AIRPORT TRAVEL MODEL UPDATE AND DATA COLLECTION

PHX
PHOENIX SKY HARBOR

PhxMesa Gateway Airport

HDR

MARICOPA ASSOCIATION of GOVERNMENTS

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Acronyms and Abbreviations

ASC	Alternative Specific Constant
AWAM	Anonymous Wireless Address Matching
AZA	Phoenix-Mesa Gateway Airport
LOS	Level of Service
LRT	Light Rail Transit
MAG	Maricopa Association of Governments
PHX	Phoenix Sky Harbor International Airport
TAZ	Traffic Analysis Zone

1.0 Introduction

The Maricopa Association of Governments (MAG) is the metropolitan planning organization for the Phoenix area. The current MAG Regional Travel Forecasting Model is a state-of-the-practice, trip-based, four-step model that estimates travel demand for automobiles and trucks for an average weekday. MAG is developing a regional activity-based model. Both models emphasize special travel generator sub-models such as the Arizona State University sub-model, Phoenix Sky Harbor International Airport (PHX) sub-model, and planned special events models. The special travel generators play a crucial role in regional travel patterns. To update and recalibrate these models, MAG conducted a series of innovative, large-scale special generator surveys, including a regional airports survey, an Arizona State University survey, and a special events survey. Results of the special events survey were presented in previous Transportation Research Board publications. This paper details the data collection approach and methodology used for the regional airports survey, and elaborating on the innovative data collection techniques used to execute the survey.

PHX is the nation's sixth-busiest passenger airport, with more than 40 million passengers in 2012. Its sub-model was updated and calibrated in 2008 based on air passenger and meeter/greeter surveys conducted in 2005. Substantial changes in regional travel demand, the socioeconomic environment, and regional transportation networks necessitated an update to the airport sub-model. Another major factor is the emergence of the Phoenix-Mesa Gateway Airport (AZA) as a significant regional travel generator. Commercial passenger service at this airport grew 33 percent from 2011 to 2012.

Both airports share certain markets, and airport choice affects regional travel patterns. Although PHX will remain the region's largest airport, expansion plans for AZA make it important to explicitly address airport choice issues and to model AZA-related travel at a greater level of detail. These factors—as well as the need for newer data for the airports' planning purposes—led MAG, the City of Phoenix, the City of Mesa, and both airports to initiate a regional airports survey, which was conducted in the spring of 2012. A multiagency technical advisory group provided overall guidance and coordination for the airport surveys.

This study was conducted by MAG with HDR Engineering, Inc., as the prime consultant and with Cambridge Systematics, Inc., WestGroup Research, Inc., and Kevin Tierney as subconsultants. It focused on developing and implementing a plan to collect all aspects of airport data and then using the data to develop a new airport ground access sub-model for AZA and PHX. This new sub-model will provide more detailed forecasts of airport-related travel.

Past Studies

The Transportation Research Board's Airport Cooperative Research Program (ACRP) Report 26: *Guidebook for Conducting Airport User Surveys* is a valuable reference for planning all aspects of air passenger, meeter/greeter, and employee surveys. It summarizes the commonly used data collection approaches and survey data elements. ACRP Synthesis Report 5: *Airport Ground Access Mode Choice Models* describes a range of recent airport ground access modeling efforts and data uses to develop these models. Recent intercept survey efforts by team members at the Minneapolis/St. Paul Airport and at special events venues in the Phoenix area provided lessons for the uses of technology in performing special generator travel surveys at sites with high percentages of regional visitors. Recent Phoenix airport studies include the City of Phoenix Aviation Department's PHX passenger and meeter/greeter survey report and the Williams Gateway Airport Authority's *Airport Master Plan for Phoenix-Mesa Gateway Airport*.

This report details the survey design, sampling plan, survey instruments, data expansion, data collection, traffic data collection, and documents the steps used to create the airport sub-model.

2.0 Survey Design

From the very early stages of survey design, it became clear that a variety of datasets should be collected in a coordinated manner and that different data collection techniques would be needed to satisfy all project goals. Table 2-1 summarizes the various objectives that shaped the survey design; determined data needs, data sources, and sample sizes; and resulted in a complex, coordinated data collection effort completed by MAG staff, both airports, and different consultant teams.

Table 2-1. Survey design inputs

Objective of data collection	Data to be collected	Methodology or data source	Planned sample size
Primary data – mainly for modeling, planning, and analysis			
MAG regional four-step model recalibration and update	Departing air passengers' socioeconomic characteristics and modes of travel to the airport	Intercept surveys at gates	7,200 complete surveys were originally planned, detailed targets determined at the survey design stage
	Meeter/greeter origins and mode of travel	Intercept surveys (waiting areas, curbside, parking lots) and/or web-based surveys	Targets determined at the survey design stage
	Employee's socioeconomic characteristics and modes of travel to the airport	Web-based survey	No sampling required; 100% distribution
MAG activity-based model development	Residents' travel diary on the day of air travel	Intercept surveys at gates	250 completed surveys
	Visitors' survey – full travel diary on the day previous to air travel	Intercept surveys at gates	1,000 samples Residents' average weekday travel covered in the household survey, but limited information on visitors' travel

