
- 5) New round of balancing

where:

- $n \in N$ = Unique index of HTS household samples across all Districts
- $t = 1, \dots, T$ = Districts in the region
- $i = 1, \dots, I$ = Meta-controls
- $X[n][t]$ = Household weight in each District
- $a[n][i]$ = Coefficients for n^{th} household contribution with respect to i^{th} meta-controls
- $z[i][t]$ = Coefficients for each household contribution with respect to meta-controls
- $w[i][t]$ = Values of meta-controls by Districts
- $A[i]$ = Values of controls to be met
- $Z[i]$ = Totals for meta-controls

After processing List Balancing and Meta-balancing procedures, we obtain the HTS household sample weights as real numbers. Complete details of the PopSyn methodology could be found in Vovsha et al (2014).

3.3.7 Results of Expansion and Weighting Process

Table 3.9 shows comparisons of HTS weighted distributions with marginal control distributions for both Maricopa and Pinal County. All variables in Table 3.9 were used in the HTS expansion weight estimation process as control distributions at either Meta (Region) or District level. The results depicted in Table 3.9 shows that the HTS weight estimation process yielded a weighted survey sample whose characteristics closely replicate marginal control distributions across all control variables for both Maricopa and Pinal Counties. In general, the difference between the weighted survey sample distributions and the control distributions are very small. However, the category of zero vehicle household is shown a difference of 6.7% from the marginal control value although this category is controlled in the expansion process. This is caused from missing samples for zero vehicle households in a couple of districts. Note that there are just two category values (0 and 1+ autos) for household vehicle count and three category values (0, 1, and 2+ workers) for household worker count controlled in this expansion weight process because of household sample limitations.

Table 3.9 Comparison of HTS Weighted Distributions with Marginal Control Distributions for Control Variables Only for Maricopa County

Variable Name	Variable Category	Marginal Control	HTS Estimated Weight	Difference	Percent Difference
Household Variables					
Household Size	1	444,241	444,645	-404	-0.1%
	2	541,743	541,778	-35	0.0%
	3	269,777	269,735	42	0.0%
	4	446,333	445,936	397	0.1%
Household Vehicle Count	0	107,872	100,689	7183	6.7%
	1+	1,594,218	1,601,405	-7187	-0.5%
Household Income	1	350,949	349,077	1872	0.5%
	2	339,686	340,019	-333	-0.1%
	3	373,715	374,069	-354	-0.1%
	4	366,775	367,489	-714	-0.2%
	5	270,964	271,441	-477	-0.2%
Household Worker Count	0	434,641	435,004	-363	-0.1%
	1	685,326	686,678	-1352	-0.2%
	2+	582,124	580,412	1712	0.3%

Table 3.10 presents a comparison of distributions between the weighted household travel survey sample and the 2012-2016 ACS 5-year summary file data (for both counties). This comparison was done for four different variables:

- Household size (7 categories)
- Householder race (4 categories)
- Vehicle count in household (5 categories)
- Vehicle deficiency/sufficiency (3 categories)

It should be noted that the actual weight estimation process treated some of these variables as controls, but with different category definitions. For example, household size is a control in the survey weighting and expansion process executed in this effort, but the variable was defined as a four-category variable when executing PopSyn. Also, Household vehicle ownership was treated with two category values (zero vehicles vs one or more vehicles). The variable of householder race with four categories is not included as a control variable in the estimation process. Thus the comparison presented in Table 3.10 is a more robust test of the quality of the survey weighting process. It is very encouraging to see that the weighted survey sample and the ACS summary file data depict very similar patterns. The distributions in the weighted HTS sample and the ACS summary file data are very close for all four variables considered in the comparison. The largest percent difference is just 3.6%, corresponding to householder race (in other race category). Although all four

variables were only partially controlled or completely uncontrolled in the HTS expansion weight estimation process, the results of the expansion weight estimation shows a very close match between the weighted survey sample and the 2012-2016 ACS SF data.

Table 3.10 Comparison of Distributions between Weighted Survey Sample and 2012-2016 ACS Summary File Data

Variable Name	Variable Category	ACS SF 2012-16 (N=1,596,641)	Weighted HTS Sample (N=1,702,094)	Percent Difference
Household Size	1	26.5%	26.1%	0.3%
	2	33.6%	31.8%	1.8%
	3	14.7%	15.8%	-1.1%
	4	12.8%	15.1%	-2.2%
	5	6.9%	7.0%	-0.1%
	6	3.2%	2.8%	0.4%
	7+	2.2%	1.3%	0.9%
Householder Race	White	83.2%	80.9%	2.3%
	Asian	3.3%	2.6%	0.7%
	Black or African American	5.1%	4.5%	0.6%
	Other	8.4%	12.0%	-3.6%
Household Vehicle Count	0	6.4%	5.9%	0.5%
	1	37.5%	37.3%	0.2%
	2	38.9%	40.1%	-1.1%
	3	12.5%	11.7%	0.7%
	4+	4.7%	5.0%	-0.3%
Vehicle Sufficiency or Deficiency in Household	Zero Vehicle	6.4%	5.5%	0.9%
	Deficiency	4.9%	4.0%	0.9%
	Sufficiency	88.7%	90.5%	-1.8%

While Table 3.9 through Table 3.10 present comparisons of univariate distributions (weighted sample distributions versus either control distributions or 2012-2016 ACS SF distributions), Table 3.11 shows comparisons for a bivariate distribution defined by number of workers in the household and household vehicle ownership. The ACS provides a number of bivariate distributions that may be used to test the validity of the survey weighting process. The bivariate distribution of workers and vehicle ownership considers two key dimensions of much interest to transport modelers, therefore, this bivariate distribution is used for validation of the survey weighting process. In the result of the expansion weight estimation, there is no relative difference over 2.0% across all categories or cells of the bivariate distribution (see Table 3.10). Overall, it can be concluded that the bivariate distributions show very similar patterns between the weighted survey sample and the 2012-2016 ACS SF data for both Maricopa and Pinal County.

Table 3.11 Comparison of Bivariate Distribution of Household Workers by Vehicle Ownership between 2012-2016 ACS Summary File Data and Weighted HTS Sample

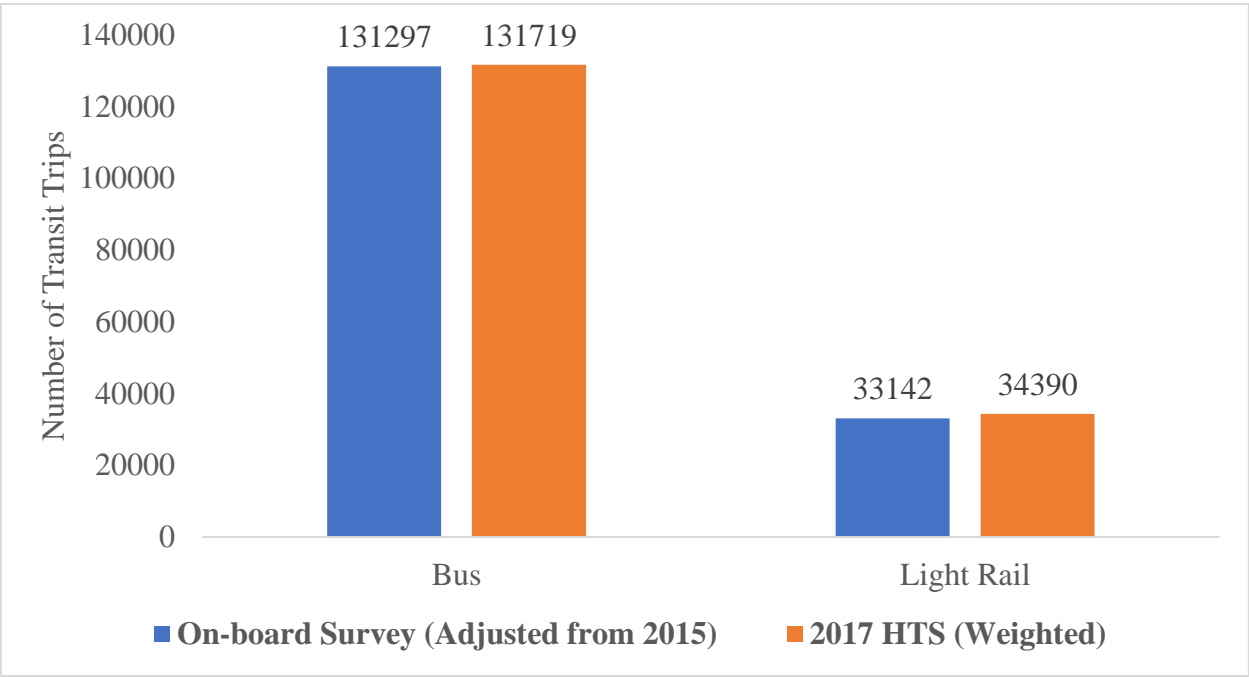
Number of Workers	Vehicle Ownership	ACS SF 2016 (N=1,596,641)	Weighted HTS Sample (N=1,702,094)	Percent Difference
0 Workers	No Vehicle	3.8%	3.7%	0.1%
	1 Vehicle	14.7%	13.1%	1.6%
	2 Vehicles	6.8%	7.0%	-0.2%
	3+ Vehicles	1.4%	1.8%	-0.3%
1 Worker	No Vehicle	2.1%	2.2%	-0.1%
	1 Vehicle	19.3%	21.3%	-2.0%
	2 Vehicles	14.1%	13.5%	0.6%
	3+ Vehicles	4.2%	3.4%	0.8%
2 Workers	No Vehicle	0.5%	0.0%	0.4%
	1 Vehicle	3.2%	2.8%	0.4%
	2 Vehicles	16.7%	18.4%	-1.6%
	3+ Vehicles	7.0%	6.5%	0.6%
3+ Workers	No Vehicle	0.1%	0.0%	0.1%
	1 Vehicle	0.3%	0.1%	0.2%
	2 Vehicles	1.3%	1.2%	0.1%
	3+ Vehicles	4.5%	5.1%	-0.7%

3.3.8 Results of Expansion Weight in Trip Characteristics

The HTS Expansion weight process considers for not only household level variables but also a trip level variable of interest. Although trip level variables were interested in the previous estimation of expansion weight for 2009 NHTS data, only household level variables were included because of algorithm for expansion weight process was not advanced enough to cover multi geography levels. Therefore, it was not very well that the expansion weights in the previous survey data represent trip characteristics especially for transit trips because trip variables of interest were not included in the previous estimation process. The current version of PopSyn has enhanced to be able to estimate the expansion weight at both Meta-(county or region) and District-levels. It means that a trip variable can be included at the different geography level such as Meta-level.

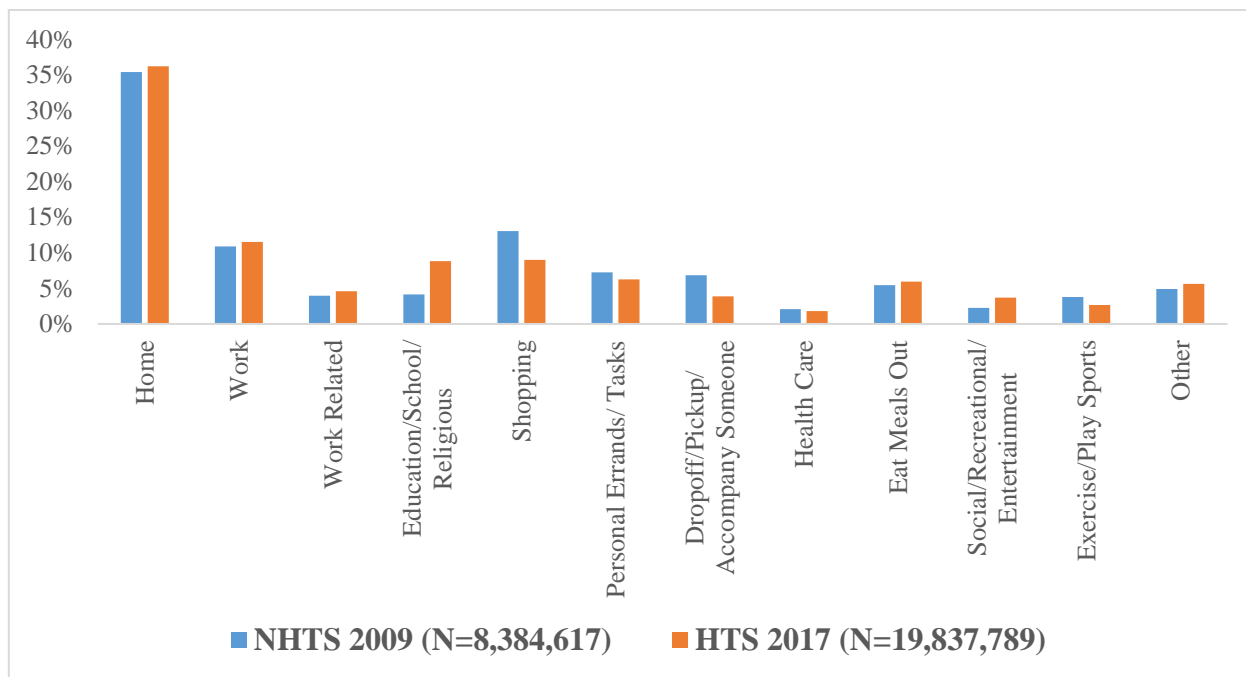
The number of transit trips with two category values (either bus or light rail) is controlled at the Meta-level (MAG model region). The target values for the variable are obtained from 2015 On-board Survey. Figure 3.15 shows a trip distribution by transit mode. The weighted HTS transit trips shows a good matching to the target.

Figure 3.15 Comparison of Trips by Transit Mode



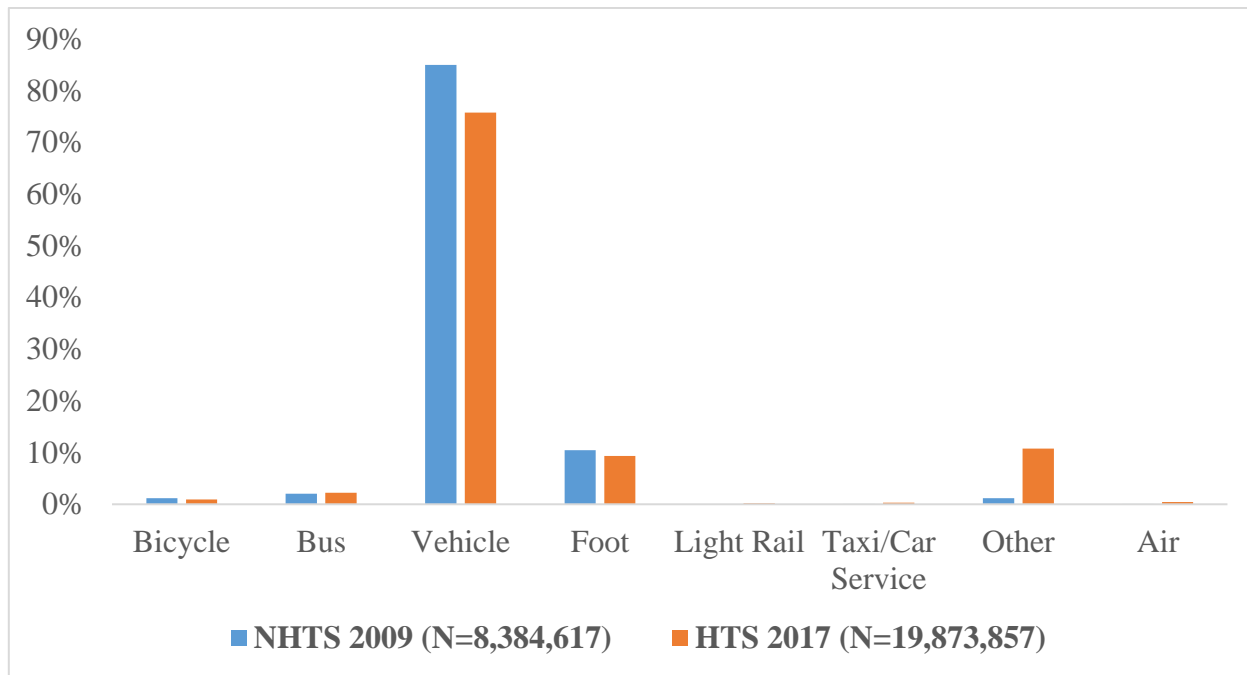
The household travel survey weighting procedure essentially weights the survey sample so that various socio-economic and demographic distributions of interest are closely matched between the weighted survey sample and the census or MAG socio-economic data. To further validate the weighting procedure, it is beneficial to compare travel characteristics between the weighted HTS and other sources of data such as the ACS or the 2008-2009 National Household Travel Survey (NHTS).

Figure 3.16 shows a comparison of trip distribution by trip purpose between the weighted 2008 - 2009 NHTS and the weighted HTS sample. The comparison controls for day of week by including only weekday travel data.