Objective of data collection	Data to be collected	Methodology or data source	Planned sample size
Transportation planning and traffic analysis at the airports	Speed, travel times, and origins-destinations between terminals	Bluetooth and radar	11 locations surrounding terminals and near airports that allow for analysis of cut-through traffic for transportation planning purposes
Airport planning and traffic analysis at the airports, survey data expansion, and model validation	Traffic counts on the airports' premises and near the airports	Tubes and radar	Locations surrounding terminals and near the airports and model validation
Airport planning and traffic analysis at the airports, survey data expansion, and weighted data validation	Automobile occupancy counts	Windshield and manual methods	Locations surrounding terminals and near the airports
Secondary data – mainly for data expansion and validation			
Employee survey data expansion	Badging and other employee data	City of Phoenix Aviation Department, Phoenix-Mesa Gateway Airport	Full coverage
Survey data analysis, expansion, and validation	Detailed parking information (parking location and check-in/check-out times)	City of Phoenix Aviation Department, Phoenix-Mesa Gateway Airport	Full coverage for the survey days
Survey design and survey expansion by time of day, gate, and terminal	Detailed flight information	Airports, aviation departments, *Official Airline Guide*, airlines, Bureau of Transportation Statistics	All flights on the survey days, as well as the same days in adjacent months and previous year
Survey expansion	Equipment information	Bureau of Transportation Statistics	Seating capacity of different aircraft types

Sampling Plan

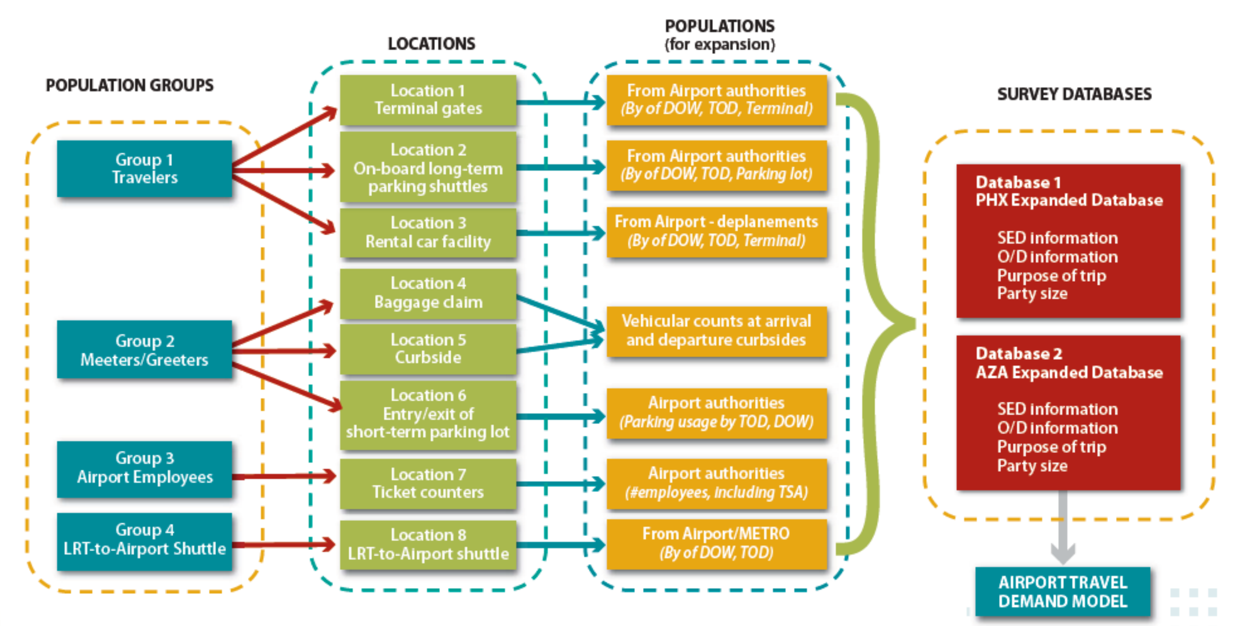
The sampling plan sought to balance the statistical data requirements of the anticipated travel demand modeling and other potential analytical data uses against the practical realities of survey data collection in complicated and fluid airport settings. The goal of the survey task was to achieve at least 6,000 complete surveys. MAG's experience with the special events paper-based intercept survey showed that a 20 percent oversample is necessary to compensate for discarded incomplete surveys, erroneous information, and unusable surveys. With this in mind, the target number of samples to be collected was set at 7,200. This target included surveys collected during pretests. As the data collection progressed, the study team noted that the use of the tablet-based survey resulted in increased accuracy and significantly fewer discarded incomplete surveys. In response to this observation, the original target of 7,200 surveys was reduced at the end of the project.

The decision was made to survey only departing passengers rather than both arriving and departing passengers. Departing passengers frequently are idle once they have arrived at the departure gate, giving the opportunity to conduct the survey, whereas arriving passengers are generally anxious to immediately proceed to their next destination. Additionally, connecting passengers were not surveyed because they would generally not have made use of the airport ground transportation facilities.

Types of Stratifications

The intent of the airport survey was to collect travel information pertaining to the trip and the traveler accessing/egressing the two airports in the MAG region. To better represent the universe of populations using the airports, the desired sample size was stratified, as shown in Figure 2-1.

Figure 2-1. Populations involved in airport survey



The airport user can fall under one of the four population groups:

- travelers (or air passengers)
- meeters/greeters
- airport employees
- light rail transit (LRT)-to-airport shuttle

Travelers, meeters/greeters, and airport employees may also be LRT shuttle users.

Air Passengers

For sampling purposes, the air passengers were stratified by terminal (by airline), primary destination, and time of departure from the two airports. This resulted in a good representation of all kinds of travelers using the two airports.

- PHX – Terminal 2 (Alaska, Great Lakes, United, Continental)
- PHX – Terminal 3 (American, Delta, Frontier, Hawaiian, Northwest, JetBlue, Sun Country)
- PHX – Terminal 4 (US Airways, Southwest)
- PHX – Terminal 4 International (Aeromexico, Air Canada, British Airways, WestJet)
- AZA – Terminal (Allegiant, Spirit)

These air passengers were also stratified by their primary destination, as indicated below. This provided a good sample representation of travelers who use the airports for both business and pleasure.

- Domestic – For travelers who fly to any destination within the United States. This included day-trippers who fly in and out on the same day, as well as travelers who are away from Phoenix for more than a day. All terminals at PHX and AZA were potential survey locations to capture these travelers.
- International – For travelers who go abroad (any country other than the United States). This applied only PHX Terminal 4 at the Canadian Airlines, Aeromexico, WestJet, and British Airways gates.

It was also necessary to capture the time period of travel to and from these airports, and this was achieved by sampling different departure times of air passengers based on a review of airport flight data. These departure times reflect the flight departures, not the time travelers departed their origins. The flight departures were thus chosen because precise estimates of number of flights departing in these time periods could be obtained from flight data used for the expansion of the surveys by time period. The time periods included[1]:

- morning peak period – 5 a.m. to 9 a.m. (4 hours)
- midday off-peak period – 9 a.m. to 4 p.m. (7 hours)

[1] These time periods differ from the MAG model time periods and were determined using airport data to better reflect activity at the airport.

- evening peak period – 4 p.m. to 8 p.m. (4 hours)
- late evening – 8 p.m. to midnight

Employees

About 20,000 workers access/egress PHX each day. These employees were grouped into ten major categories based on the nature of the work and their employers, as discussed later in this section. About 1,600 daily workers access/egress AZA and its premises. These employees are those who work at the airport and also those who work adjacent to the airport but travel into/out of the airport premises.

To conserve resources, employee surveys were conducted online. This helped to reserve more intensive survey methods for other target groups, such as air passengers.

Meeters/Greeters

Two types of meeters/greeters were considered: those who drop air passengers off and those who pick air passengers up at the two airports. There was no need to survey meeters/greeters who drop off air passengers because their information was gathered while doing air passenger surveys at the terminal gates in both the airports.

The meeters/greeters who came to the airports to pick up air passengers were intercepted at four locations:

- cell phone lots – tablet or online/mail survey, depending on the cooperation of respondents
- checkpoint waiting areas – tablet or online/mail survey, depending on the cooperation of respondents
- curbside – online only, given the lack of enough time to complete the surveys
- one-question surveys

It was also necessary to capture the time period of travel of the meeters/greeters to and from the airports. This was achieved by surveying during the same time periods as air passenger surveys.

Air Passenger Transit

To gather sufficient information on the access/egress mode of travel to and from airports, the sampling plan also included small quotas for travelers using rental car shuttles, parking at long-term parking lots, and riding LRT shuttles.

Long-Form Trip Diary Surveys

The study team took advantage of this survey effort to collect information on nonresidents' and residents' activity and tour-based airport travel behavior. To obtain information related to all activities and trips made by airport travelers on the day of travel to/from airports, the surveys were presented in the form of a trip diary survey. This was referred to as the long-form survey in the sampling plan memorandum. The following are descriptions of the survey respondents:

- Nonresidents – Visitors who flew into or out of either of the two airports. Nonresidents were asked to provide an entire trip diary for the day prior to the day of departure. This recorded their travel behavior in terms of activities, places visited, start/end times, and modes of travel.
- Residents – Travelers who reside in Arizona for 6 months of the year.

Air Passenger Populations

The air passenger populations were developed using flight schedule data for both PHX and AZA. This information included time of departure, time of arrival, airline, days of the week when the flight was offered, origin or destination airport, and type of aircraft. Because the actual numbers of passengers on each flight was unknown, the number of seats available was used as a proxy for the number of passengers. This information was used to develop summary statistics of passengers.

For PHX travelers, passenger seats were cross-tabulated across direction of travel (inbound and outbound), time of day, terminal, and flight time. International trips, which leave from and arrive at Terminal 4 only, are tabulated separately. In addition, Terminal 4 trips are further segmented by airline (either US Airways or Southwest), since Terminal 4 handles a large number of trips.

For travel distance, trips were divided into short-domestic and long-domestic. Short-domestic trips include all origins/destinations in California, Arizona, Nevada, Utah, Colorado, and New Mexico. They also include El Paso, Texas. Long-domestic trips include all other domestic origins/destinations.

Table 2-2 presents the summary statistics for weekly outbound PHX passengers. Most international trips depart in the midday period. It is important to note that only one international destination served by PHX is outside of North America (London, United Kingdom). International passengers traveling overseas must connect through other airports, and these passengers cannot be distinguished with this dataset. In fact, there would be a substantial number of domestic short-distance passengers that are connecting to domestic long-distance destinations as well. Table 2-3 shows summary statistics for weekly outbound passengers at AZA.

Table 2-2. Summary statistics for outbound PHX air passengers

Time period	Terminal	Distance	Seats/week	Percentage
Morning	International	Long	3,732	0.80
Morning	2	Short	3,606	0.77
Morning	2	Long	8,282	1.78
Morning	3	Short	2,506	0.54
Morning	3	Long	14,551	3.12
Morning	4 – US Airways	Short	16,921	3.63
Morning	4 – US Airways	Long	26,912	5.78
Morning	4 – Southwest	Short	25,936	5.57
Morning	4 - Southwest	Long	11,290	2.42
Midday	International	Long	16,603	3.56
Midday	2	Short	5,689	1.22

Midday	2	Long	10,684	2.29
Midday	3	Short	5,455	1.17
Midday	3	Long	19,745	4.24
Midday	4 – US Airways	Short	37,897	8.13
Midday	4 – US Airways	Long	56,693	12.17
Midday	4 – Southwest	Short	35,142	7.54
Midday	4 - Southwest	Long	30,938	6.64
Evening	International	Long	1,795	0.39
Evening	2	Short	1,638	0.35
Evening	2	Long	4,282	0.92
Evening	3	Short	3,745	0.80
Evening	3	Long	5,027	1.08