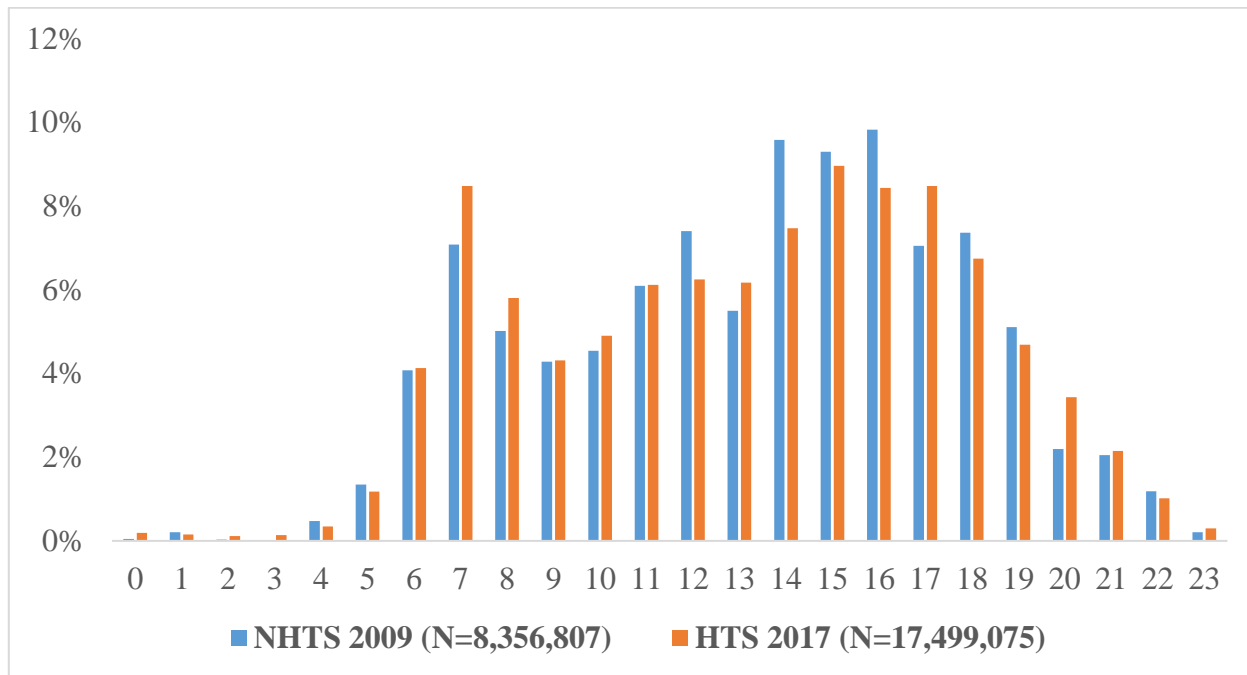
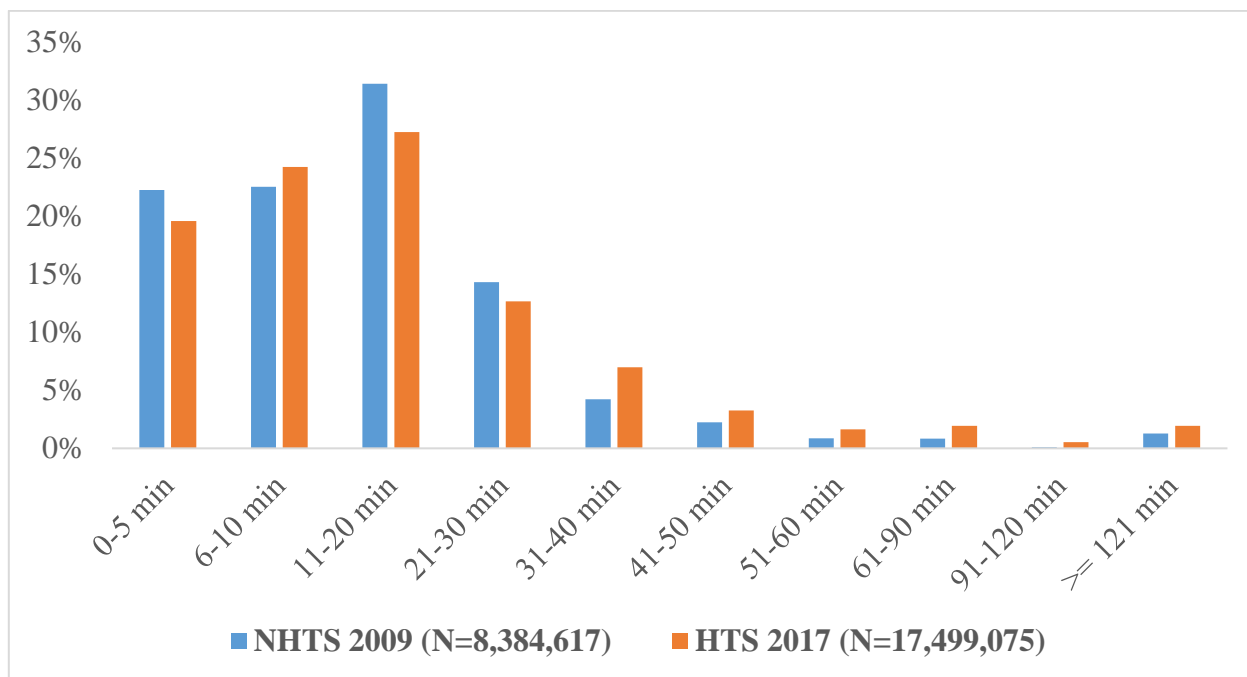
Figure 3.16 Comparison of Distribution of Trips by Purpose

It can be seen that there is a slight increase in the proportion of work and work-related trips. The percentages for all other trip purposes are fairly consistent between the two survey samples, although there is a drop in shopping (possibly due to more online shopping), drop-off/pick-up/accompany someone (possibly due to the dramatic growth of ride-hailing services that were non-existent in 2009), and an increase in school or school-related. There is also a growth in “other” trip purposes, suggesting that people may be engaging in more complex or technology-enabled activity types that are difficult to define or categorize into traditional trip purpose definitions. Overall, the weighted travel survey sample depicts a pattern that is consistent with expectations. The higher proportion of work and work-related trips is consistent with the notion that a smartphone app-based travel survey (such as that implemented in 2017) is likely to capture and track short work-related trips and service calls (made by service professionals or delivery personnel) more accurately. Such trips are likely to be missed in traditional travel survey protocols. A number of these service professionals were found to be present in the respondent sample of the 2017 HTS. Some of these individuals made many work-related service calls over the course of a day and the smartphone app captured all of these trips effectively.

Figure 3.17 shows a comparison of distributions of trips by transportation mode between the weighted HTS trip data and the NHTS 2009 data. The pattern of trip mode choice between the two survey datasets is virtually identical, with a slight increase in light rail share as expected. There is also a slight increase in bus usage and an associated drop in vehicle mode share. There is a significant increase in other mode observed in the HTS. It may be caused by an increase of scooter or skate board usage. However, we need to conduct a further investigation on other mode choice.

Figure 3.17 Comparison of Distribution of Trips by Transportation Mode

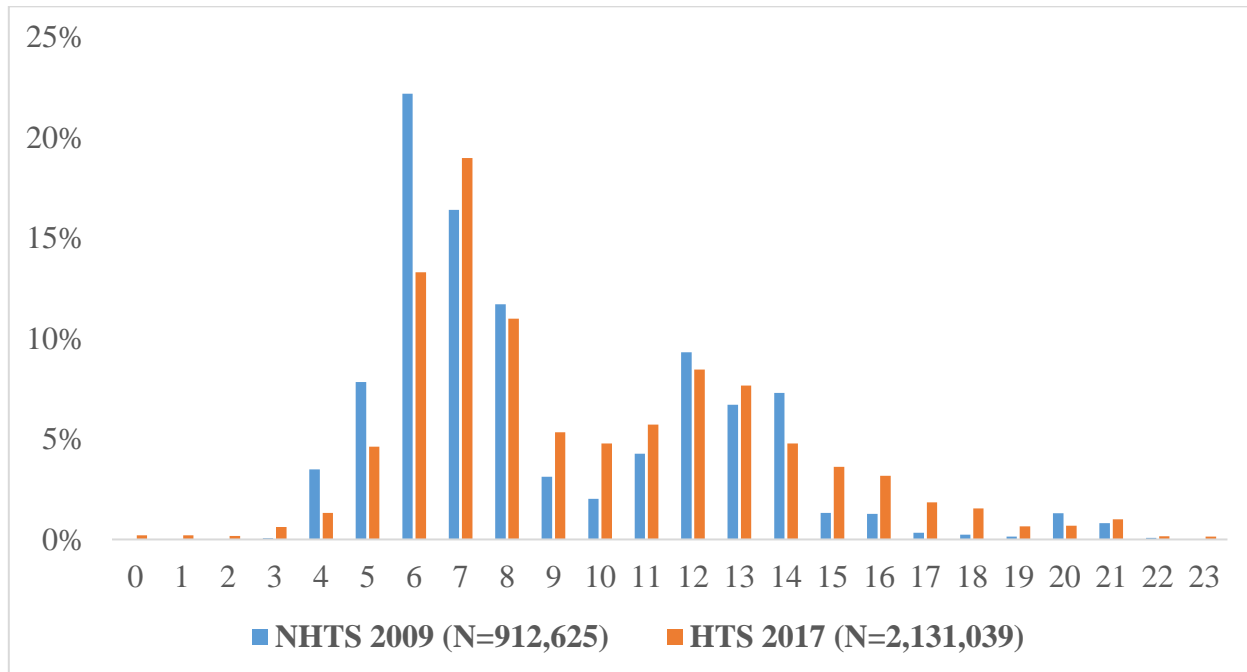
The time of day distribution of travel and trip length (minute) distribution for all trip purposes are shown in Figure 3.18 and Figure 3.19 respectively. Although there are some minor differences in the time-of-day distribution between the 2017 and 2008 survey data sets, the overall patterns are quite consistent between the two survey data sets. It appears that there is a shift in trip departure times towards the later evening hours between 2009 and 2017. It is not entirely clear as to why that would occur; it is possible that a recovering economy has spurred greater participation in activities in the evening hours (discretionary activities). It is also possible that there is an increase in the number of workers who are working late shifts (e.g., Uber/Lyft drivers working in the evening when there is higher demand and possibility of surge pricing). The shift in departure time choice warrants further investigation. Similarly, Figure 3.19 shows the distribution of trips by trip length. It can once again be seen that the weighted HTS sample depicts a trip length (minute) distribution that is quite consistent with that depicted in the weighted 2009 survey sample. There is a slight shift towards longer trip lengths in 2017, consistent with an economic recovery wherein individuals return to work, access (better) job opportunities farther away and engage leisure activities at more distant locations, compared to the times of economic downturn. In other words, it appears that there is a somewhat lower travel demand in 2009 survey data compared to the 2017 HTS data. In general, however, the patterns are quite similar and the small differences between the two survey years can be attributed to contextual/economic conditions, sample composition, and changing millennial behavior patterns (as they age).

Figure 3.18 Distribution by Trips by Time-of-Day*All Trip Purposes***Figure 3.19 Distribution of Trips by Trip Length***All Trip Purposes*

The time-of-day distribution of work travel (trip departure time) and the distribution of work trips by length (minutes) are shown in Figure 3.20 and Figure 3.21, respectively. More dramatic differences are observed between the 2009 survey sample and the 2017 HTS sample in the context of work trip departure time and

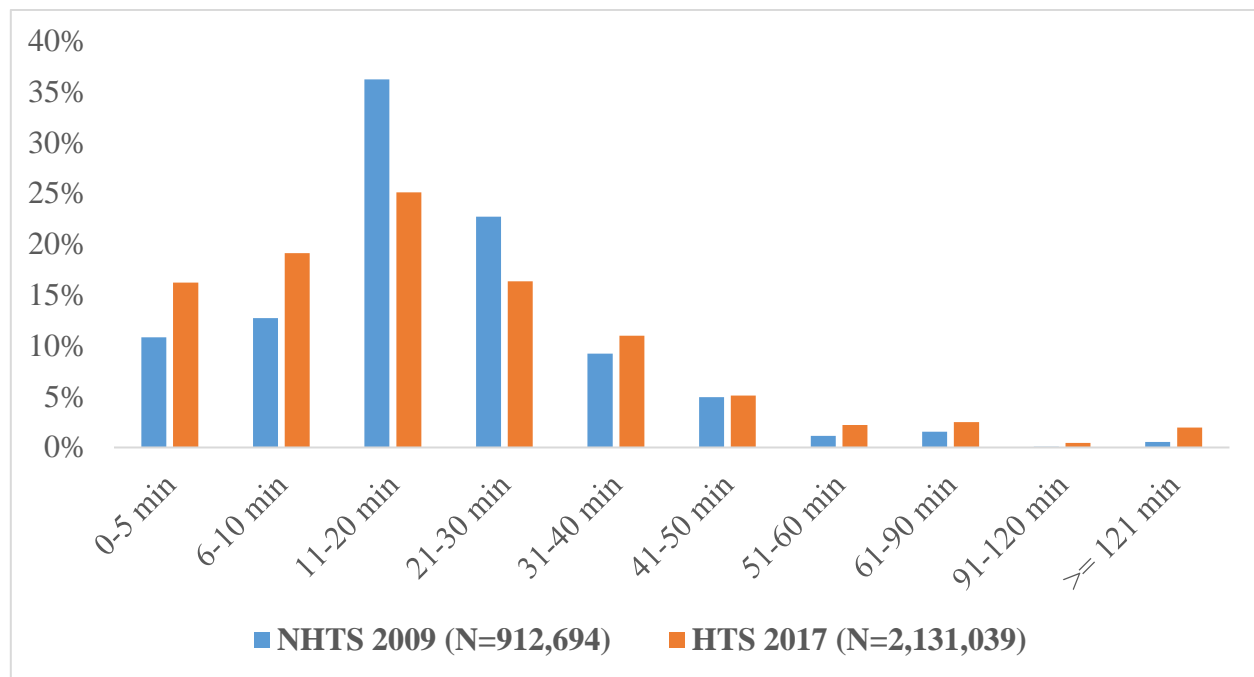
trip length distribution. In Figure 3.20, it is seen that the work trip departure time has shifted to later periods in the day in a very noticeable fashion when compared with the 2009 survey sample. It is not entirely clear as to why there is such a shift in time of day of work travel between 2009 and 2017. It is possible that the 2017 data is capturing work-related service calls that were entirely missed in the 2009 survey. These activities can happen throughout the day, including the afternoon and evening hours, thus rendering the 2017 distribution quite different from the 2009 distribution. It is also possible that the economic recovery may have motivated individuals to obtain second jobs and take advantage of the sharing economy. Part time job options such as (Uber/Lyft) might account for some of the increase in late afternoon and evening work trip departures.

Figure 3.20 Distribution by Work Trips by Time-of-Day



Finally, Figure 3.21 shows the distribution of work trips by trip length (in minutes). While the overall patterns are not very different between the two survey years, it is clear that the distribution in 2017 is shifted towards smaller trip lengths. There is a particularly noticeable increase in the very short trip range of 0-5 minutes and 6-10 minutes. Once again, it appears that the ability of the smartphone-app based travel survey to capture many short work trips associated with movements of employees within the establishment premises, service calls or home-based deliveries may be contributing to these differences. Additional investigation is necessary to fully identify the reasons for the increase in the proportion of work trips that are between 0-5 minutes and 6-10 minutes. The percent of work trips in very long trip duration bins (greater than 1 hour) also shows noticeable increases; the reason for this is not entirely clear and additional investigation of the data is warranted before definitive conclusions about changes in behavior can be made. In general, it is found that the weights do not necessarily change the nature of these graphs or distributions, suggesting that the weighting process is not dramatically shifting or changing activity-travel characteristics and associated distributions. Thus, differences, such as those seen in the graphs of this section of the chapter, may be attributed to real shifts in behavior or changes in survey administration and data collection protocols (technologies) as opposed to any weighting and expansion-related effects.

Figure 3.21 Distribution of Work Trips by Trip Length



Appendix A. Communication Materials

A.1 Press Releases

An initial press release announcing the project was distributed on July 25th, 2015.

Figure A.1 Initial Press Release



MAG to Undertake Innovative Household Travel Survey

PHOENIX (July 25, 2015) –The Maricopa Association of Governments (MAG) is conducting the 2015 MAG Household Travel Survey to understand the travel behavior of Valley residents in Maricopa, Pinal, and portions of Yavapai and Gila counties. Residents who choose to participate will be asked to provide details of the travel patterns of those living in the household.

The survey is an important component in the regional transportation planning process. Information from the survey is used to understand commute patterns and other aspects of travel behavior in the region, which helps transportation planners determine where new roads or improvements may be needed in the future. The last travel survey was conducted in 2008. An update is required to provide data on the travel choices, preferences, and needs of the public.

Starting in the summer of 2015 and through the spring of 2016, advance letters for the MAG Household Travel Survey will be sent to randomly selected households asking residents to go online and answer survey questions. Respondents will be offered a choice of survey methods, including a specially-designed GPS device and a smart phone application. The use of a smartphone application to collect household travel information will be the first of its kind in the nation and will reduce the burden on respondents while increasing the accuracy of the information received.

About one in 200 Valley households will be surveyed. Each selected household will represent hundreds of other households in the area, so participation, while completely voluntary, is very important for the overall success of the survey.

MAG has contracted with Abt SRBI, WestGroup Research, and Mobile Market Monitor to coordinate data collection, including the surveys hosted on MAGtravelsurvey.org, phone and mail contact with area households, and smartphone application and GPS device deployment.

Residents wishing to learn more about the survey may visit the project page at: azmag.gov/travelsurvey or the survey website at: MAGtravelsurvey.org

###

A second press release in support of the project was published August 8th, 2016:

Figure A.2 Second Press Release

MAG Launches App-Based Household Travel Survey

FOR IMMEDIATE RELEASE

CONTACT: Kelly Taft
Communications Manager
(602) 254-6300

PHOENIX (August 8, 2016) —Where are you headed today? This simple question is an important one for the Maricopa Association of Governments (MAG). The agency is seeking 14,000 people to join the 2016 MAG Household Travel Survey. This app-based household travel survey is one of the first of its kind in the nation using a smartphone app to reduce the burden on respondents while increasing the accuracy of the information received.

Current travel data helps planners improve "livability" in the Phoenix region by understanding the travel patterns of Valley drivers, bike riders, transit users and pedestrians in Maricopa, Pinal, and portions of Yavapai and Gila counties. MAG's Travel Survey is so important that participants are compensated for completing the survey. Since the last survey took place in 2008, the region has grown tremendously. Several new transportation modes, such as light rail and RAPID bus service are in place that have changed how we travel. A formal evaluation of the transportation needs of area residents helps state and local officials make decisions to improve roads, reduce congestion, improve walking and bike paths, and improve public transportation.

Respondents will download a free application on their smartphone. The app logs data on where participants go over two days. Later, respondents will confirm, add to, and submit their information online.

Residents wishing to participate or learn more about the survey may visit: MAGtravelsurvey.org.

###

A.2 List of Champions

Table A.1 List of Champions

City/Organization	Contact's Title (If Available)
AAA Arizona	Public Affairs Specialist
Apache Junction	PIO
ASU	Associate Vice President
Avondale	Director
Buckeye	Marketing & Com Manager
Carefree	Town Manager
Casa Grande	PIO
Cave Creek	Town Clerk
Chandler	PIO
Chicanos Por La Causa	Public Affairs Director
City of Maricopa	Asst. to the City Manager/PIO
Downtown Chandler	
El Mirage	Intergovernmental Representative
Florence	Intergovernmental Representative
Fort McDowell Yavapai Nation	Intergovernmental Representative
Fountain Hills	PIO
Friendly House	Director of Community Affairs
Gila Bend	Town Clerk
Gila River Indian Community	Director of Communications and Public Affairs
Gila River Indian Community	Intergovernmental Representative
Gilbert	Media & Community Relations Administrator
Glendale	Intergovernmental Representative
Goodyear	Communications & Marketing Manager
Greater Phoenix Chamber	Communications Manager
La Raza Development Corporation	Community Wellness Specialist
League of Arizona Cities and Towns	Communications & Education Assistant
Litchfield Park	Intergovernmental Representative
Maricopa County	Digital Program Manager
Maricopa County	PIO
Maricopa County Air Quality	Communication Officer
Maricopa County Board of Supervisors	Communications Director
Maricopa County Office of Communications	
Maricopa County Transportation	PIO
Mesa	PIO

City/Organization	Contact's Title (If Available)
Mesa	PI & Communication Specialist
Peoria	Director of Communications & Public Affairs
Phoenix	Streets, Arts & Culture-PIO
Phoenix	Transit
Phoenix	PIO
Phoenix	Parks and Rec-PIO
Phoenix Indian Center	Executive Director
Pinal County	Town Manager
Queen Creek	Dir of Comm., Mrktng. and Recreation
Salt River Pima-Maricopa Indian Community	Gov. Affairs Officer
Scottsdale	PIO - Transportation
Surprise	PIO
Surprise	PIO
Tempe	PIO Public Works/Water
Tempe	PIO Transit
Tempe Downtown Association	President/CEO
Tolleson	Public Affairs Administrator
Town of Guadalupe	Interim Town Manager
Town of Paradise Valley	Town Clerk
Valley Metro	Communications Manager
Wickenburg	Town Manager
Youngtown	Public Safety Manager
Youngtown	Town Manager

A.3 Email to Champions

Figure A.3 Email to Project Champions



Dear Champion:

Thank you, in advance, for helping us get the word out about the MAG Household Travel Survey. As you know, it is crucial for us to obtain information about regional travel patterns.

This is the first in a series of three monthly requests. **The posts contained herein are for publication between: Monday, August 8 – Friday, August 12.**

Helping is as easy as taking these two steps:

1. Please publish any of the attached messages via your **Facebook, NextDoor, Twitter, community or council newsletters, email lists or website** to help us get as much participation in the survey as possible.
2. After you've published, posted, or sent a message – please fill out the attached tracking form and send it back to me. Feel free to leave the information posted.