Time period	Terminal	Distance	Seats/week	Percentage
Evening	4 – US Airways	Short	22,541	4.84
Evening	4 – US Airways	Long	12,952	2.78
Evening	4 – Southwest	Short	19,202	4.12
Evening	4 – Southwest	Long	14,388	3.09
Nighttime	International	Long	3,072	0.66
Nighttime	2	Short	190	0.04
Nighttime	2	Long	2,267	0.49
Nighttime	3	Short	0	0.00
Nighttime	3	Long	6,090	1.31
Nighttime	4 – US Airways	Short	14,980	3.21
Nighttime	4 – US Airways	Long	9,346	2.01
Nighttime	4 – Southwest	Short	7,426	1.59
Nighttime	4 - Southwest	Long	4,464	0.96

Table 2-3. Summary statistics for outbound AZA air passengers

Time period	Terminal	Distance	Seats/week	Percentage
Morning	Gateway	Short	420	2.57
Morning	Gateway	Long	5,040	30.90
Midday	Gateway	Short	3,248	19.91
Midday	Gateway	Long	4,620	28.32
Evening	Gateway	Short	280	1.72
Evening	Gateway	Long	1,695	10.39
Nighttime	Gateway	Short	1,008	6.18
Nighttime	Gateway	Long	0	0.00

Sample Sizes for Air Passengers

Air passengers, by far, account for the most travel to and from both airports. Therefore, the 2011 actual enplanements and deplanements for March—the peak month for travel—were used to compute required sample sizes for PHX and AZA. These data were obtained from the two airports' websites.

The sample size for PHX air passengers was computed at a 95 percent confidence level and 2 percent precision level, while for AZA it was computed at a 5 percent precision level. Table 2-4 shows total air passengers, by airport, and the desired sample sizes.

Table 2-4. Air passenger volume and desired sample sizes for air passengers

PHX	
Enplanements – March 2011	1,857,081
Deplanements – March 2011	1,880,483
Enplanements per day	59,906
Deplanements per day	60,661
Sample size – enplanements	**2,400**
Sample size – deplanements	**2,401**
Total sample size (at 95% confidence level, 2% precision)	**4,801**
AZA	
Total air passengers – 2011	927,000
Passengers per day	2,540
Sample size (at 95% confidence level, 5% precision)	**346**
PHX share of air passenger sample size	93%
AZA share of air passenger sample size	7%

As indicated in Table 2-4, 4,801 surveys were required from PHX air passengers, while 346 surveys were required from AZA air passengers. PHX air passengers were further segmented by terminal. To accomplish this, the average of actual enplanements and deplanements from PHX for March 2011 was obtained, and the relative percentages were computed for the four terminals: 2, 3, 4, and International. Given the lack of information on actual US Airways and Southwest air passengers, a 50-50 split was assumed at Terminal 4. These percentages were used to stratify the 4,801 survey sample down to sample sizes by terminal, as shown in Table 2-5.

The long-form trip diary surveys for nonresidents and residents were also taken into account in the total samples required from the survey effort. Noting a dearth of nonresident surveys in its datasets, MAG established target sample sizes of 1,000 for nonresidents and 250 for residents. These sample sizes were allocated to different terminals at PHX using the same percentage splits used for the short-form surveys. Table 2-5 shows the sample sizes required for both long-form and short-form surveys, by terminal, at the two airports.

Table 2-5. Sample sizes of air passengers, by terminal

Terminal	Average of enplanements and deplanements (March 2011)	Percentage	Sample sizes	Long form – nonresidents	Long form – residents	Short form sample sizes
Terminal 2	148,238	8	381	74	18	288
Terminal 3	260,107	14	668	130	32	506
Terminal 4 – Domestic	1,347,529	72	3,462	672	168	2,621
Terminal 4 – US Airways *(assume a 50% split)*			1,731	336	84	1,310
Terminal 4 – Southwest *(assume a 50% split)*			1,731	336	84	1,310
Terminal 4 – International	112,909	6	290	56	14	220
		Total for PHX air passengers	**4,801**	**933**	**233**	**3,635**
		Total for AZA air passengers	**346**	**67**	**17**	**262**
		Total for all air passengers	**5,146**	**1,000**	**250**	**3,896**

The discussion and sample sizes presented from this point forward are for the short-form surveys only, which are further stratified by primary destination and time of departure.

To capture all kinds of air passengers traveling to various destinations, the primary destination was also used as another stratification layer in the sample size allocations. This was applied only to PHX Terminal 4, which handles international travelers. These statistics are presented in Tables 2-1 and 2-2 for PHX and AZA airports.

It is also important to get a good sample of air passengers traveling at all times of day. This is essential to both expanding the surveys to appropriate time periods and also to position surveyors at terminal gates during all the four time periods. The time of departure information was derived from the March and April 2012 flight schedules obtained from PHX and AZA. Using a combination of departing seats and flight schedules, the time of departure distributions were obtained as presented in Tables 2-1 and 2-2 for PHX and AZA airports. These distributions were applied to the sample sizes derived from Table 2-5 to obtain desired sample sizes by terminal, primary destination, and time of departure for both airports (see Table 2-6).

Table 2-6. Sample sizes of air passengers, by terminal, primary destination, and time of departure

Terminal	Time of departure			Percentage	Sample size
PHX					
Terminal 2	Morning (5 a.m. to 9 a.m.)	11,888	—	32	94
	Midday (9 a.m. to 4 p.m.)	16,373	—	45	129
	Evening (4 p.m. to 8 p.m.)	5,920	—	16	47
	Nighttime (8 p.m. to 12 a.m.)	2,457	36,638	7	19
Terminal 3	Morning	17,057	—	30	154
	Midday	25,200	—	45	227
	Evening	8,772	—	16	79
	Nighttime	5,027	56,056	9	45
Terminal 4 – US Airways	Morning	43,833	—	22	290
	Midday	94,590	—	48	625
	Evening	35,493	—	18	235
	Nighttime	24,326	198,242	12	161
Terminal 4 – Southwest	Morning	37,226		25	328
	Midday	66,080		44	582
	Evening	33,590		23	296
	Nighttime	11,890	148,786	8	105
Terminal 4 – International	Morning	3,732		15	33
	Midday	16,603		66	145
	Evening	1,795		7	16
	Nighttime	3,072	25,202	12	27
				Total for PHX air passengers	**3,635**
AZA					
	Morning	5,460	—	33	88
	Midday	7,868	—	48	126
	Evening	1,975	—	12	32
	Nighttime	1,008	16,311	6	16
				Total for AZA air passengers	**262**
				Total for air passengers	**3,896**

To ensure that the sample sizes presented above in Table 2-6 would yield statistically significant model components, precision levels (or margins of error) at the 95 percent confidence level were computed for each sample size quota. For small sample sizes, these were increased to 100 so a reasonable precision level could be established. The revised sample size quotas are presented in Table 2-7, along with precision levels.

Table 2-7. Revised sample sizes with precision levels at 95 percent confidence level

Location	Time of day	Bumped up low sample sizes	Precision or margin of error (+/–) at 95% confidence level
PHX			
Terminal 2	Morning (5 a.m. to 9 a.m.)	100	10%
	Midday (9 a.m. to 4 p.m.)	129	9%
	Evening (4 p.m. to 8 p.m.)	100	10%
	Nighttime (8 p.m. to 12 a.m.)	100	10%
	Total for Terminal 2	**429**	
Terminal 3	Morning	154	8%
	Midday	227	7%
	Evening	100	10%
	Nighttime	100	10%
	Total for Terminal 3	**581**	
Terminal 4 – US Airways	Morning	290	6%
	Midday	625	4%
	Evening	235	7%
	Nighttime	161	8%
	Total for Terminal 4 – US Airways	**1,310**	
Terminal 4 – Southwest	Morning	328	5%
	Midday	582	4%
	Evening	296	6%
	Nighttime	105	10%
	Total for Terminal 4 – Southwest	**1,310**	
Terminal 4 – International	Morning	100	10%
	Midday	145	8%
	Evening	100	10%
	Nighttime	100	10%
	Total for Terminal 4 – International	**445**	
	Total for PHX	**4,076**	
AZA			
	Morning	75	11%
	Midday	126	9%
	Evening	60	13%
	Nighttime	60	13%
	Total for AZA	**321**	
	Total for air passengers	**4,397**	

A significant portion of PHX air passengers ride the LRT, park at the long-term parking lots, and use rental cars to access and egress the airport. To get a good sample of these riders, additional surveys were conducted on the LRT shuttle, long-term parking lot shuttles, and the rental car shuttle. A sample of 100 surveys each—LRT shuttle, long-term parking shuttle, and rental car shuttle—were conducted throughout the day. The number of surveys was spread evenly across the four major time periods, as shown in Table 2-8. Sampling for the LRT and rental car shuttles was pretested to determine whether sufficient time was available to conduct an on-board interview between stops.

Table 2-8. Sample sizes of PHX air passengers riding shuttles

Location	Time of departure	Percentage	Sample size	Precision levels at 95% confidence level
Onboard LRT shuttle	Morning (5 a.m. to 9 a.m.)	25	25	
	Midday (9 a.m. to 4 p.m.)	25	25	
	Evening (4 p.m. to 8 p.m.)	25	25	
	Nighttime (8 p.m. to 12 a.m.)	25	25	
		Total for PHX onboard LRT shuttle	**100**	**10%**
Onboard long-term parking lot shuttle	Morning	25	25	
	Midday	25	25	
	Evening	25	25	
	Nighttime	25	25	
		Total for PHX long-term parking lot shuttle	**100**	**10%**
Onboard rental car shuttle	Morning	25	25	
	Midday	25	25	
	Evening	25	25	
	Nighttime	25	25	
		Total for PHX onboard rental car shuttle	**100**	**10%**

Sample Sizes for Employees

The total number of employees at the two airports was derived from the badge file. Tables 2-9 and 2-10 show the distribution of employees by major employer category. The required sample sizes for these two airports was computed at the 95 percent confidence interval, and at the 5 percent and 10 percent precision levels, respectively, for PHX and AZA (shown in Table 2-11).

Table 2-9. PHX employees, by category

Category	Description	Employee count
AC	Airline	968
AIR	Airline	5,341
CON	Concessions	1,462
COP	City of Phoenix	1,497
CTR	Contractor	4,949
FBO	Fixed based operator	250
FG	Federal government	1,674
GA	General aviation	84
GT	Ground transportation	2,980
LEO	Law enforcement officer	232
VEN	Vendor	216
	Total PHX employees	**19,653**

Table 2-10. AZA employees, by category

Category	Employee count
Airport staff	114
Airline	168
Airline service provider	118
Based aircraft owner	111
Contractor	175
Federal government	118
Fire department	33
Law enforcement officer	36
School	285
Tenant	330
Test group	151
Vendor	5
Total AZA employees	**1,644**

Table 2-11. Sample sizes for PHX and AZA employees

Airport	Number of employees	Sample size	Confidence and precision level
PHX	19,653	392	95% confidence, 5% precision
AZA	1,644	94	95% confidence, 10% precision

Sample Sizes for Meeters/Greeters

As indicated earlier, meeters/greeters who drop off air passengers were not intercepted because their modes of travel were captured at the terminal gates through the air passenger surveys.

The meeters/greeters who pick up air passengers were captured at two locations: cell phone lots and curbside. The desired sample sizes for this group were estimated from what was left over after allocating sample sizes for air passengers and airport employees, as shown in Table 2-12. A leftover sample of 767 was used as the target for the meeters/greeters at both airports, which was further split for PHX and AZA using relative shares of air passenger samples allocated to the two airports.