Next month new messages will be sent that you can use to refresh these messages. Feedback is always welcome. We're looking for the best ways to engage your subscribers.

If at any time you need help with a post or graphic, please let me know.

Thank you again,

The MAG Travel Survey Team

A.4 Social Media Communications

Figure A.4 Sample of Messaging Provided to Champions

MAG Household Travel Survey Messages – August 2016

Social Media Posts

Facebook:



WHERE ARE WE GOING?

MAGTravelSurvey.org

Message 1: Just like the pets you often take along, we're curious to know where you're going. Sign up and share your travel info to help us make your future travel experience better. MAGTravelSurvey.org/FB

Message 2: Answer a few quick questions today to qualify for the MAG Household Travel Survey. We'll give you \$10 per participant for completing the survey. You'll be helping improve the future of transportation in the Valley. MAGTravelSurvey.org/FB

NextDoor:



WHERE ARE WE GOING?

MAGTravelSurvey.org

Message 1: Just like the pets you often take along, we're curious to know where you're going. Sign up and share your travel info to help us make your future travel experience better. MAGTravelSurvey.org/ND

Message 2: Answer a few quick questions today to qualify for the MAG Household Travel Survey. We'll give you \$10 per participant for completing the survey. You'll be helping improve the future of transportation in the Valley. MAGTravelSurvey.org/ND

Figure A.5 Additional Messaging Provided to Champions

Emailed Newsletter Articles



Message 1: Your BFFs (Best Furry Friends) aren't the only ones who want to know where you're going. So do we! The Maricopa Association of Governments (MAG) hopes to make your future trips better by finding out how you travel. We'll make it easy by providing an app you can download right to your smart phone! Whether you are driving to work, taking kids to school, going on a date, walking your dog, biking, or taking transit, your travel information is **important** info we need to plan for our region's future transportation needs. Participants will be paid for completing the survey while also contributing to a better future for us all. www.MAGTravelStudy.org/EM

Message 2: Frustrated by traffic? Want a better biking or transit experience? Sign up for a two-day travel survey and tell the Maricopa Association of Governments (MAG) a little about your travel so we can help make your trips better. First, we need to understand how people use the region's transportation network to develop solutions for the future! Download the app to share your info and earn \$10 per household member 6 years and older. www.MAGTravelStudy.org/EM

Printed Newsletter Articles



Message 1: Your BFFs (Best Furry Friends) aren't the only ones who want to know where you're going. So do we! The Maricopa Association of Governments (MAG) hopes to make your future trips better by learning more about how you travel in the Valley. We'll make it easy by providing an app you can download right to your smart phone! Whether you are driving to work, taking kids to school, going on a date, walking your dog, biking, or taking transit, your travel information is **important** info we need to plan for our region's future transportation needs. Participants will be compensated for their time while contributing to a better future for us all. www.MAGTravelStudy.org/N

Message 2: Frustrated by traffic? Want a better biking or transit experience? Sign up for a two-day travel survey and tell the Maricopa Association of Governments (MAG) a little about your travel. We're working to make your trips better. But first, we need to understand how people use the region's transportation network to develop solutions for the future! Download the app to share your info and earn \$10 per household member 6 years of age and older. www.MAGTravelStudy.org/N

In addition to the electronic media promoted by GCI staff, printable English and Spanish fact sheets highlighting the key elements of survey and opportunity to participate were provided for use at events and distribute as appropriate. The same graphic was resized to be used as an 11" X 17" printable poster in PDF format which was emailed to Champions with the ability to post in high traffic areas.

Info sheets and flyers were created to be used with existing mailing lists for email distribution. The info sheet was sent to champions with a request to send it to their mailing lists. MAG sent the info sheet via the agency's eGov Delivery account. The info sheet featured the same images that were used as English and

Spanish info sheets. The only difference was that the image was embedded into the body of email messages. The info sheets are shown in Figure A.6 and Figure A.7.

Figure A.6 Project Infographic

English

*WHERE DO YOU GO?
HOW DO YOU GET THERE?*

WE'RE CURIOUS BECAUSE...
YOUR travel information is the key to creating a useful, convenient transportation network that meets everyone's needs! Whether you commute to work by car or public transit, drive kids to school, travel very little, or bike everywhere - WE NEED YOU!

JOIN THE HOUSEHOLD TRAVEL SURVEY
Answer a few quick questions at
MAGTravelSurvey.org/p
After answering our survey you will be directed to our mobile app.

\$10
for each person
in your household
(age 6 and up)!

WHO ARE WE?
The Maricopa Association of Governments (MAG) works closely with all the jurisdictions in the Valley to plan and build our regional transportation system, including freeways, streets, bus and rail, bike trails and sidewalks. That's why it is important for us to have the best information possible about what projects are most needed or wanted.



WHERE ARE WE GOING?
MAGTravelSurvey.org

Need more information? Contact us:
MagTravelSurvey@AskArizona.com
602-707-0085

Figure A.7 Project Infographic
Spanish



**¿A DONDE VAS?
¿Y CÒMO SE LLEGA ALLÍ?**

TENEMOS CURISIDAD PORQUE...

Su información de viaje es la clave para crear un útil y conveniente red de transportación que satisfice las necesidades de todos. Ya sea si manejas o tomás transportación pública, llevas a tus hijos al escuela, viajas muy poco o usas una bicicleta para todos lados - ¡TE NECESITAMOS!

ÚNASE A LA ENCUESTA HOY
Conteste unas preguntas en
MAGTravelSurvey.org/f
Después de contestar estará se conectara a una aplicación para continuar

\$10
por cada persona en su hogar (mayor de 6 años) que complete su registro de transporte!

¿ QUIEN SOMOS?


La Asociación de Gobiernos Maricopa (MAG) trabaja muy de cerca con las jurisdicciones en el valle para planear y construir nuestro sistema de transportación regional, incluyendo autopistas, calles, camiones y tren ligero, rutas para las bicicletas y banquetas. Por eso es importante que tengamos la mejor información posible sobre cuáles proyectos son más necesitados y queridos.



WHERE ARE WE GOING?
MAGTravelSurvey.org

¿Necesita mas infomacion?
Contàctenos a **MagTravelSurvey@**
AskArizona.com
602-707-0085

A.4.1 Examples of Social Media Posts by Champions

Rio Salado College November 10, 2016 ·  Like Page

Your BFFs (Best Furry Friends) aren't the only ones who want to know where you're going!

The Maricopa Association of Governments (MAG) hopes to make your future trips better by learning more about how you travel in the Valley.

Whether you're driving to work, taking kids to school, going on a date, walking your dog, biking or taking transit-- your travel information is important info MAG needs to plan for our region's future transportation needs.

Take the survey now at MAGTravelSurvey.org/TW and get \$10 for your participation!

Participants will be compensated for their time while contributing to a better future for everyone in the Valley.

The Maricopa Association of Governments is a Council of Governments (COG) and the designated Metropolitan Planning Organization (MPO) for regional planning in the Maricopa region. Learn more at www.azmag.gov.

#MAGTravelSurvey #mcccd



City of Goodyear AZ Government January 9 ·  Like Page

For a LIMITED TIME ONLY – Get \$100 when your household completes our survey! Share your travel info to help us make your future travel experience better! #MAGTravelSurvey MAGTravelSurvey.org/FB

WHERE ARE WE GOING?
MAGTravelSurvey.org

Limited Time Offer!
\$100 per household that completes the survey!

magtravelsurvey.org
MAGTRAVELSURVEY.ORG

1  Like  Comment  Share


Phoenix Parks September 8, 2016 · Twitter · 

Retweeted MAG (@MAGregion):
Your pets wonder where you go-so do we! Log it & you'll get \$/better trip!
#MAGTravelSurvey <https://t.co/QfGVfjHBej> <https://t.co/KFQd3zEect>

WHERE ARE WE GOING?
MAGTravelSurvey.org

MAG (@MAGregion) posted a photo on Twitter
Get the whole picture - and other photos from MAG
PIC.TWITTER.COM/KFQD3ZEECT

 Share

This Could Be PHX September 19, 2016 ·  Like Page

Maricopa Associations of Governments has put out a travel survey to help determine how you get around. See below for more info.

Your trips to the dog park, work, the hospital and school are IMPORTANT to us! We need to know where you WANDER, walk, BIKE, bus, drive – how you travel around the Valley. Share your travel info to help us make your future travel experience better! We'll give you \$10 per participant for completing the survey.

#MAGTravelSurvey <http://MAGTravelSurvey.org/FB>

**WHERE DO YOU GO?
HOW DO YOU GET THERE?**

WE'RE CURIOUS BECAUSE...
YOUR travel information is the key to creating a useful, convenient transportation network that meets everyone's needs! Whether you commute to work by car or public transit, drive kids to school, travel very little, or bike everywhere - WE NEED YOU!

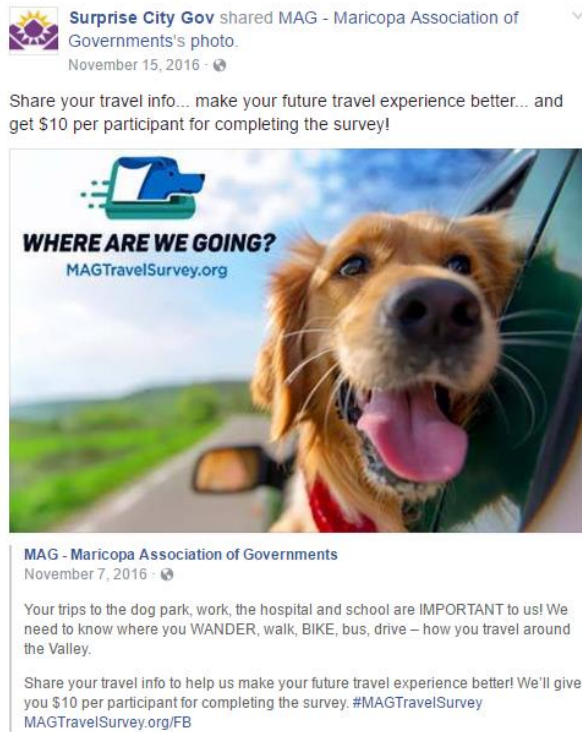
JOIN THE HOUSEHOLD TRAVEL SURVEY
Answer a few quick questions at MAGTravelSurvey.org/em
After answering our survey you will be directed to our mobile app.

\$10
for each person in your household (age 6 and up!)

WHO ARE WE?
The Maricopa Association of Governments (MAG) works closely with all the jurisdictions in the Valley to plan and build our regional transportation system, including freeways, streets, bus and rail, bike trails and sidewalks. That's why it is important for us to have the best information possible about what projects are most needed or wanted.

WHERE ARE WE GOING?
MAGTravelSurvey.org

Need more information? Contact us:
MagTravelSurvey@AskArizona.com
602-707-0085



A.5 Website

The survey website home page, as shown in Figure A.8, includes the website banner along with simple text and graphic content explaining the who, what, when, where and why of the survey. A prominent “Start Here” opt-in link was highlighted at the center of the page so users can choose to apply to participate right away; however, additional information was also visible for visitors who prefer to learn more before opting in. A “Verify” button was also available on the webpage for participants who were already recruited and were ready to move on to the next step of the study.

The other project pages include “About the Study” (see Figure A.9), “FAQs” (see Figure A.10), “APP”, “Privacy Policy” (see Figure A.11), and the ability to switch from English to Spanish.

Figure A.8 Survey Website Homepage



Figure A.9 Survey Website
About the Study Page



Welcome to the MAG Household Travel Survey

The Maricopa Association of Governments is sponsoring this study to improve "livability" in the Phoenix region. This travel survey will help regional planners understand how residents travel throughout the Phoenix region each day. A formal evaluation of the transportation needs of residents in your area helps state and local officials make decisions to improve roads, reduce congestion, improve walking and bike paths, and improve public transportation.

Participation is easy and voluntary—and all information collected is strictly confidential. Eligible households who successfully complete all requirements of the study will receive a small monetary incentive.

The first step is registering your household. Household registration is very easy and only requires about 10 to 15 minutes. The household registration survey collects information about your household and asks you to select a two-day travel period.

The second step is collecting and reporting your travel information. Participating households will be emailed detailed instructions on how to collect your travel via a GPS signal for the two selected days. There will also be directions on how to verify your travel through online travel and activity diaries for all members of your household age 6 and older. The GPS linked online travel diaries will aid you in reporting your locations, modes of transportation, activities at these locations, and time spent at these locations.

The information collected in this study is strictly confidential and secure. Data will be reported in combination with all participants for the sole purpose of regional transportation planning.

Figure A.10 Survey Website
FAQ Page



General Information

What is the MAG Household Travel Survey? -

Sponsored by the Maricopa Association of Governments, or MAG, the MAG Travel Survey is an in-depth study of the travel and activity patterns in Maricopa County and surrounding areas.

MAG is hoping to learn from 7,000 households where and how residents traveled over an assigned period of two days by having them collect GPS travel data for two days.

To make sure we hear from a representative sample of the region's population, households will be asked questions related to the characteristics of their household members and travel habits. This information will provide a picture of the daily travel routines of residents in Maricopa County and the surrounding area. Study findings will help transportation planners determine how to enhance public transportation in the area, improve roads, reduce traffic congestion, and improve walking and bicycle paths.

Who is sponsoring this survey? +

Who is conducting this survey? +

What will I be asked to do to participate in the travel survey? +

Why should I participate? +

Who is being asked to participate in the survey? +

What will MAG do with the data I provide? +

Who can I contact at MAG for more information? +

How long will you be conducting the study? +

Taking the Survey

Why do you need to know information about the household? +

How long will the survey take? +

What is meant by "travel" and "activities"? +

Why do you want to know about my activities? +

Why do you need to know when and where each activity took place? +

Why do you need to know my occupation or job? +

Why do you need to know when and where our children go to school? +

Will any of the information collected be useful for environmental purposes? +

Will information from the survey be available to the public? +

What if I don't feel comfortable answering some of the questions? +

What if out-of-the-ordinary events happen during my assigned travel days that change my travel? +

What if I travel out of the region during my assigned travel day? +

What if I don't drive a car? +

What if I don't travel very much or at all? +

Are there incentives for participating in the survey? +

Using the Smartphone App

How do I download/install the smartphone application? +

What does the Mobile Market Monitor app do? +

When should I carry my mobile phone? +

How long should I run the app during the survey period? +

Will the smartphone app affect my phone's battery? +

How can I avoid running out of battery? +

Can more than one user be registered or log in to the same account? +

Can the application be used on more than one device? +

Do I have to have a data plan to run the app? +

How much of my data plan will the application use? +

Why did my iPhone sign me out of the app? +

Is information about where I live and where I go linked to my name? +

Can you tell where I am all the time? +

Verifying your Travel

How do I verify my travel online? +

What if I have misplaced my materials? +

When can I first see my travel information from my Smartphone app online? +

Why doesn't the GPS travel information match the exact routes that I travelled? +

What if my travel information shows that I stopped at a location where I did not stop? +

What do I do if my travel information is missing travel and/or a stop is missing? +

What if I am having difficulty with the website (www.magtravelsurvey.org)? +

Need help? Lost your PIN? Email us at MagTravelSurvey@AskArizona.com, call us toll-free at 800-707-0005 or Chat With Us

Figure A.11 Survey Website
Privacy Policy Page



Welcome to the MAG Household Travel Survey

Sponsored by the Maricopa Association of Governments (MAG), this study is being undertaken as part of a larger travel study to improve transportation options in the Phoenix region.

All information you provide will be kept confidential and secure. Only WestGroup Research and MMM authorized researchers can see your information. To protect the privacy of all respondents, your data will be combined with all other responses and data will only be reported in aggregate form. Your name will never be used in any reports about the study. Your personal information will be not sold to any third party.

Understanding the opinions and behavior of people they are trying to serve helps business and government leaders make better, more efficient decisions.

Need help? Lost your PIN? email us at MagTravelSurvey@AskArizona.com, call us toll-free at 602-707-0085 or Chat With Us



A.6 Advertisements

None of the four advertising avenues evaluated/tested were successful. Each method yielded minimal or no response and only resulted in a total of six completes (5 from Valpak + 1 Facebook).

Platform	Date of Advertisement
Facebook	September 15-19, 2016
Instagram	October 6-12, 2016
Valpak	November 14-18, 2016 delivery in mailboxes, Online and in-app presence 11/14-12/14
ASU State Press Social Media Sharing	Facebook share/Retweet March 16, 2017 DeviLinks (shares all study posts on scrolling sidebar on ASU State Press website)

WestGroup Research placed Facebook and Instagram ads under their “Ask Arizona” brand to promote the study to a targeted audience with an estimated reach of 18,000 to 48,000 people on Facebook. The results were poor with very little engagement and a total of one complete.

Facebook/Instagram Target Audience:


- IOS and Android users only (mobile platform they use to access Facebook).
- Ages 18 to 64.
- Target 50/50 male/female.
- English language.
- Reside within 25 mile radius of Phoenix.

WestGroup placed a Valpak coupon-style ad for the November mailing to two geographic “zones” selected by MAG. Each zone contains 10,000 household for a total of 20,000 HTS coupon-style ads delivered to unique households. The special Valpak offer was the opportunity to use a special link to earn double the incentive (\$20 per person age 6+ vs. \$10). Only 8 households completed the full recruit and only 5 households successfully completed the study.

In an effort to promote the study to ASU students online, we tested the low-cost option of having the ASU State Press (university online newspaper) share one Facebook post and Retweet one Tweet about the study. Additionally, for two weeks the ASU State Press website would include all social media shares from our Facebook page on a scrolling sidebar on their page (along with all other advertisers). Ask Arizona posted about the study nearly every day for two weeks to leverage this exposure. There was no traceable traffic generated from these efforts.

A.6.1 Advertising Examples

Participate in the MAG Travel Survey to help make getting around the Valley easier!



WHERE ARE WE GOING?
MAGTravelSurvey.org/VP

We are all on the go... Sometimes with best friends in tow!

The Maricopa Association of Governments (MAG) works with local government to plan and build our regional transportation system, including freeways, streets, bus and rail, bike trails and sidewalks. Whether you commute to work by car or public transit, drive kids to school, travel very little or bike everywhere – WE NEED YOU!

Find out more: MAGTravelSurvey.org | 602-707-0085 | MAGTravelSurvey@AskArizona.com
All information is completely confidential. *Only those who complete all study requirements receive payment.


Easily share travel via smart phone app

► **Begin by answering a few questions at MAGTravelSurvey.org/VP**

GET PAID*
~~\$10~~ **\$20 per person**
in your home age 6+ when you complete study

Valpak Special – Get paid DOUBLE!*
To Get \$20 per person
Instead of only \$10,
you MUST SELECT VALPAK as how you heard about the survey when you register!

Para que sus viaje a través del valle sean mas fáciles, ¡Participe en la Encuesta de Traslados Familiares de la Asociación de Gobiernos de Maricopa (MAG).



WHERE ARE WE GOING?
MAGTravelSurvey.org/VP

Todos estamos en el camino... a veces con nuestros mejores amigos!

La Asociación de Gobiernos de Maricopa (MAG) trabaja con las municipalidades en el valle para planear y construir el sistema de transporte regional, que incluye autopistas, calles, autobuses, tren ligero, y rutas de bicicletas y banquetas. Ya sea que llegue a su trabajo manejando o por transporte público, lleve a sus hijos a la escuela, viaje muy poco o use una bicicleta para todos lados – ¡NECESITAMOS SU AYUDA!