Table 2-12. Sample size allocations for PHX and AZA meeters/greeters

Category	Number
Total target sample size	7,200
Sample size for long-form nonresident air passenger survey	1,000
Sample size for long-form resident air passenger survey	250
Sample size for short-form air passenger survey (including rental car, long-term parking, and LRT shuttles)	4,697
Sample size for PHX employees	392
Sample size for AZA employees	94
Leftover sample size for meeters/greeters	767
PHX – meeters/greeters (93%)	715
AZA – meeters/greeters (7%)	51

The 715 sample size for PHX meeters/greeters was further split into two: cell phone lots and curbside, using an assumed split of 50 percent. However, due to the small sample size of 51, the AZA meeters/greeters were not stratified any further, but attempts were made to survey at all potential locations to obtain a representative sample. This is shown in Table 2-13. These were further stratified by time of departure using the total inbound air passengers by time period from the observed March 2011 statistics.

Table 2-13. Sample sizes for PHX and AZA meeters/greeters, by location

<table>
<tr><th>Location</th><th>Sample size</th><th colspan="3">Inbound PHX air passengers by time of departure</th><th>Sample size</th><th>Precision level at 90% confidence level</th></tr>
<tr><td rowspan="4">PHX cell phone lots</td><td rowspan="4">286</td><td>Morning (5 a.m. to 9 a.m.)</td><td>69,310</td><td>14%</td><td>39</td><td>13%</td></tr>
<tr><td>Midday (9 a.m. to 4 p.m.)</td><td>219,971</td><td>43%</td><td>124</td><td>7%</td></tr>
<tr><td>Evening (4 p.m. to 8 p.m.)</td><td>128,316</td><td>25%</td><td>72</td><td>10%</td></tr>
<tr><td>Nighttime (8 p.m. to 12 a.m.)</td><td>90,575</td><td>18%</td><td>51</td><td>11%</td></tr>
<tr><td rowspan="4">PHX arrival curb</td><td rowspan="4">286</td><td>Morning</td><td colspan="2" rowspan="4">Same as above</td><td>39</td><td>13%</td></tr>
<tr><td>Midday</td><td>124</td><td>7%</td></tr>
<tr><td>Evening</td><td>72</td><td>10%</td></tr>
<tr><td>Nighttime</td><td>51</td><td>11%</td></tr>
<tr><td colspan="5">Total for PHX meeters/greeters</td><td>572</td><td></td></tr>
<tr><td colspan="5">Total for AZA meeters/greeters (cell phone lots, baggage claim, curbside)</td><td>51</td><td>11%</td></tr>
</table>

Survey Instruments

The main instrument was a custom OpinionMeter tablet-based application that featured a Google Maps interface to interactively capture address-level trip origin and destination information. The respondent would provide an address or landmark to start the search. Next, the surveyor would find the general location, sharing the tablet with the respondent to find the detailed location, allowing the person to help locate and drop the map pin. Data were uploaded to the OpinionMeter servers after each completed survey. This allowed MAG staff to monitor survey accuracy in real time.

The complexity of this data collection effort required multiple survey instruments: a short-form air passenger survey, a resident long-form air passenger survey, a visitor long-form air passenger survey, a meeter/greeter survey, and an airport employee survey. Because each airport needed separate instruments, eight survey instruments were programmed and managed. Table 2-14 summarizes short-form and long-form air passenger intercept survey questions.

Given the need for a trip diary survey with address-level trip origin and destination information, a paper instrument was not employed for the air passenger survey. In addition to flexibility and ease of use, the tablet survey realized some cost savings compared with a paper instrument by minimizing data entry costs. While coding and debugging the multiple survey instruments required more effort than anticipated, the cost of the tablet survey was compatible with the project budget.

The meeter/greeter survey was conducted using both a tablet-based instrument and a web-based questionnaire. Both instruments included the interactive Google Map interface to identify address-level trip origin locations, although for the web-based survey this was left to the respondent. Postcards with the web address were distributed to meeter/greeters waiting at the airport cell phone lots and inside the passenger terminals. A gift card incentive was offered to encourage survey responses.

The employee survey was conducted using a web-based questionnaire.

Figure 2-2 shows the introductory screen of the tablet-based air passenger survey.