Para más información: MAGTravelSurvey.org | 602-707-0085 | MAGTravelSurvey@AskArizona.com
Toda su información se mantendrá de manera confidencial. *La recompensa será entregada solamente después de que complete todos los requisitos de la encuesta.

Comparta fácilmente sus viajes a través de una aplicación de teléfono inteligente.

► **Para comenzar, conteste unas preguntas visitando la página web, MAGTravelSurvey.org/VP**

¡RECIBA SU RECOMPENSA!
~~\$10~~ **\$20 por cada persona**
de su hogar que sea mayor de 6 años, cuando termine la encuesta.


¡Promoción especial de Valpak recibirá una recompensa DOBLE!*
Cuando complete el formulario, para recibir \$20 por persona
(en vez de \$10),
usted tendrá que seleccionar VALPAK para hacernos saber cómo se enteró de la encuesta.

AT&T LTE 6:12 PM 65%

Search

Ask Arizona
Sponsored

Get paid to improve transportation around the Valley! Share your travel habits via our Travel Survey App and earn money for each member of your household.



WHERE ARE WE GOING?
MAGTravelSurvey.org


iPhone and Android Users
magtravelsurvey.org [Learn More](#)

Like Comment Share

News Feed Requests Messenger Notifications More

Instagram

Ask Arizona Sponsored



WHERE ARE WE GOING?
MAGTravelSurvey.org

[Sign Up](#)

Help plan the Valley's future! Get \$10 per person in your home age 6+ to share your trips via an app with MAG - the Maricopa Association of Governments.



MAG Travel Survey

Participate in the MAG Travel Survey To find out more call us today!

📞 (602) 707-0085



Coupons for this service

Register using the Valpak Coupon Link to Get Paid Double!
Receive \$20 (normally \$10) Per Household Member age 6+.
You MUST complete all study requirements and select VALPAK to qualify!

[Details](#)

⌚ Expires

[Visit Website](#)

MAG Travel Survey
(602) 707-0085

[Visit Website](#)

Photos



Video

Answer a few simple questions at <http://magtravelsurvey.org/VP> and GET PAID \$20 PER PERSON living in your household, age 6+ (instead of \$10 per person) when you complete the study. You MUST SELECT VALPAK as how you heard about the survey when you register. We are all on the go... sometimes with best friends in tow! **MAG works** with local

[More](#)

Additional Links [Visit Our Website!](#)
[Click Here to Register!](#)

Public Posts



ASU State Press  shared Ask Arizona's post.
March 16 · 

Ask Arizona is looking for ASU Students! Click the link below and complete the [travel survey](#) to get \$100! #advertisement



Ask Arizona
March 15 · 

NEEDED 2000 ASU STUDENTS! For a LIMITED TIME ONLY – Get \$100 when your household completes our survey! Share your travel info to help us make your future travel experience better! #MAGTravelSurvey [MAGTravelSurvey.org/ASU](#)



[www.magtravelsurvey.org/ASU](#)

MAGTRAVELSURVEY.ORG



The State Press @statepress · Mar 16

Yes! Ask Arizona is looking for ASU Students -- complete the travel survey to get \$100!

Ask Arizona @AskAZSurvey

ASU STUDENTS Limited time offer: \$100 per household that completes the #MAGTravelSurvey [MAGTravelSurvey.org/ASU](#)



1



1



A.7 Details on In-Person Interceptors

During the early stages of the project, the team experimented with sending intercept interviewers to events hosted by Valley Metro in an attempt to recruit residents to participate in the study. Unfortunately, the events were “walk around” events with many vendors offering giveaways for visiting the booths. Our interceptors did not have a booth and did not have anything to give residents, other than a \$10/person/household incentive upon study completion. In addition, the recruit survey took a significant amount of time and residents were not inclined to participate. These efforts generated fewer than 5 recruited households and the approach was quickly terminated.

When the recruitment focus turned to ASU staff and students, it was necessary to go on to the campus to recruit the students through intercept interviews as the university was not able to assist in sending out email invitations. Learning from our earlier experience with intercepts, WGR intercept interviewers were sent to the ASU Tempe campus with iPads to intercept ASU students and staff and request that they complete the brief pre-recruit survey to determine if they would qualify for the study. This survey took fewer than 5 minutes to complete and the promise of a \$100 incentive per household for study completion was a strong motivator in convincing participants to complete the pre-recruit survey.

Interceptors spent most of their time recruiting on the Tempe campus near the Memorial Union. The hours for intercepting were between 10 am and 4 pm on most days since that is when the campus was the busiest and this particular area was a place for students to congregate and pick up food during the lunch time hours. Near the end of the recruiting effort, the university requested the team to move off campus. The City of Tempe and Valley Metro provided permissions for the interceptors to work at the Tempe Transit Center as well as at the light rail station located on Rural and University. Similar recruiting hours were used at these locations.

Near the conclusion of the study, the decision was made to complete additional intercept interviews at the Central Station transit center to attempt to boost the representation of transit users in the study sample. With permission from the City of Phoenix and Valley Metro, WGR interceptors were on the light rail and bus platforms, assisting transit users in completing the pre-recruit survey. While the intercepts at public events were not successful, the ASU and transit center recruits were greatly successful, with more than 70% of the recruited students and staff completing the study (73% and 72%, respectively) and 68% of those recruited at the Central Station completing the study.

Overall, interceptors were more successful when they were working around public transit areas and around ASU's main campus. Also, it was more successful when they could make the sign-up short and sweet for the participants instead of a long process (i.e., only completing the pre-recruit survey instead of the full recruit survey). This allowed us to e-mail the qualified households a household PIN and a link to finish signing up for the study on their own time.

Appendix B. Survey Instruments

B.1 Pre-Recruit Survey

Once GPS loggers were removed from the methodology and the study switched from outbound ABS sample recruitment to convenience sampling for smartphones only, it became necessary to determine each household's eligibility to participate in the study prior to completing the full recruit survey.

In addition to determining study eligibility, the pre-recruit survey was used as a secondary method of determining the source of awareness for the study. While many participants used a unique tracked link to access the survey, others frequently came in through the MAGTravelSurvey.org website and the pre-recruit survey captured the recruitment source for those entering the study through this generic entry point.

Initially, the pre-recruit survey was envisioned as the tool for screening out households as certain quota groups were filled (household size, age, transit use, employment status, etc.) However, it was never used to control access by demographic variables. It was eventually used to screen participants for recruitment source so we could not only track school district representation for calculating donation amounts, but also screen out potential participants as recruiting efforts became more targeted (e.g., access limited only to ASU students and staff).

Participants spent an average of 2-5 minutes completing the pre-recruit survey. Actual length depended on how thoroughly they read the study description and each instruction as well as the length of time required to determine household smart phone compatibility.

The MAG HTS Pre-Recruitment Survey primarily included questions designed to screen out ineligible households and those that fell into full quota categories. The following is a comprehensive list of the pre-recruit questions and Figure B.1 to Figure B.2 show screenshots of the survey:

1. How did you hear about the MAG Travel Survey? (Select all that apply).
2. Select the statement that describes your college living situation: (Dorm, Off-campus).
3. Which of the following categories best describes your age?
4. What is your zip code?
5. INCLUDING YOURSELF, and all other adults, and children of all ages, how many people currently live in your household?
6. Do you have an iPhone or Android smart phone?
7. Do ALL other members of your household age 16 or older have an iPhone or Android smart phone?
8. Please provide your email address and phone number below.

Households did not qualify for the recruit survey if they met any of the following conditions:

- Household did not have app compatible smartphones for all age 16+.

- Age of respondent was <18.
- Household not located in a zip code within the MAG region.
- Quota for recruit population closed (ASU staff, ASU students, ASU student residing in dorm, school districts).
- Household refused to provide contact information or answer required questions.

Figure B.1 Pre-Recruit Survey Opening Page

MARICOPA ASSOCIATION of GOVERNMENTS

Thank you for your interest in the Maricopa Association of Governments (MAG) Travel Survey. Ask Arizona/WestGroup Research of Phoenix is facilitating this research study for MAG.

The next few questions help determine your household's eligibility to participate.

If you qualify for the study you will:

- Complete the online registration.
- Download a smartphone app (for all age 16 and up)
- Answer questions online about travel for those age 6 and older
- Receive \$100 per household!

Your responses and all study related data are confidential and participation is voluntary.

Contact us at 602-707-0050 or via email at MAGTravelSurvey@AskArizona.com


****HOUSEHOLDS MAY ONLY PARTICIPATE AND RECEIVE PAYMENT ONCE.****

By continuing with this survey, you confirm that you are at least 18 years old and have read this consent form.

CONTINUE

For assistance at any time, email us at MagTravelSurvey@AskArizona.com, call us toll-free at 602-707-0085 or [Chat With Us](#)
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Figure B.2 Pre-Recruit Survey Warning Page



**MARICOPA
ASSOCIATION of
GOVERNMENTS**

MAG HOUSEHOLD PRE-RECRUIT SCREENING SURVEY

Thank you for your interest in the Maricopa Association of Governments (MAG) Travel Study. This study is being conducted by West Group Research, a Phoenix-based research firm.

The information gathered will be used by MAG to plan for the transportation needs of your community. Your responses and the data obtained from this study are confidential and participation is voluntary. Your information will be combined with thousands of other households and reviewed as a whole for statistical purposes only. The next few questions will help determine if your household is eligible to participate in this travel study.

If you qualify for the study, you will complete the full registration online and each member of your household age 16 and older will collect travel data for the same two days using a smart phone application. After the travel period, you will visit a website to confirm the accuracy of the travel data and answer questions about your travel. Households that satisfy all requirements of the study will be sent \$10 per household member age 6 and older as a thank you for participating.

If you have any questions about the MAG Household Travel Survey, contact the helpline at 602-707-0085 or email us at MAGTravelSurvey@AskArizona.com

By continuing with this survey, you confirm that you are at least 18 years old and have read this consent form.

BACK

CONTINUE

For assistance at any time, email us at MagTravelSurvey@AskArizona.com, call us toll-free at 602-707-0085 or [Chat With Us](#)

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Figure B.3 Example of Pre-Recruit Survey Participant Source of Awareness Page



MARICOPA ASSOCIATION of GOVERNMENTS

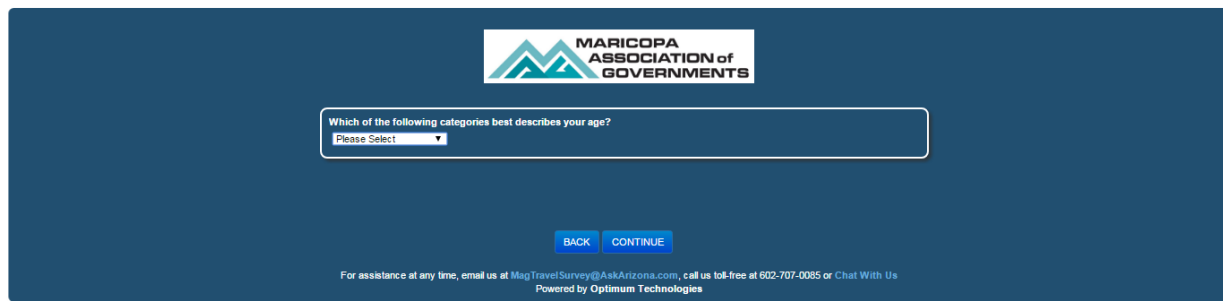
How did you hear about the study?

- ☐ ASU Student
- ☐ ASU Faculty/Staff
- ☐ Both - I am an ASU student and an employee
- ☐ West Mag
- ☐ Recruited at Central Station
- ☐ None of the above

[BACK](#) [CONTINUE](#)

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Figure B.4 Pre-Recruit Survey Age Question



MARICOPA ASSOCIATION of GOVERNMENTS

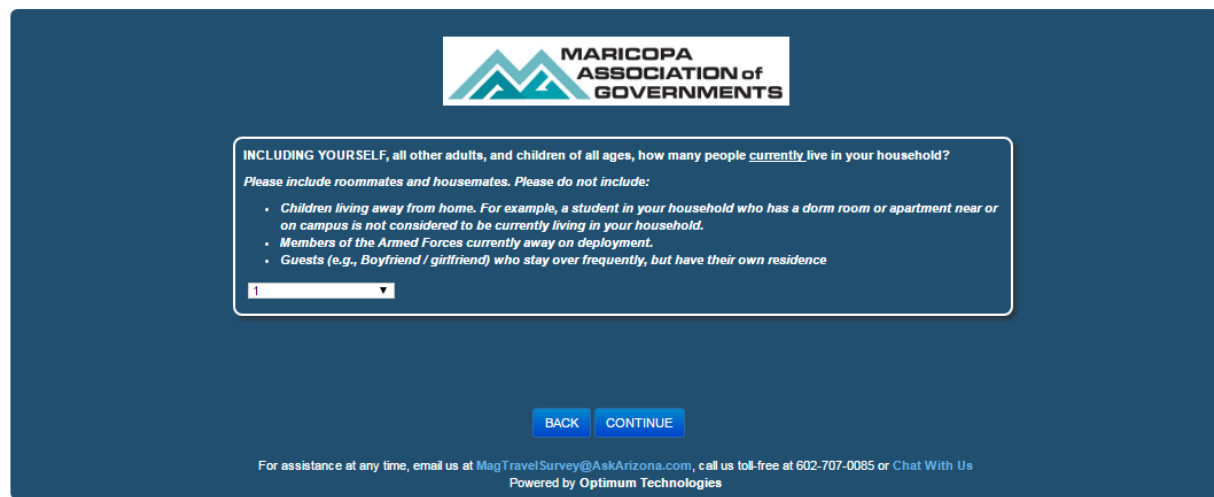
Which of the following categories best describes your age?

Please Select ▼

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Figure B.5 Pre-Recruit Survey Number of People in Household Page



MARICOPA ASSOCIATION of GOVERNMENTS

INCLUDING YOURSELF, all other adults, and children of all ages, how many people currently live in your household?

Please include roommates and housemates. Please do not include:

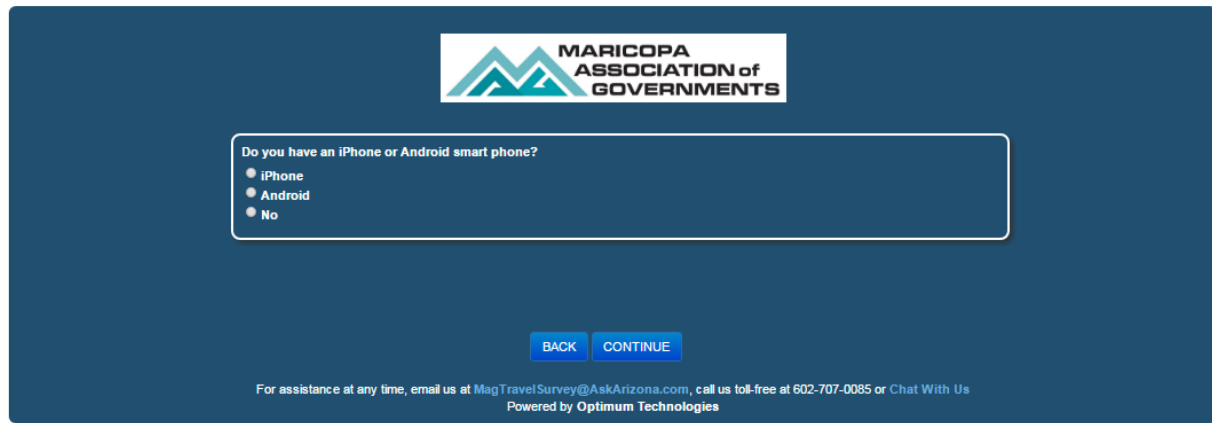
- Children living away from home. For example, a student in your household who has a dorm room or apartment near or on campus is not considered to be currently living in your household.
- Members of the Armed Forces currently away on deployment.
- Guests (e.g., Boyfriend / girlfriend) who stay over frequently, but have their own residence

1 ▼

[BACK](#) [CONTINUE](#)

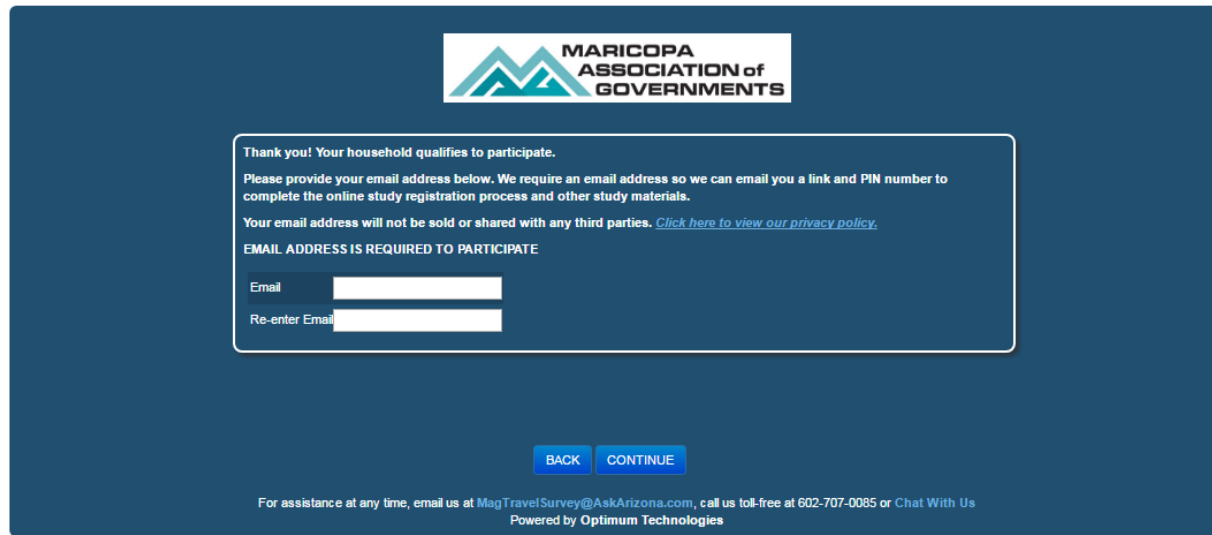
For assistance at any time, email us at MagTravelSurvey@AskArizona.com, call us toll-free at 602-707-0085 or Chat With Us
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Figure B.6 Pre-Recruit Survey Smartphone Ownership Page



The screenshot shows a survey page with a dark blue background. At the top center is the Maricopa Association of Governments logo, which consists of a stylized mountain range icon and the text "MARICOPA ASSOCIATION of GOVERNMENTS". Below the logo is a white-bordered box containing the question "Do you have an iPhone or Android smart phone?" and three radio button options: "iPhone", "Android", and "No". At the bottom of the page are two blue buttons labeled "BACK" and "CONTINUE". Below these buttons is a line of small text: "For assistance at any time, email us at MagTravelSurvey@AskArizona.com, call us toll-free at 602-707-0085 or Chat With Us. Powered by Optimum Technologies".

Figure B.7 Pre-Recruit Survey Qualification Page



The screenshot shows a survey page with a dark blue background. At the top center is the Maricopa Association of Governments logo, which consists of a stylized mountain range icon and the text "MARICOPA ASSOCIATION of GOVERNMENTS". Below the logo is a white-bordered box containing the following text: "Thank you! Your household qualifies to participate. Please provide your email address below. We require an email address so we can email you a link and PIN number to complete the online study registration process and other study materials. Your email address will not be sold or shared with any third parties. [Click here to view our privacy policy.](#) EMAIL ADDRESS IS REQUIRED TO PARTICIPATE". Below this text are two input fields: "Email" and "Re-enter Email". At the bottom of the page are two blue buttons labeled "BACK" and "CONTINUE". Below these buttons is a line of small text: "For assistance at any time, email us at MagTravelSurvey@AskArizona.com, call us toll-free at 602-707-0085 or Chat With Us. Powered by Optimum Technologies".

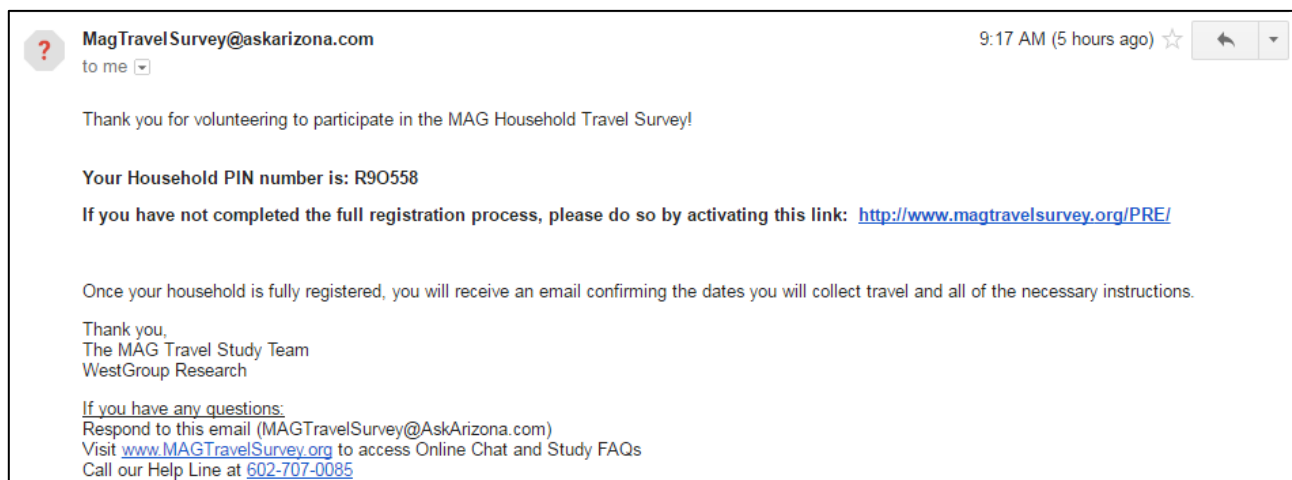
Figure B.8 Pre-Recruit Survey End Page for Qualifying Participants

Upon completion of Pre-Recruit Survey participants were:

- Notified if eligible or ineligible to participate, or if follow-up required to determine eligibility, as shown in Figure B.5.
- Given the option to continue to recruit survey if qualified, as shown in Figure B.6.
- Sent follow-up “invitation” e-mail with PIN and link to complete full recruit survey, as shown in Figure B.9.

When a participant completed the whole Pre-Recruit Survey, they were notified of their eligibility to participate in the study. Regardless of the point of disqualification, respondents were not notified until they finished the full pre-recruit survey to prevent them from identifying the reason for ineligibility and ideally discouraging them from attempting to try and sign up again using different answers to “cheat” the system.

When the participant completed the pre-recruit survey and qualified, they would receive an automatic email with their Household PIN and a link to the Recruit Survey so they could finish signing up. They also had the option of staying in the pre-recruit survey and clicking “Continue” and moving on to the start of the Recruit Survey.

Figure B.9 Email with PIN number and Link to Full Recruit Survey

B.2 Recruit Survey

The time required to complete the Recruit survey ranged between 5 and 15 minutes, depending on various household factors. Larger households spent more time answering multiple questions about each household member. The number of vehicles and jobs in the household also had an impact on the length of the survey. The Recruitment Survey generally included questions that fell into the following categories:

1. Vehicles available to household:
 - a. How many working vehicles are available to your household?
 - b. For each vehicle in your household, please indicate the type, make, model, model year, fuel-type and mileage.
 - c. What is the ownership status of the above vehicle?
 - d. Thinking about the licensed drivers in your household and all available vehicles, please indicate the primary driver of each vehicle.
2. Household composition:
 - a. INCLUDING yourself, all other adults, and children of all ages, how many people currently live in your household?
 - b. For each household member: Name/Nickname, gender, age, relationship to respondent.
3. Employment (household members 16+):
 - a. Employment status.
 - b. Do you primarily work at home for your job or business?
 - c. What is your employer's industry?
 - d. Employment details for one household member.
 - e. Work schedule/flexibility of schedule/ability to work from home.
 - f. Employer's provision of transit passes, parking, special parking for carpool, etc.
4. Education/School Status:
 - a. Student status (part time, full time).
 - b. Highest level of school completed.
5. Demographics:
 - a. Do you consider yourself to be Hispanic, Latino, or Spanish?
 - b. Which of the following racial categories describe you?
 - c. Please select the category that best describes the total 2016 combined income for everyone living in your household.

6. Eligibility Questions/Contact Questions:

- a. Do you have a smartphone?
- b. What type of smartphone do you have?
- c. For each additional member of your household 16 years old or older; please indicate whether he or she has a compatible smartphone.
- d. What is your home address?
- e. May we have < NAME> mobile phone number so we may text important information about participation in the study?
- f. May we have your permission to send < NAME> text messages?
- g. You have the option of receiving your incentive via a check we will mail to your house or through an Amazon gift card that we will e-mail to you. Please select.

B.2.1 Modifications Based on Different Phases of Study

Changes Made between pilot (Fall 2015) and main survey (Spring 2016)

The recruit survey was modified slightly after the Fall 2015 pilot study and prior to the launch of the main study in March 2016. The changes made were primarily to make the tool more user friendly for respondents and easier for WestGroup staff to support participants, and include:

- There were questions and statements added that provided a warning to respondents that refusing to answer a question would result in termination. These “second chances” prevented respondents from accidentally being terminated from the survey (which was a common complaint during the pilot study).
- The option of receiving an Amazon gift card via email was added (or they could still select to receive a check by mail). This was a cost saving measure.
- Participants were required to provide at least an email address and their phone number was requested. (In the pilot they were only required to provide a mailing address).
- Participants were asked for permission to send texts related to the study.

Changes made between Spring 2016 and Fall 2016 data collection

After spring data collection was completed, the option of having a GPS logger provided for data collection was removed. The recruit survey instrument was modified to remove language that referred to the loggers and to receiving study materials via physical mail. At this time, all study instructions would be provided via email only.

Participants were required to provide a primary phone number for contact during the study. (In addition to being required to provide an email address and physical address.)

Changes made between Fall 2016 and Spring 2017 data collection.

The incentive was changed to a flat rate of \$100 per household thus the instrument was changed to reflect this. (Previously it was a calculation based on the number of household members age 6+ X \$10. This was replaced with the flat rate.)

B.2.2 Sample Screenshots of Recruit Survey

Figure B.10 Spring 2017 Recruit Survey Welcome Page

MARICOPA ASSOCIATION of GOVERNMENTS

Congratulations! You are eligible to participate!
Please call 602-707-0085 if you'd prefer to sign up over the phone or if you have any trouble viewing the survey.
Upon completing all study requirements: **Your household gets \$100!**
Your responses and data are confidential and participation is voluntary
PRESS CONTINUE TO SIGN UP!
For more information: Visit www.MAGTravelSurvey.org or Call 602-707-0085.
***HOUSEHOLDS MAY ONLY PARTICIPATE AND RECEIVE PAYMENT ONCE.**

If you received a Study Code, enter it now:

CONTINUE

For assistance at any time, email us at MagTravelSurvey@AskArizona.com, call us toll-free at 602-707-0085 or Chat With Us
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Figure B.11 Recruit Survey Vehicle Availability Page

MARICOPA ASSOCIATION of GOVERNMENTS


How many working vehicles are available to your household?
Please count ALL working owned and leased cars, vans, trucks, and motorcycles, as well as vehicles available for REGULAR USE to your household, such as company vehicles. Include RVs, mopeds, golf carts and ATVs only if they are used for local trips.

Please Select ▼

BACK CONTINUE

For assistance at any time, email us at MagTravelSurvey@AskArizona.com, call us toll-free at 602-707-0085 or Chat With Us
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Figure B.12 Recruit Survey Participant Name Page




Now we'd like to ask a few questions about you. This will help us prepare the study materials you will need to complete the next portion of the study.

This information is for research purposes only. Your personal information will not be shared with any third parties. [Please click here to review our privacy policy.](#)

Please enter your first name, nick name, or provide your initials

For assistance at any time, email us at MagTravelSurvey@AskArizona.com, call us toll-free at 602-707-0085 or Chat With Us
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Figure B.13 Recruit Survey Participant Demographics Page



The following questions are for Kelli Test.

What is your gender?

- ☐ Male
- ☐ Female
- ☐ Other
- ☐ Rather Not Say


What is your age?

- ☐ Enter exact age below
- ☐ Not Sure
- ☐ Rather Not Say

Age:

For assistance at any time, email us at MagTravelSurvey@AskArizona.com, call us toll-free at 602-707-0085 or Chat With Us
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Figure B.14 Recruit Survey Phone Number Page




Please enter Kelli Test's mobile phone number so we may text important information about participation in the study. If you own a smartphone, this will include a link to the app needed for the study. Enter digits only, no dashes or other punctuation.
A mobile phone number is required for participation in this study.

Phone

[BACK](#) [CONTINUE](#)

For assistance at any time, email us at MagTravelSurvey@AskArizona.com, call us toll-free at 602-707-0085 or [Chat With Us](#)
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Figure B.15 Recruit Survey Choice of Incentive Page



As previously mentioned, your household will receive \$100 for collecting and verifying travel for all members of the household aged 6 and older.

You have the option of receiving your incentive via a check mailed to your home or through an Amazon gift card that we will e-mail to you. If you choose the Amazon gift card you will receive your incentive faster.

- ☐ Receive Amazon Gift Card via E-mail
- ☐ Receive Check via Mail

[BACK](#) [CONTINUE](#)

For assistance at any time, email us at MagTravelSurvey@AskArizona.com, call us toll-free at 602-707-0085 or [Chat With Us](#)
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Figure B.16 Recruit Survey Home Address Page

MARICOPA ASSOCIATION of GOVERNMENTS

What is your home address?

Enter your address

Street Number

Street Name

Suite/Apt Number

City

State

Zip

Country

☐ Prefer Not to Answer

Your home address is required for participation in this important study. We need it to mail the payment for participating to you and also to ensure residents from all over the region are being included in the study and to mail payment to you. *Your address will not be sold or shared with any third parties. [Click here to view our privacy policy.](#)*

☐ I choose NOT to participate in this study

For assistance at any time, email us at MagTravelSurvey@AskArizona.com, call us toll-free at 602-707-0085 or Chat With Us
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Figure B.17 Recruit Survey Travel Date Selection Page

MARICOPA

Your household's assigned travel period begins on . Is this date and the day immediately following this date good days for you to participate in the study? *Keep in mind that we need travel diaries for all types of travel days, regardless if it is a typical travel day or not.*

☐ Yes

☐ No, please show me more available dates

☐ I don't want to participate in this study

For assistance at any time, email us at MagTravelSurvey@AskArizona.com, call us toll-free at 602-707-0085 or Chat With Us
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Figure B.18 Recruit Survey Thank You and Next Steps Page

MAG Travel Survey

Thank you! This completes the first portion of the survey. Please check your email for complete study instructions.

Your household's travel assignment begins on **Monday, January 30**. After each of your two travel days, you will access your online travel diary to verify the GPS information and answer questions related to your travel.

You may always request help by calling 602-707-0085, visiting www.MAGTravelSurvey.org, or emailing MAGTravelSurvey@AskArizona.com.

Thank you for your household's participation in this important survey. It will help state and local agencies understand your travel needs, improve roads and public transportation, reduce congestion, and expand walking and bike paths.

You may now close this browser window.

For assistance at any time, email us at magtravelsurvey@askarizona.com or call us at 602-707-0085.

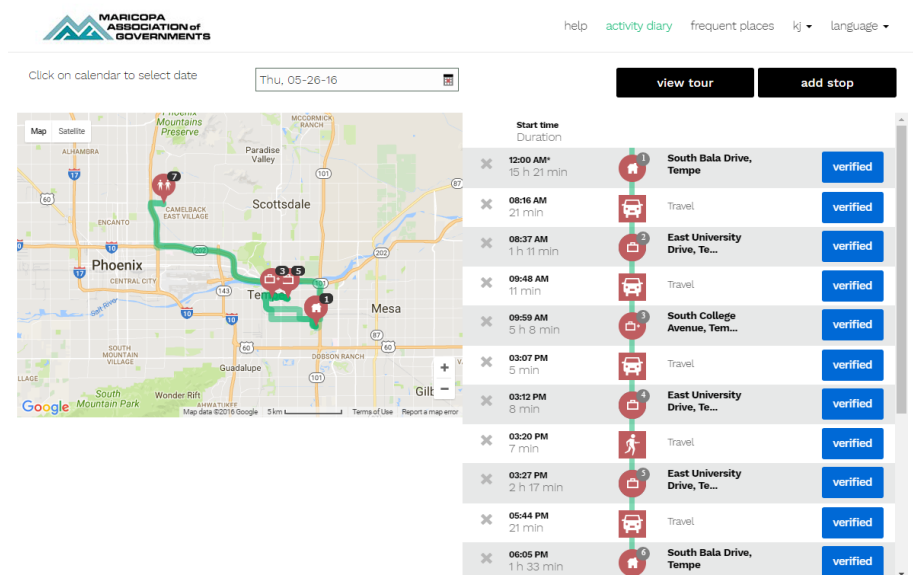
B.3 MMonitor Application and Prompted Recall Validation

The MMonitor mobile sensing software that is downloaded as an application on a Smartphone or loaded on to a GPS device, processes GPS data into a series of trips and stops and infers modes and activities using highly refined intelligent algorithms. The data collected from the MMonitor system:

- Has high spatial and temporal accuracy
- Can precisely captures stops, complex tours, and walking trips, and
- Includes ability to accurately capture supplemental trip and activity information.

Survey participants could view their activity diary featuring a timeline and a map on their smartphone or online, as shown in Figure B.19.

Figure B.19 MMonitor Map and Activity Diary



Prompted recall validation involved filling in supplemental information; and amending incorrectly inferred data, such as the mode of travel used for a particular trip. Household member names and vehicle make and model information obtained from the Recruit Survey is uploaded to the MMM system so that household members and vehicles could be linked to each trip made.

The following supplemental questions were asked for each travel segment:

1. Number of other people in your traveling party? *Select: 0, 1, 2, 3, 4, 5+*
 - a. (If 1 or more): Who was with you? *Select: Household Members only, Non-Household Members only, Both Household and Non-Household Members*
 - i. (if Household Members) Please specify which household members were with you: *(drop-down list of household members)*
2. Please tell us how you travelled. *Select: Foot, Vehicle, Bus, Light Rail, Bicycle, Taxi/Car Service, Air, Other*
 - a. (if Vehicle)
 - i. Please specify which vehicle *(drop-down list of household vehicles)*
 - ii. Were you the driver? *Select Yes, No*
 - iii. Parking Place *Select Street, Residential Garage/ Driveway, Commercial or Public Parking lot/garage, Other*
 - b. (if Bus) Bus Type. *Select: Inter-city public bus, School bus, Charter bus, Intra-city private bus, Shuttle bus*
 - i. (if Inter-city bus) Bus Route Number *(Text box)*
 - ii. (if Shuttle Bus) Shuttle Bus Type *Select: Orbit/Express, ASU Circulator, Scottsdale Trolley, Other*
 - c. (if Light Rail) How did you pay for this trip? *Select Transit pass, One day pass, Single trip ticket, Other*
 - d. (if Taxi/Car Service)
 - i. Fare Paid *(text box)*
 - ii. Was your fare reimbursable? *Select Yes, No, Not Applicable*
 - iii. Which of the following services did you use? *Select Taxi, Uber, Lyft, ExecuCar, Other*

Figure B.20 MMonitor Travel Segment Bus Selected

6 AM : 47 of Current day

Number of other people in your traveling party

☒ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5+

Bus type

☐ Inter-city public bus

☐ School bus

☐ Charter bus

☐ Intra-city private bus

☐ Shuttle bus

Please tell us how you travelled

☒ Foot

☐ Vehicle

☒ Bus

☐ Light Rail

☐ Bicycle

☐ Taxi/Car Service

☐ Air

☐ Other

submit

Figure B.21 MMonitor Travel Segment Taxi/Car Service Selected

6 AM : 47 of Current day

Number of other people in your traveling party

☒ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5+

Was your fare reimbursable?

☐ Yes

☐ No

☐ Not applicable

Please tell us how you travelled

☐ Foot

☐ Vehicle

☐ Bus

☐ Light Rail

☐ Bicycle

☒ Taxi/Car Service

☐ Air

☐ Other

Fare Paid

Which of the following services did you use?

☐ Taxi

☐ Uber

☐ Lyft

☐ ExecuCar

☐ Other

Figure B.22 MMonitor Travel Segment Light Rail Selected

6 AM : 47 of Current day

Number of other people in your traveling party
☒ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5+

How did you pay for this trip?
☐ Transit pass
☐ One day pass
☐ Single trip ticket
☐ Other

Please tell us how you travelled

- ☐ Foot
- ☐ Vehicle
- ☐ Bus
- ☒ Light Rail
- ☐ Bicycle
- ☐ Taxi/Car Service
- ☐ Air
- ☐ Other

submit

The following supplemental questions were asked for each activity segment:

3. Which of the following activities did you do at this stop? Select Primary Home, Work, Shopping, Social/Recreational/Entertainment, Change Travel Mode/Transfer, Work Related, Education/School/Religious, Health Care, Eat Meals Out, Exercise/Play Sports, Personal Errands/Tasks, Dropoff/Pickup/Accompany Someone, Secondary Home, Other
 - a. (if one or more selected) Which one is your main activity (drop-down list of previously selected activities)
 - b. (if Dropoff/Pickup/Accompany Someone)
 - i. Which of the following activities did you do at this stop? Select Dropped off passenger(s), Picked up passenger(s), Accompanied passenger(s) to his/her activity
 - ii. Please indicate one or more activities that the passenger(s) you were transporting engaged in at this stop. Select Primary Home, Work, Shopping, Social/Recreational/Entertainment, Change Travel Mode/Transfer, Work Related, Education/School/Religious, Health Care, Eat Meals Out, Exercise/Play Sports, Personal Errands/Tasks, Dropoff/Pickup/Accompany Someone, Secondary Home

Figure B.23 MMSMonitor Activity Segment Two Activities Selected

Primary Home

Work

Work Related

Education/School/Religious

Shopping

Personal Errands/Tasks

Change Travel Mode/Transfer

Dropoff/Pickup/Accompany Someone

Health Care

Eat Meals Out

Social/Recreational/Entertainment

Exercise/Play Sports

Secondary Home

Other

Which was your **main** activity?

Eat Meals Out

Social/Recreational/Entertainment

B.4 Child Diary

The child diary was accessed online via same website as study registration and GPS app travel verification. The instructions for completing the child diary are shown in Figure B.24.

Figure B.24 Child Diary Instructions Page

**MARICOPA
ASSOCIATION of
GOVERNMENTS**

Instructions for On-line Travel Diary

This travel diary is for Child Test.

Child's travel information must be entered for the same date that ALL household members have VERIFIED their GPS collected travel.

Adults should fill out diaries for children or fill them out with the child.

Include ALL trips the child made—This includes drive-thrus, quick stops for gas, picking up or dropping off someone, walking the dog, etc. Report all ways the child traveled to a destination.