Figure 2-2. Tablet-based air passenger survey

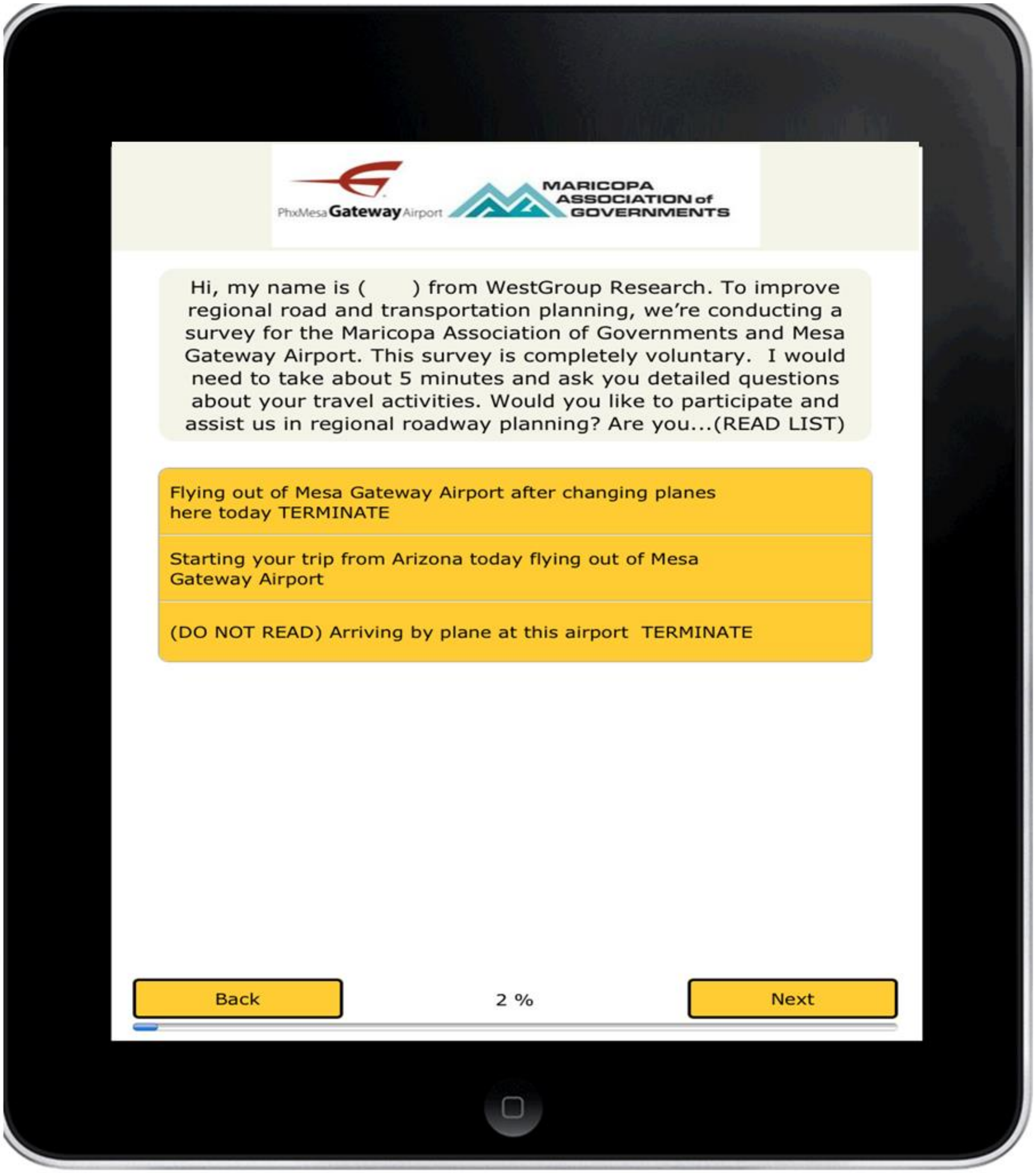


Table 2-14. Airport survey question summary

Description	Survey questions
Air passenger short-form and long-form questions	Record gender Do you live in Arizona, or were you here for a visit? What is the primary purpose of your trip today? Record interview location Record airport/terminal What terminal will you be flying out of today? Which airline are you flying out on today? What is your flight number? Is that your final destination? What state is your final destination? Where were you before coming to the airport today? Where on the map is that location? What is the address or what are the nearest cross streets of the location you came from? What was the one main mode of transportation you used to travel to the airport today? Were you dropped off or did you park? What time did you start your trip to the airport today? Including yourself, how many adults and children are traveling in your party today? Are you all in the same household, or different households? How many children are under 18 in your party? In what category does your age fall? Including yourself, how many people live in your household? How many registered cars, trucks, or motorcycles are available to your household? What best describes your employment status? What category describes your total combined household income last year?
Air passenger long-form trip diary questions for residents or visitors	My next questions are about your activities yesterday. What time did you first leave home yesterday to go anywhere? Where did you go? What is the name of that location? What is the address or what are the nearest cross streets of the location you came from? Where on the map is that location? How did you travel to that location? Including you how many people made this trip? What time did you leave that location? After that, where did you go? [Trip diary sequence is repeated until the previous day's travel was concluded.]
Meeter/greeter survey	When you were given the postcard at the airport, were you there to meet incoming air passengers? What date was it that you were at the airport to meet incoming air passengers? What airline did the people you met fly in on? What city and state did they fly from into the airport? What time was their flight due to arrive? What was the one main mode of transportation you used to travel to the airport to meet your passengers? Where were you before coming to the airport to meet your passengers? What is the name of this place? What is the address or what are the nearest cross streets of the location you came from?

Description	Survey questions
	Where on the map is that location?
	What time did you start your trip to the airport? What time did you arrive at the airport? How many people traveled with you to the airport? Are the people you met full-time Arizona residents, part-time Arizona residents or were they here for a visit? What was the primary purpose of the trip of the people you met at the airport? Where did you go when you left the airport? Where is the location on the map? When you left the airport, how did you travel to your next location? What is your age? Including yourself, how many people live in your household? How many registered cars, trucks, or motorcycles are available to your household? What best describes your employment status? What was your total combined household income last year?
Meeter/greeter one-question survey	Where will you go when you leave the airport? (Home, work, restaurant, shopping, other)
Airport employee survey	What is the name of your employer? Did you work at the airport over the past seven days? Did you work at the airport over the past thirty days? On which of the past seven days did you work at the airport? On your last completed work shift, what was the one main mode of transportation you used to travel to the airport? Where were you before coming to the airport that day? What is the address or nearest cross streets of the location you came from? Where on the map is that location? What time did you start your trip to the airport that day? What time did you arrive at the airport that day? Including yourself, how many people traveled with you to the airport that day? Where did you go after leaving the airport that day? Where on the map is that location? What was the one main mode of transportation you used to travel from the airport that day? What time did you leave the airport that day? What is your age? Including yourself, how many people live in your household? How many registered cars, trucks, or motorcycles are available to your household? What best describes your employment status? (Employed full time, employed part time, other, refused) Which best describes your total combined household income last year?

3.0 Data Collection

Air Passenger Intercept Surveys

The data collection effort started with pretests in March 2012 and concluded in May 2012. It included air passenger intercept surveys, meeter/greeter surveys, airport employee surveys, and traffic data. The air passenger data collection required extensive coordination between MAG, the consultant team, and the airports through all stages of the project.