For example, if they walked to a bus stop and then rode the bus to school:

1. Select "walk" as the type of transportation
2. Answer "Yes" to the question asking if they used a second type of transportation for the trip.
3. Select "Bus" when asked again for transportation type.

Note: If a travel type took place for less than 5 minutes, do not record it.

Need Help? Have Questions?
Contact a Travel Study Coordinator
Helpline: 602-707-0080
Chat with us at MAGTravelSurvey.org
MAGTravelSurvey@ASKArizona.com

CONTINUE

For assistance at any time, email us at MagTravelSurvey@AskArizona.com, call us toll-free at 602-707-0085 or Chat With Us
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The child diary asked the following questions as shown in Figure B.25 to Figure B.28:

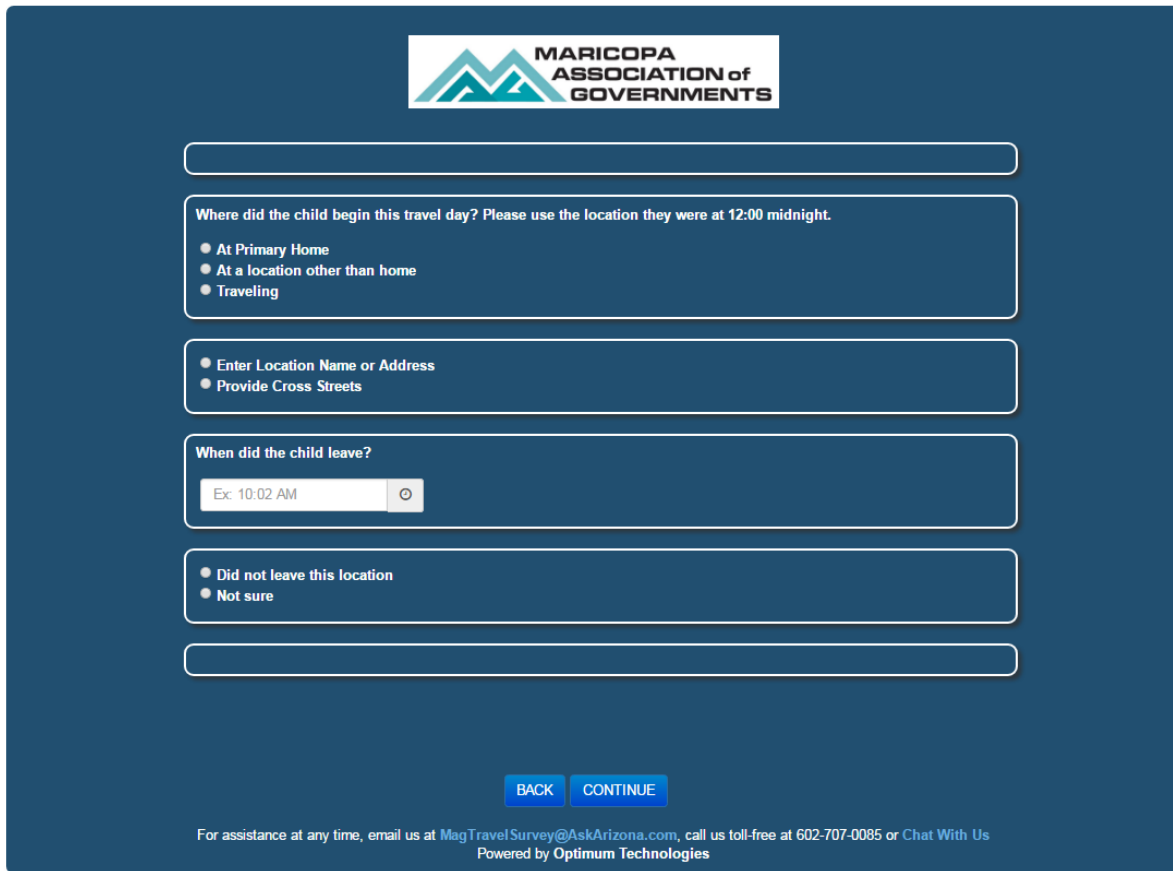
- Date of travel.
- Name of household member entering travel information.
- Child's starting location.
- Location type/activity type.
- Time child left location.
- Mode of transportation and co-passengers.
- Next location.
- Time arrived at next location.
- Next location type/activity type.
- Continued for each location throughout child's day.

Figure B.25 Child Diary Date of Travel Page



The screenshot shows a dark blue background with the Maricopa Association of Governments logo at the top center. Below the logo is a white-bordered box containing the text "What date of travel is this for?". Underneath this text is a text input field with the example "Ex: 06/05/2017" and a calendar icon to its right. Below the date input is another white-bordered box with the text "Who is providing the travel information in this online diary for Child Test?". Underneath this text is a dropdown menu. At the bottom of the form are two blue buttons labeled "BACK" and "CONTINUE". Below the buttons is a line of small text: "For assistance at any time, email us at MagTravelSurvey@AskArizona.com, call us toll-free at 602-707-0085 or Chat With Us. Powered by Optimum Technologies".

Figure B.26 Child Diary Child's Starting Location Page



The screenshot shows a dark blue background with the Maricopa Association of Governments logo at the top center. Below the logo is a white-bordered box containing the text "Where did the child begin this travel day? Please use the location they were at 12:00 midnight.". Underneath this text are three radio button options: "At Primary Home", "At a location other than home", and "Traveling". Below these options is another white-bordered box containing two radio button options: "Enter Location Name or Address" and "Provide Cross Streets". Below this box is another white-bordered box containing the text "When did the child leave?". Underneath this text is a text input field with the example "Ex: 10:02 AM" and a clock icon to its right. Below the time input is another white-bordered box containing two radio button options: "Did not leave this location" and "Not sure". At the bottom of the form is a single empty white-bordered box. Below this box are two blue buttons labeled "BACK" and "CONTINUE". Below the buttons is a line of small text: "For assistance at any time, email us at MagTravelSurvey@AskArizona.com, call us toll-free at 602-707-0085 or Chat With Us. Powered by Optimum Technologies".

Figure B.27 Child Diary Activity Information Page

What was the child's main activity?
(Options to Select From)

☐ PRIMARY HOME

☐ EDUCATION/SCHOOL/RELIGIOUS

☐ ACCOMPANY SOMEONE TO THEIR ACTIVITY/RIDE ALONG

☐ SOCIAL/RECREATIONAL/ENTERTAINMENT

☐ EXERCISE/PLAY SPORTS

☐ EATING MEALS OUT

☐ HEALTHCARE

☐ SHOPPING

☐ PERSONAL ERRANDS/TASKS

☐ 2nd HOME/RESIDENCE

☐ OTHER

When did the child arrive?

You stated the child left to travel to this location at 9:02 AM on 06/05/2017. Please make sure the arrival time is AFTER 9:02 AM but before 11:59 PM the same day.

Ex: 10:02 AM

☐ Not Sure

When did the child leave?

(This time should be LATER than the arrival time you entered above.)

Ex: 10:02 AM

☐ Did not leave this location

☐ Not sure


BACK

CONTINUE

For assistance at any time, email us at MagTravelSurvey@AskArizona.com, call us toll-free at 602-707-0085 or Chat With Us

Powered by Optimum Technologies

Figure B.28 Child Diary Travel Information Page



What type(s) of transportation did the child use to go to their next destination?

- ☐ Passenger in car/truck/van/golf cart/motorcycle/ATV
- ☐ Walk/Skateboard
- ☐ School Bus
- ☐ Public Bus/Any Bus other than School Bus
- ☐ Light Rail
- ☐ Commuter Rail
- ☐ Amtrak
- ☐ Bicycle
- ☐ Motorcycle/Moped
- ☐ Taxi/Shuttle/Car Service/Uber
- ☐ Paratransit (for disabled)
- ☐ Air
- ☐ Other

Did your child travel by a second type of transportation for this same trip?

- ☐ Yes
- ☐ No

Not including the child, how many other people were also on this trip?

- ☐ None/Child Traveled Alone
- ☐ Enter Number of People with Child

What was the child's destination for this trip?

You may look up the address by entering the proper name of the location (name of school, business, church, etc.) or put a street address in the look up box below and click the address from the options provided.

You may also select to enter the nearest cross-streets, if you do not know the address.

- ☐ Enter Location Name or Address
- ☐ Provide Cross Streets

Appendix C. Survey Technology and Processes

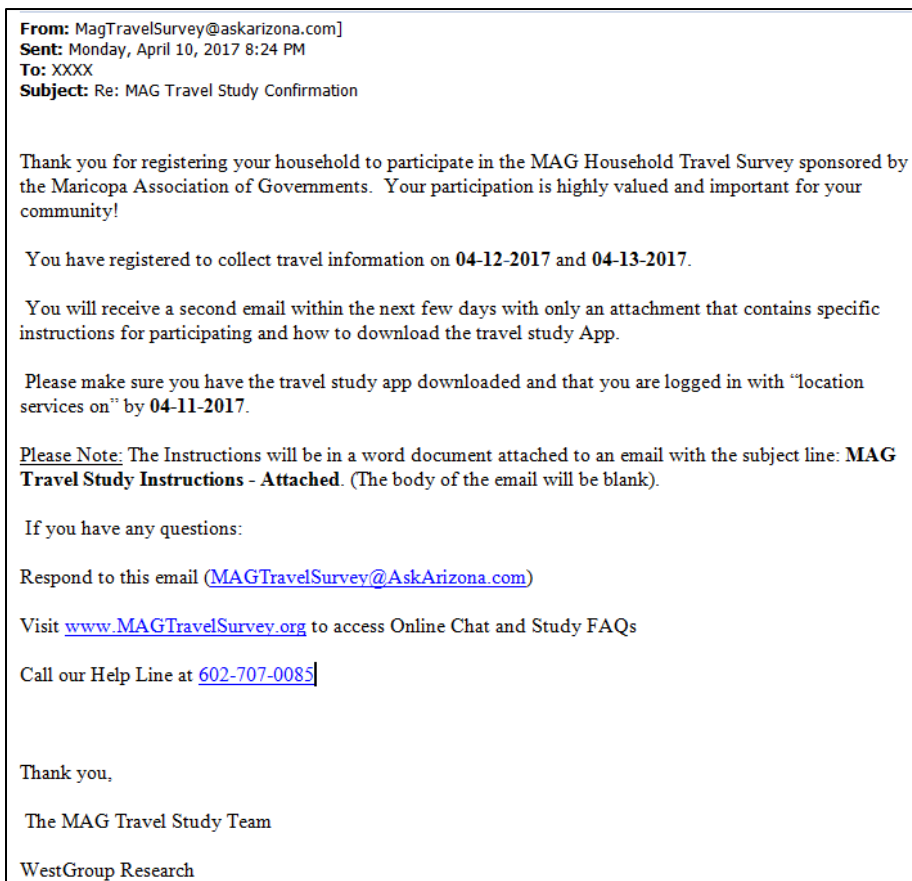
C.1 Post-Recruit Survey Activity and Communications

C.1.1 App-Only Households

Confirmation Email

Within 24 hours of completing the Recruit Survey, participants received an automated confirmation e-mail, as shown in Figure C.1. It thanked them for signing up, confirmed their assigned travel dates, and let them know their full instructions would be sent in a second email.


Figure C.1 Confirmation Email



Instruction Email

Within 48 hours of the confirmation email, participants received an "Instruction email", which included an attached word document with their full instructions on how to participate. These instructions contained all necessary study information including their assigned travel dates, assigned data collection method for each household member, instructions on downloading and logging into the app, their individual Participant Access Codes (PACs), and instructions on verifying their travel data online. Instructions were created and emailed via mail merge from a file created by HQ.

Figure C.2 Instruction Email




Thank you for participating in this important travel study. Included are your selected travel dates, assigned methods for recording travel, and all necessary instructions.

You are assigned to participate on **2/8/2017** and **2/9/2017**. For these TWO DAYS, household members assigned to collect travel data using the Smartphone app must carry their Smartphone whenever they leave home, even for walks or bike trips.

To Download the Smartphone GPS app:

iPhone users: Search MMMonitor in the App Store

Android users: Search Mobile Market Monitor in Google Play/PlayStore.



Look for this App icon

ALL: Each smart phone user needs to download and open the App. SIGN IN: Enter the assigned App Code (PAC) from the chart below as both Username and Password. NOTE: PAC codes are case sensitive, enter as shown.

To Verify Travel:

Go to www.magtravelsurvey.org and click "VERIFY". Enter this PIN: **50IH20** and select a name from the drop down list to verify travel for each person in an online GPS diary. NOTE: Your PIN is case sensitive, enter as shown.

For Child Diary: Select child's name from list and enter travel for the SAME DATE that GPS travel was verified.

Getting Your Incentive:

To qualify for the incentive, your entire household must collect travel data for TWO of the SAME days, and verify travel for the SAME DAY. **After these requirements are met, we will send your household its incentive of \$100.**

Your participation is very important and sincerely appreciated.

Assigned Method of Recording Travel

Household Member Name	Record Travel by:	Participant Access Code (PAC)	Household Member Name	Record Travel by:	Participant Access Code (PAC)
[Redacted]	Smartphone App	50IH2001			
[Redacted]	Smartphone App	50IH2002			
[Redacted]	Child Diary				
[Redacted]	N/A				

Text of Participant Access Codes and Link to MMM App

Two days prior to their travel date, participants were sent an automated text message with their individual Participant Access Codes to log into the app and a link to download the MMM app.

Figure C.3 Text of Participant Access Code and Link to MMM App

To begin, please download MAG Travel Study App at
<http://www.magtravelsurvey.org/app.html>
 To log in enter [Redacted] as username and password.

Text/Email Reminder to Travel

One day before their travel starts, participants received an automated text or email reminder that their travel starts the next day and provided the helpline number for assistance.

Figure C.4 Reminder to Travel Text Message

Travel Study is tomorrow. All in household 16+ must have app downloaded. See prior texts/emails for info or call 602.707.0085. Carry phone everywhere!

Figure C.5 Reminder to Travel Email

From: MagTravelSurvey@AskArizona.com
Sent: Tuesday, January 17, 2017 8:13 AM
To: XXXXXXXXXXXXXXXXXXXXXXXXXX
Subject: MAG Travel Survey - Reminder to Travel Tomorrow!

[Thank you for participating in the MAG Household Travel Survey. Your participation is very important and valuable to your community!

You registered your entire household to collect travel data on **2017-01-12** and **2017-01-13**. If they have not already done so, household members assigned to collect GPS travel information via Smartphone App should download the app by this evening so your household is ready to record travel the entire day tomorrow.

If your household is not set to record travel, contact us for help or to reschedule your travel dates as necessary.

Please see the instructions emailed for directions on how to download the study app and perform all study tasks.

Once you complete all study requirements, your household will receive \$100.00 – Thank you!

To contact us please:
Respond to this email
Visit www.MAGTravelSurvey.org to access Online Chat Help and Study FAQs
Call Help Line at 602-707-0085

Sincerely,
The Travel Study Team
WestGroup Research

Text/Email Reminder to Verify Travel

Once the household had collected GPS travel for all household members for at least one of the same days, it received an automated text or email reminder to verify travel.

Figure C.6 Reminder to Verify Travel Text Message

Don't forget to verify your travel
<http://www.magtravelsurvey.org/>
 Click the Verify button, log in
 with [REDACTED] and select your
 name.

Figure C.7 Reminder to Verify Travel Email

From: MagTravelSurvey@AskArizona.com [mailto:MagTravelSurvey@AskArizona.com]
Sent: Tuesday, December 13, 2016 12:02 PM
To: [REDACTED]
Subject: Last Step - Reminder to Verify for Travel Survey!

Thank you for participating in the MAG Travel Study! Your household has successfully collected travel data. **However, it does not appear you have verified travel in the online activity diary for all household members for the same day.**

This simply means you need to log on to the website to answer questions about your travel. At least one household member has not fully verified their travel yet, or has verified travel for the wrong day. To complete this verification, please follow these steps:

To verify your travel:

1. Go to MAGTravelSurvey.org
2. Click on "Verify"
3. Enter PIN [REDACTED] (All Caps) and Select Continue
4. Select person to verify.
5. Use calendar to select date of travel (**same date must be verified for all household members**)
6. Click "Verify" on each part of the travel data (Each stop and each time you traveled) and click through all available options (activity at location, how many people travelled with you? etc.)
7. After answering all questions, **click submit** on *each* part of the travel data to save it in our database. You will know you have done this correctly when the name changes from Verify to "Verified" and the color becomes a darker blue.
8. Continue to verify each travel segment until all say "Verified" in dark blue.
9. Repeat these steps as needed for all household members.

Once your household is fully verified for the same day, we will send your incentive! Thank you!

If you need to contact a Travel Study Coordinator for assistance:
 Email MAGTravelSurvey@AskArizona.com
 Call Helpline 602.707.0085
 Chat with us at MAGTravelSurvey.org

Survey Completion Email

Once all study requirements were confirmed as complete by a Travel Study Coordinator, participants received an automated email alerting the household that they had met all study requirements and would be receiving their incentive.

Figure C.8 Survey Completion Email

From: MagTravelSurvey@askarizona.com
Sent: Monday, May 15, 2017 3:28 PM
To: XXXX
Subject: MAG Travel Survey is Complete! Thank you!

Thank you for participating in the MAG Household Travel Survey!

Your household has met all study requirements and the incentive will be sent to you in approximately two to three weeks. If you requested a check, it will be mailed. If you requested an Amazon e-giftcard it will be emailed to the email address you provided. We apologize but we cannot make changes to the method of payment selected.

Thank you,

The MAG Travel Study Team
WestGroup Research

MAG Household Travel Study Contact Information|
Email: MAGTravelSurvey@AskArizona.com
Help Line: [602-707-0085](tel:602-707-0085)
Website: www.MAGTravelSurvey.org (for Online Chat and Study FAQs)

Pay Incentive

WGR included complete households in next batch of incentives and, according to the method selected by the participant, either emailed an Amazon gift-card or mailed a printed check.

C.1.2 GPS Logger Households

Spring 2016 data collection included loggers programmed and shipped by SRBI. The following outlines the *additional* steps and tasks required when data was collected via GPS loggers.

1. Optimum HQ generated and sent a daily file to SRBI containing household/registration information for logger households (households with 1+ member participating via GPS logger).
2. SRBI programmed loggers and assigned to specific household members.
3. Logger households were informed their full instructions would arrive in a FedEx package a day or two prior to their assigned travel dates. This package would also contain GPS logger(s) for household members participating with a logger.
4. Approximately two days prior to their assigned travel dates, participants received a FedEx package containing GPS logger(s) and full study instructions for all household members.
5. SRBI periodically sent WestGroup a FedEx tracking file to have on-hand to assist respondents reporting they had not received the survey package.
6. Logger-specific troubleshooting and correction (including user error, malfunctioning devices, household members incorrectly using each other's devices, devices not initially programmed prior to shipment/not transmitting travel information).

7. Logger/travel date reassignment; logger recovery and reassignment for households with malfunctioning devices, as well as for households and individual household members registered to use the app initially but that needed to change to logger for some reason (compatibility issues, lost or broken phone, etc.) Note: this process was lengthy as device reissuance turnaround time ran from 3-4 weeks up to six weeks.
8. Logger recovery – phone and email communication with households to recover loggers prior to issuing incentive (including providing additional return shipping labels).

Figure C.9 GPS Logger Household Instruction Letter



FIRST NAME LAST NAME
 ADDRESS 1
 ADDRESS 2
 ADDRESS 3

Thank you for participating in this important travel study. Included are your selected travel dates, assigned methods for recording travel, GPS Logger(s) and charger(s), and all necessary instructions.

You have chosen to travel < ASSN > and < ASSN1 >. For these TWO DAYS, all household members 13 and older must carry their GPS Logger or Smartphone whenever they leave home, even for walks or bike trips.

To Download the Smartphone GPS app:

iPhone users: Search MMMonitor in the App Store

Android users: Search Mobile Market Monitor in Google Play/Play Store.



ALL: Each smart phone user needs to download and open the App. SIGN IN: Enter the assigned App Code (PAC) from the chart below as both Username and Password.

To Verify Travel:

Go to www.magtravelsurvey.org and click "VERIFY". Enter this PIN: <<PIN >> and select a name from the drop down list to verify travel for each person in an online GPS diary. App users may verify travel directly through the app by clicking "DIARY".

To access the **Online Child Diary** for children ages 6-12, select their name and submit travel for the same day.

Getting Your Incentive:

To qualify for the incentive, your entire household must collect GPS travel data for TWO of the SAME days, verify travel for the SAME day, and return any GPS Loggers using the enclosed, stamped envelope. **After these requirements are met we will send your household its incentive of \$< INAMT >.**

Your participation is very important and sincerely appreciated.

Assigned Method of Recording Travel

Household Member Name	Record Travel by:	Participant Access Code (PAC)	Household Member Name	Record Travel by:	Participant Access Code (PAC)
Name1	Mode1	Code1	Name7	Mode1	Code1
Name2	Mode2	Code2	Name8	Mode2	Code2
Name3	Mode3	Code3	Name9	Mode3	Code3
Name4	Mode4	Code4	Name10	Mode4	Code4
Name5	Mode5	Code5	Name11	Mode5	Code5
Name6	Mode6	Code6	Name12	Mode6	Code6

Questions or Concerns? Contact our Helpline at 602-707-0085
 Online Help available at: www.MAGTravelSurvey.org

C.2 Optimum HQ

After a brief pilot in late 2015, the teams working with MAG identified numerous areas where automation could assist them in data gathering, transfer, and reporting amongst the teams; and communications, tracking, and signups when dealing with survey participants. Traditional solutions utilizing spreadsheets, shared directories, and constant emails and versioning utilized during the pilot simply wouldn't scale when the full survey and participant counts were taken into consideration. Prior to the implementation of HQ, household status reports were generated at the beginning of each travel day; these reports were used for household prioritization and staffing assignments. However, this method was a significant barrier to staff efficiency, as many household statuses changed significantly throughout the day, rendering these reports outdated very quickly.

The team purchased Optimum HQ service to assist in automating the process. OptimumHQ is a no or low code platform in which organizations can tailor solutions that fit their business needs rapidly and without the need for teams of developers and lengthy development cycles. Optimum HQ was developed to streamline project management through utilization of a project database, as well as automate data gathering, transfer, and reporting among consultant teams. With OptimumHQ, every aspect of the survey and data collection was automated through robotic process automation (RPA) and with API integrations with supporting vendors. Meanwhile, human efforts were focused on strategy and escalation of participant support functions rather than the day-to-day operational needs around data.

Optimum HQ allowed for the following:

- Manage staffing assignments and communication:
 - Real-time prioritization and coding of households so staff could proceed according to current status/information, as shown in Figure C.10.
 - Ability to assign each staff member a “caseload” of households to contact each shift.
 - Documentation of all staff communication/interventions with households (all touchpoints).
 - Integration with data collection partners to manage and track the distribution of loggers as well as monitor the status of the APP download and travel status of all households
 - Monitor daily/weekly scheduled travel to allow for distribution across days of the week as well as manage staffing and overall system demands.
- Automation:
 - Project status reporting.
 - Data transfer among consultant teams.
 - Communication with respondents.
 - » Registration confirmations.
 - » Study instructions.

- » Email reminders.
- » Text reminders.
- Monitoring of data collection effort:
 - Ongoing ability to track and monitor quota groups

Provided client with 24/7, real-time status of data collection efforts by outreach mode and access to key data exports, as shown in

- Figure C.11.
- Allowed project team to document champion communications and outreach efforts as well as monitor impact of outreach efforts on recruitment rates

Figure C.10 Optimum HQ Real-Time Household Status Tracking

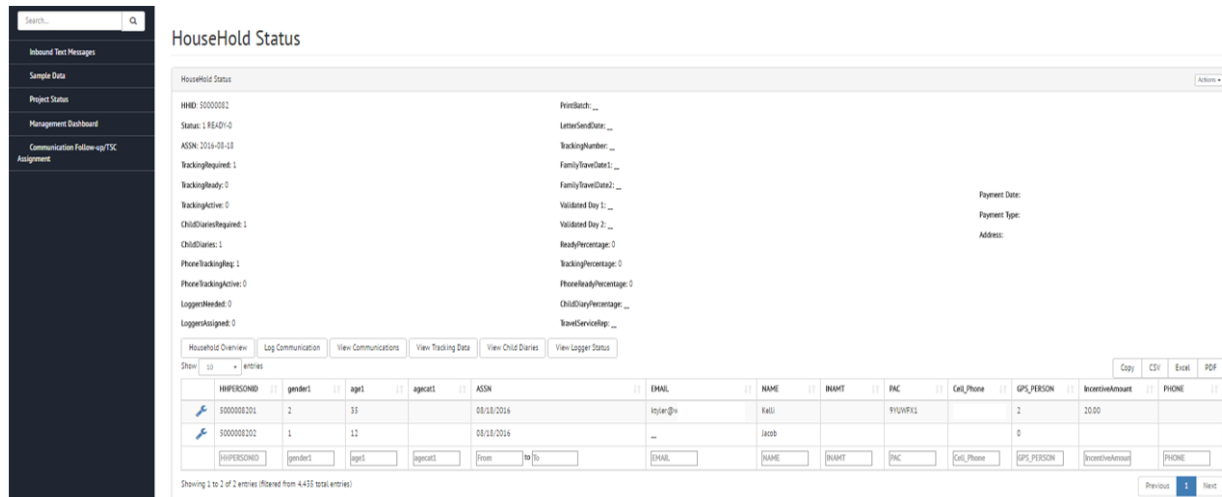
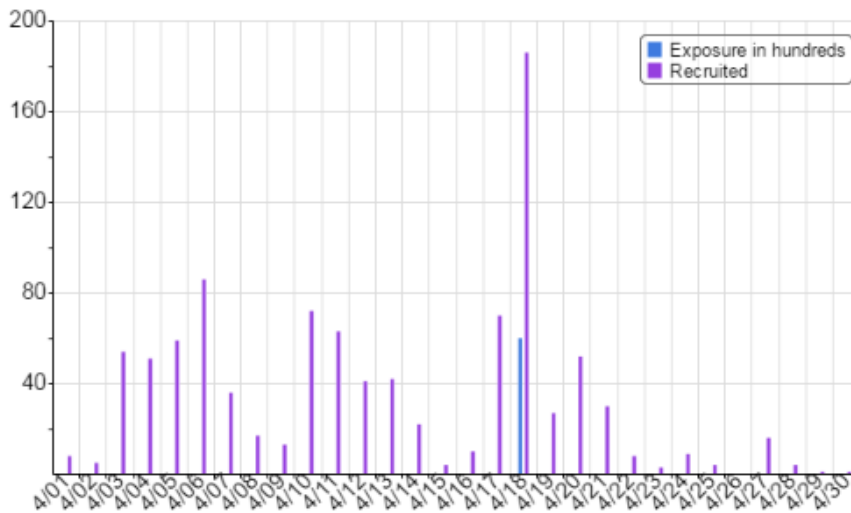


Figure C.11 Optimum HQ Real-Time Exposure and Recruitment Numbers by Date

C.3 Travel Survey Coordinators

During the pilot test, only fifteen percent of households completed all study requirements with no staff assistance. It was clear that providing participants with adequate, timely, and easy to access support would be vital to increase the percentage that successfully completed all study requirements. It was critical to remove the unique barriers each household encountered to keep them engaged and “get them to complete.” As a result, the position of “Travel Study Coordinator” was developed to provide a “high touch”, “hands on” approach to improve not only the participant experience but also maximize the completion rate.

Travel Study Coordinators (TSCs) provided participants with multi-faceted assistance throughout every phase of the study in order to maximize the completion rate of recruited households. They provided the following support:

- Assistance with recruit survey completion:
 - Completion over the phone as requested.
 - Verifying/providing respondents with survey PIN numbers.
- Customer service:
 - Answering FAQs (via helpline, live chat, and email) about all aspects of the study including privacy concerns, study eligibility and requirements, and incentives.
 - Establishing rapport with participants to increase household engagement and encourage study participation.
- Technology troubleshooting.

- Basic smartphone issues: downloading and logging into the app, enabling location services.
- App issues: password difficulties, phone incompatibilities.
- GPS loggers: malfunctioning loggers, user error.
- Targeted interventions:
 - High priority households: certain demographics (such as large households or Spanish-speaking households) were coded as high priority due to exceptionally low recruitment numbers or statistics indicating additional barriers to successful study completion.
 - Households with partial study involvement: many households successfully completed some aspects of the study (typically partial collection or verification of GPS data) without independently completing all requirements. Prompt intervention (communication with households including reminders, additional instructions, and assistance when needed) proved very effective at converting households to complete status.
 - Travel verification assistance, including editing GPS travel data as needed to remove phantom stops or add in missed travel details.
- Travel Study Coordinator interaction with MMMonitor Application.
 - Troubleshooting for participants experiencing difficulties with MMM Application (user error, compatibility issues, download challenges).
 - TSCs had “backdoor” access to the SMS interface in MMM through an “impersonate” functionality. This allowed TSCs to see the GPS data of study participants.
 - This access made it possible for TSCs to identify participants requiring assistance/intervention due to insufficient travel data or provide households with assistance in verifying travel data. Levels of assistance ranged from providing additional instructions to full staff verification of all household travel.
 - Execute a full “human” check of all households documented as “complete” by automated system.

Equipped with Optimum HQ’s resources, the Travel Study Coordinator team successfully monitored the progress of study participants to maximize engagement and the final completion rate. Due to consistently lower than expected recruitment rates, this staff was the critical mitigating force for increased participant retention and survey completion. They achieved this by delivering engaging customer service, efficient problem solving, and responsive communication. HQ allowed the staff to leverage automated communication and processes so coordinator efforts were highly targeted and highly efficient and focused on retention, completion, and high quality data.

This strategy resulted in an impressive retention rate for recruited households: approximately 60% of recruited households successfully met all study requirements; even more notably, of households who reached the GPS data collection phase of the study, nearly all (97%) remained engaged through study completion. Travel Study Coordinators were cost-effective in that they vastly increased retention and the completion rate, improved data quality, and were efficient due to support from an automated and organized system.

Appendix D. Imputation of Missing Data

Despite the best efforts to minimize missing data in a household travel survey, every survey will have missing or erroneous data that could reduce the effective sample size of the survey. The 2017 HTS data also contains missing data, particularly for some sensitive household or person attributes (for example, household income). The survey protocol strived to get respondents to answer all questions in the survey; however, missing data is inevitable in a household travel survey of this nature. When respondents are uncomfortable or unwilling to disclose certain information, they may choose responses such as “Not sure”, “Rather not say”, “Prefer not to provide”, or “Other” in the survey.

In some instances, missing data can be easily imputed through logic checks. To the degree possible, missing data was imputed for a number of attributes where logical consistency checks provided an obvious value to fill the gap in data. These logic checks were effective in taking care of all attributes where the amount of missing data is small. Any remaining missing data is of such small degree that the loss of sample is not of concern. However, the one variable where this is a more serious issue and logic consistency checks cannot offer an imputation mechanism is that of household income. Household income is a very important variable for transportation modeling, travel behavior analysis, and weighting and expansion of data to match population distributions and totals. Imputing household income is an important step in ensuring maximum recovery and utilization of sample from the survey. Prior to execution of the weighting and expansion step, a household income imputation process was developed and applied. A multinomial logit (MNL) model of household income level was estimated using observations in the survey sample that provided household income information. The model was then applied using Monte Carlo simulation techniques to predict or estimate an income value for households that did not provide a valid household income. The details of the imputation procedure is described in this section.

D.1 Development of Model to Impute Missing Income

A multinomial logit (MNL) model was specified and estimated to impute income for households that did not furnish income data. The HTS includes a total of 6,307 households that provided complete and validated travel survey data. Of these households, 777 did not report income or had missing person-level data for critical variables such as age, gender, education, employment status, and/or race (which could be used as predictors of income). It was found that 5,530 households reported complete information for all critical variables of interest (including income) in the survey. Therefore, the multinomial logit (MNL) model of household income is estimated using 5,530 household observations.

The MNL model specification includes variables related to the income levels of other households in the vicinity of the household with missing income to capture spatial interaction and agglomeration effects. In addition, variables that describe employment status, education attainment, household race, vehicle ownership, household lifecycle stage and structure/composition, number of adults/retired persons, and age of children are included as explanatory variables. More detailed explanations of the explanatory variables in the income model are provided in this section.

Employment and Education of Household Members

The first set of variables to consider for an income imputation model is the number of household members by employment status (part time or full time) and education attainment level (low, college, or graduate). Education attainment level and employment status are generally expected to be highly correlated with the

level of income. For example, full time employment and higher levels of education are likely to be associated with higher levels of annual income. Specific definitions for the work status and education attainment level are listed below:

- Work status is collected in the survey. The question in the survey asked respondents to choose one of 11 options. The variable is aggregated into three categories, namely, unemployed, employed part-time, or employed full-time.
- Level of education attainment was grouped into three categories: 1) low education (persons with no college level education), 2) college education (this category includes a bachelor or associate degree, or completed vocational or technical training), and 3) high education (persons who achieved a graduate degree or greater).

The variables were combined using interaction terms to reflect the interaction between education level and work status in influencing income. As employment status and education level are person-level variables, household level indicators were derived by aggregating person level data to obtain the number of individuals in the household that fall into various joint education-employment classes.

Lifecycle Indicators

The income imputation model includes a set of variables related to the structure of households; these are also referred to as lifecycle variables. In this model estimation effort, the number of adults, number of retired adults, and the age of the youngest child in the household were used as explanatory variables. It is likely that lifecycle stage and household structure are closely related to household income. For example, income may increase with the number of working-age adults, younger households may have lower income than more mature households; and the presence of a very young child at home may influence labor force participation decisions – which in turn affect household income. Households with retired adults may have lower household income compared with those who do not have retired adults. Lifecycle indicator variables are defined as follows:

- Number of adults in households: This variable is grouped into two categories, namely, one adult households, and two or more adult households. Adults are those who are 18 years or older.
- Number of retired adults in households: This variable is grouped into two categories, namely, one retired adult, and two or more retired adults.
- Child age: The age of the youngest child in the household is considered as an indicator of lifecycle stage and household structure. The child age is grouped into three categories: 0 – 5 years, 6 – 15 years, and 16 – 17 years.

Eight lifecycle indicator variables are considered for estimating an income imputation model by combining three factors (number of adults, youngest child age group, and number of retired adults): 1) household with one adult and no children, 2) household with one adult and youngest child age 0 through 5 year, 3) household with 2+ adults and youngest child age 0 through 5 year, 4) household with one adult and youngest child age 6 through 15 year, 5) household with 2+ adults and youngest child age 6 through 15 year, 6) household with 2+ adults and youngest child age 16 through 17 year, 7) household with one retired adult and no children, and 8) household with 2+ retired adults and no children.

Household Vehicle Ownership

The count of household vehicles is used as an explanatory variable for income imputation. Despite a very mature state of car ownership in many markets in the country, there remains a fairly strong correlation between household vehicle ownership and household income. Household vehicle information collected in the survey is aggregated into three categories: 0, 1, or 2+ vehicle counts.

Income Distribution of Surrounding Households

The last set of variables included in the model corresponds to the income distribution of surrounding households. Household income may show spatial patterns where households of similar income levels tend to cluster together in neighborhoods. These spatial correlation patterns can be captured in a simple way by including information about income distribution of households in the vicinity of the household in question. The 2017 MAG SE data includes information about the number of households in each income quintile group at the TAZ level. Based on this information, it is possible to derive county-level income quintile group definitions. Household home locations are available in the 2017 HTS data. Using a GIS software, TAZ level income attributes are merged to the HTS household samples. The variable is defined by the proportion of households that fall within each income quintile group (county-level income quintiles) in the TAZ in which the household is located.

D.2 Model Estimation Results

The MNL model considers 18 income categories as follows: 1) Less than \$5,000; 2) \$5,000 - \$9,999; 3) \$10,000 - \$14,999; 4) \$15,000 - \$19,999; 5) \$20,000 - \$24,999; 6) \$25,000 - \$29,999; 7) \$30,000 - \$34,999; 8) \$35,000 - \$39,999; 9) \$40,000 - \$44,999; 10) \$45,000 - \$49,999; and 11) \$50,000 - \$59,999; 12) \$60,000 - \$74,999; 13) \$75,000 - \$99,999; 14) \$100,000 - \$124,999; 15) \$125,000 - \$149,999; 16) \$150,000 - \$199,999; 17) \$200,000 - \$249,999; and 18) \$250,000 or more. The last income category (\$250,000 or more) is used as the base for model estimation. The MNL model is estimated on 5,530 household observations. The model consists of 124 parameters with 17 constants. In order to check goodness of fit, log-likelihood values are examined and the final model is compared with a constants-only model. The goodness-of-fit statistics indicate that the final model is suitable for imputing household income (see Table D.1).

Table D.1 Goodness of Fit for the Final MNL Model of Household Income

Statistics	Value
Number of observations	5,530
Log-likelihood value at convergence: final model	-12482.43
Log-likelihood value at convergence: constants-only model	-14861.65
Number of parameters: final model	124
Number of constants	17
Likelihood ratio chi-square statistic	4758.44
Degrees of freedom (DOF)	107
Critical chi-square value (DOF = 107, level of significance = 0.001)	157.952

Table D.1 presents estimation results for the final MNL model of household income used to predict income for the households who did not report income. Overall, the model offered results that were along expected lines and captured the intrinsic associations between socio-economic and demographic variables on the one hand and household income levels on the other hand. By considering an 18 category income variable, the model is able to impute household income at a rather disaggregate resolution. The estimated model is next applied in a microsimulation mode to impute household income for those households that did not report income in the household survey. An interpretation of the model estimation results is provided below:

Household Vehicle Ownership

Household vehicle ownership is found to be strongly associated with household income with a very discernible pattern. Lower household vehicle ownership levels are associated with lower income levels while higher household vehicle ownership is associated with higher income levels. Thus, despite the model region exhibiting high levels of vehicle ownership, there is a strong association between vehicle ownership and household income.

Employment Status and Education Attainment of Household Members

Households characterized by individuals who are part-time workers and have lower levels of education are likely to exhibit lower levels of income. On the other hand, households with more full time workers who have a higher education level are likely to fall into higher income groups. There is a discernible trend that households with more full time workers are more likely to belong to high income groups regardless of the level of education attainment (although full time employment status and education level are likely to be correlated themselves). The presence of individuals with higher education attainment level also contributes to higher income levels for households, regardless of whether the individuals are part-time or full-time workers.

Lifecycle Indicators

Households with one adult and no children are more likely to fall into lower income groups. An interesting finding is that households with retired adults and no children are likely to belong to a high income group, possibly due to wealthy retired households in the valley. In the estimation results, it is hard to find any trend of household income related with youngest child age groups in the households. Some of the other trends are not as clear-cut, but in general, it appears that households with children are more likely to fall into the middle income categories as expected. Households with 2+ adults (more nuclear-family households) are likely to fall into middle-income categories, while households with 1 adult and children (single parent households) are less likely to belong to higher income groups as evidenced by the string of negative coefficients for high income categories for this market segment. .

Income Distribution of Surrounding Households

Spatial agglomeration effects are captured through the introduction of variables that depict the proportion of households falling into different quintile groups within the residence TAZ of the household in question. As expected, there are strong spatial association effects. The variable representing the percent of households in the lowest income quintile contributes positively toward the likelihood that the household in question falls into lower income categories. Similarly, the variable representing the percent of households that fall into the middle income quintile is positively associated with households falling into the middle income groups.

Interestingly, however, the percent of households falling into the highest income quintile does not significantly impact the likelihood that a household falls into different income categories. Only one category (\$40,000 - \$44,999) depicts a negative coefficient for this highest income quintile variable, suggesting that the spatial association may be weaker at higher income levels. It is also found that the percent of households in income quintiles 2 and 4 did not significantly impact the likelihood that households fall into specific income categories at all. It is possible that the other variables included in the data set were able to capture some of the spatial association effects represented by these income distribution variables.

Table D.1 Estimation Results for Multinomial Logit Model of Household Income

<i>Income Category Alternatives</i>	<i>Constant</i>	<i>Vehicle Ownership</i>	<i># of Full time low educated workers</i>	<i># of Full time college educated workers</i>	<i># of Full time graduate workers</i>	<i># of Part time low educated workers</i>	<i># of Part time college educated workers</i>	<i># of Part time graduate workers</i>
Less than \$5K	2.96 (9.41)	-1.82 (-12.15)		-3.75 (-8.85)	-4.02 (-3.98)	1.16 (4.25)		-2.95 (-2.89)
\$5K - \$9,999	2.25 (6.73)	-1.88 (-11.52)		-2.27 (-6.61)		1.96 (7.33)	1.39 (8.9)	-1.95 (-1.92)
\$10K - \$14,999	2.6 (9.29)	-1.79 (-11.17)		-1.36 (-5.5)		1.53 (5.27)	1.16 (7.31)	
\$15K - \$19,999	3.11 (13.38)	-1.33 (-9.08)		-1.58 (-6.98)	-3.28 (-3.25)	1.05 (3.49)	0.66 (3.99)	
\$20K - \$24,999	2.93 (13.06)	-1.09 (-8.51)	0.91 (2.57)	-0.72 (-4.47)	-2.02 (-3.89)			
\$25K - \$29,999	2.34 (10.48)	-1.08 (-8.23)	1.65 (5.08)			0.59 (1.87)		
\$30K - \$34,999	2.02 (9.17)	-0.71 (-5.82)	1.75 (5.56)			0.55 (1.83)		
\$35K - \$39,999	2.27 (10.81)	-0.79 (-7.01)	1.57 (5.08)					
\$40K - \$44,999	1.31 (4.27)	-0.57 (-5.44)	1.43 (4.43)	0.39 (2.89)	1.18 (6.24)			-1.53 (-2.15)
\$45K - \$49,999	1.35 (6.15)	-0.3 (-3.14)	1.49 (4.66)	0.33 (2.51)	1.44 (8.18)			
\$50K - \$59,999	0.79 (3.55)		1.84 (6.45)	0.56 (5.03)	1.51 (9.62)			
\$60K - \$74,999	0.8 (3.72)		1.71 (5.96)	0.92 (8.77)	1.7 (11.16)			
\$75K - \$99,999	0.7 (3.24)	0.27 (4.25)	1.99 (7.15)	1.19 (11.59)	2.33 (16.04)			
\$100K - \$124,999	0.05 (0.2)	0.38 (5.29)	1.8 (6.1)	1.2 (10.67)	2.5 (16.2)			
\$125K - \$149,999	-0.68 (-2.13)	0.71 (8.81)	1.3 (3.65)	1.24 (9.4)	2.82 (16.6)			
\$150K - \$199,999	-1.23 (-3.48)	0.79 (9.04)	1.06 (2.71)	1.1 (7.78)	2.79 (15.78)			
\$200K - \$249,999	-4.05 (-9.94)	0.84 (6.75)	1.61 (3.11)	1.76 (8.96)	3.31 (13.79)			
≥ \$250K	Fixed							

Income Category Alternatives	Lifecycle Indicators						Income Distribution of Surrounding Households			Hispanic Household
	HH with 1 adult, no children	HH with 2+ adults, youngest child age 0-5	HH with 1 adult, youngest child age 6-15	HH with 2+ adult, youngest child age 6-15	HH with 1 retired adult, no children	HH with 2+ retired adults, no children	% of HH in the TAZ with income quintile 1	% of HH in the TAZ with income quintile 3	% of HH in the TAZ with income quintile 5	
Less than \$5K	1.38 (6.53)				-3.93 (-3.89)		1.8 (4.13)			1.06 (4.83)
\$5K - \$9,999	0.86 (4.12)				-1.85 (-3.08)		1.96 (4.11)			1.05 (4.54)
\$10K - \$14,999				-2.03 (-2.0)			2.26 (4.57)			0.93 (3.8)
\$15K - \$19,999										0.63 (2.38)
\$20K - \$24,999										1.09 (5.13)
\$25K - \$29,999										0.92 (4.26)
\$30K - \$34,999				-0.88 (-2.71)						0.89 (4.23)
\$35K - \$39,999		0.44 (1.99)								0.83 (4.23)
\$40K - \$44,999								3.71 (3.9)	-1.52 (-2.93)	0.79 (4.35)
\$45K - \$49,999										0.77 (4.27)
\$50K - \$59,999				-0.51 (-3.51)				2.63 (3.6)		0.47 (3.1)
\$60K - \$74,999		0.56 (4.82)	-0.37 (-1.97)					1.7 (2.54)		
\$75K - \$99,999	-0.42 (-3.25)	0.31 (3.1)	-0.69 (-3.39)							
\$100K - \$124,999	-0.8 (-4.7)		-1.28 (-4.13)							
\$125K - \$149,999	-0.74 (-3.08)		-1.27 (-2.7)					-3.96 (-4.43)		
\$150K - \$199,999	-1.26 (-3.81)		-1.02 (-2.15)		1.85 (3.06)			-2.52 (-2.54)		
\$200K - \$249,999						1.49 (3.22)				
≥ \$250K	Fixed									

D.3 Application of Multinomial Logit Model to Impute Missing Income

The MNL model is applied to impute household income for 516 households that did not provide income information, but provided complete information for other variables that are included in the multinomial logit model of household income. The survey dataset actually includes 543 households with no income information. However, 27 out of 543 households had missing data on other critical variables such as race, education attainment level, employment status, and/or age. Hence, the estimated model cannot be applied to obtain imputed income values for the 27 households. There are two steps involved in imputing household income values for each household that has missing income; the two steps are:

- First, the multinomial logit model is applied to compute the probability that a household, based on its attributes, belongs to each of the 18 income categories.
- Second, a Monte Carlo simulation approach is deployed to predict or simulate the income category into which the household falls. This Monte Carlo simulation approach simulates or predicts income category for each household based on the probabilities estimated in Step 1.

After predicting income for the 516 households that did not report household income, a household income replication check was performed to determine the extent to which the model is able to effectively replicate household income distributions in the survey sample. Note that the replication exercise is performed on the very same sample that is used for model estimation; hence this exercise should be treated as a sample replication process as opposed to a strict model validation process. Nevertheless, a sample replication exercise provides good insights on the effectiveness of the model to replicate income distribution patterns in the sample. In addition to predicting household income for the 516 households with missing income data, household income is also estimated using the model for the full 5,530 household observations that did report household income. The set of figures furnished below show results of the replication exercise, depicting distributions of household income for different market segments defined by Hispanic race and vehicle ownership levels.

The MNL model is found to provide reasonable predictions of household income. Figure D.1 shows that the model is able to replicate the observed household distribution quite well (for the 5,530 households that reported income). For the 516 households that did not report income, the predicted distribution shows a slight emphasis towards lower income categories; this is completely consistent with expectations in that minority households and lower income households are more likely to have missing income data and hence the predicted values for the 516 households will show a skew towards lower income categories. Figure D.2 through Figure D.4 show comparison between observed income distribution, predicted distribution for the households that reported income (replication), and predicted distribution for households that did not report income by vehicle ownership class. In Figure D.2, the predicted distribution corresponds to just 33 households with missing income that fall into the zero-vehicle class. As expected, it is found that these households are skewed towards the lower income categories. Somewhat similar patterns are seen in Figure D.3 and Figure D.4. In general, the predicted distributions for households that have missing income show a pattern where the households are more likely to belong to lower income categories. Figure D.5 and Figure D.6 present comparisons for the two race groups – Hispanic and Non-Hispanic households. Consistent with expectations, Hispanic households are predicted to fall into lower income groups (see Figure D.6). This pattern is not as pronounced for non-Hispanic households, which is consistent with expectations. The model is able to replicate the income distribution pattern for those households that reported income quite well, suggesting that the predictions on households that did not report income are likely to be reasonably

consistent with actual income distribution patterns. The predicted income values were imputed for the 516 households, and the entire sample was then used for weighting and expansion.

Figure D.1 Household Income Distribution for Observed vs Imputed Sample
All Households

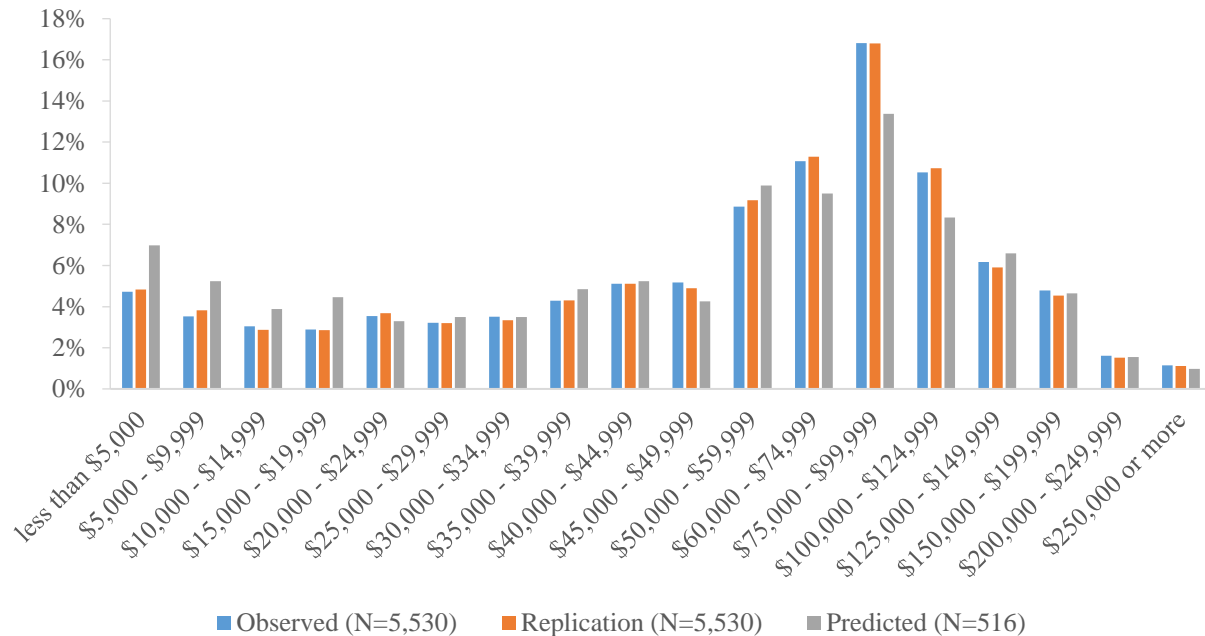


Figure D.2 Household Income Distribution for Observed vs Imputed Sample
Zero Vehicle Households



Figure D.3 Household Income Distribution for Observed vs Imputed Sample
One Vehicle Households

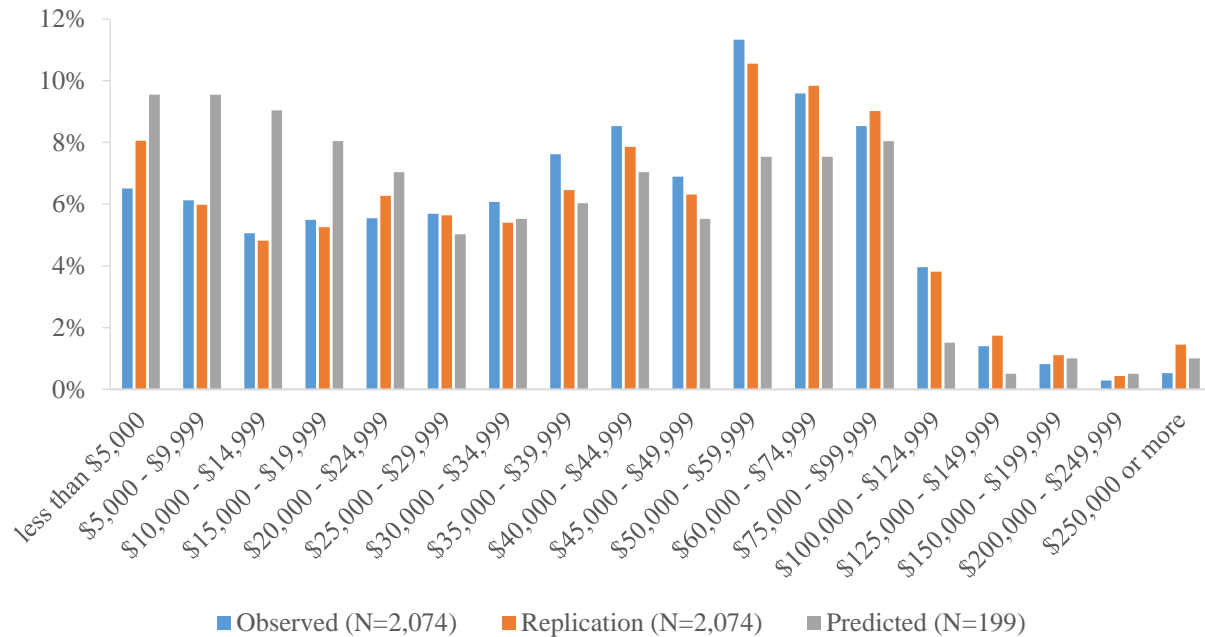


Figure D.4 Household Income Distribution for Observed vs Imputed Sample
Two or More Vehicle Households

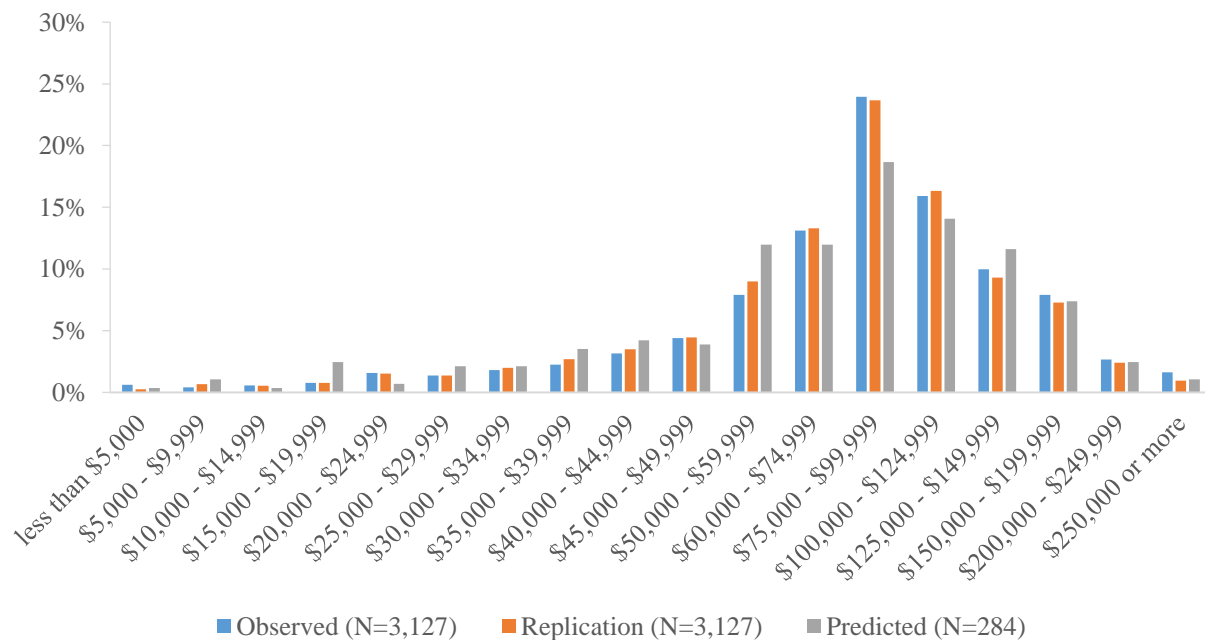


Figure D.5 Household Income Distribution for Observed vs Imputed Sample
Non-Hispanic Households

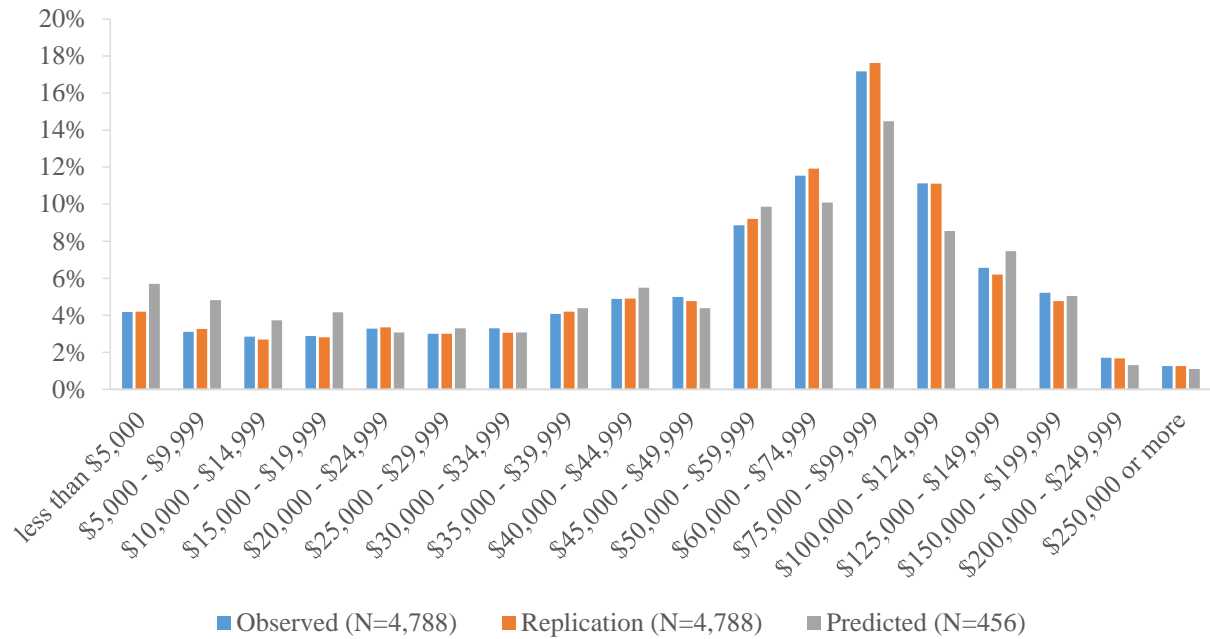


Figure D.6 Household Income Distribution for Observed vs Imputed Sample
Hispanic Households