Badging and Permissions

Air passenger intercepts were conducted in airport departure lounges while passengers waited to board their flights. Prior to the start of data collection, interviewers and supervisors had to undergo airport background checks and obtain airport security clearances from both PHX and AZA. During the 2-month data collection period, MAG and the consultant team were in constant communication with the airports regarding data collection activities. Survey team members visited both airports before pretesting to explain the project to airport personnel and law enforcement. It was important that airport staff be familiar with the project and not be surprised by the presence of survey takers during the data gathering process.

Pretests

Pretests were conducted to test the survey process and instruments. Initial tests were used to refine the survey instrument and questionnaire and identify areas for additional interviewer training. A complaint from a customer who was unsure about the authenticity of the survey underscored the need for uniforms and an emphasis on customer service. The pretest also showed that interviews were more successful when the tablet was used to engage the respondent. Additional pretests were conducted at each location to refine the survey approach and identify any technical limitations. Several questions were changed and reordered a result of the pretest to improve "survey flow." Technical issues with the tablets' Internet connections were also identified in the form of Wi-Fi weak spots and Wi-Fi login glitches (at one location). This led to replacing Wi-Fi-only tablets with 3G-capable tablets.

Training

Customer service training by PHX staff prior to the start of full-scale data collection emphasized that interviewers were airport representatives. This training paid off—only one customer complaint was received during the data collection period. In addition to customer service training, the interviewers were trained to use the mapping software used to record trip origin and destination information. The survey software allowed MAG to monitor the accuracy of the map information and to provide additional training as needed.

Data Collection

Interviewers worked in teams. Each team would carpool to the airports and pass through security. Shifts were scheduled based on the sampling plan and the number of completed surveys needed from each airport terminal location and time period to reach sampling goals.

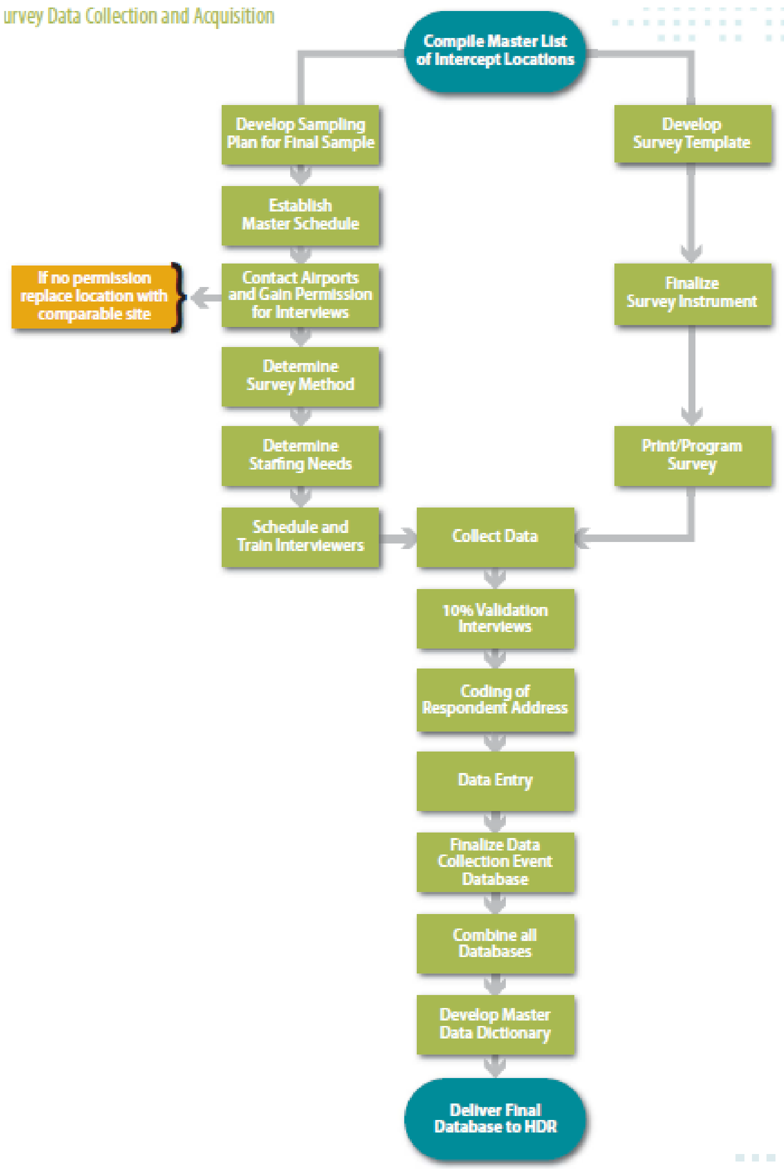
The sampling plan identified survey goals by time of day and terminal. Interviewers would move through departure lounges with active flights by approaching every third person to request an interview. During the course of the survey, two trends appeared. If several waiting passengers declined to take the survey, other passengers seemed to notice and would also decline. This had the effect of biasing the immediate waiting area against a willingness to participate in further interviews. Once this occurred, the team would move on to a different gate area. It was also discovered that passengers who were delayed or who had their flights cancelled declined interviews at an exceedingly high rate; however, there were a few exceptions where they welcomed the distraction provided by a survey. It was soon determined that from a customer service and financial standpoint, bypassing these respondents was prudent. MAG staff analyzed daily departures, worked on site distributing interviewers to gates, and managed the data collection. At all times a member of MAG's staff or another supervisor was on site to act as a liaison with both the passengers and interviewers. This point of contact was invaluable to both the public and the interviewers. The scheduling of survey teams was adjusted on a day-to-day basis after reviewing the previous day's survey results and comparing them with desired quotas.

Quality Assurance/Quality Control

The air passenger intercept surveys were reviewed by staff from MAG and WestGroup Research, Inc. Survey participants provided address or landmark information in addition to identifying a map location. MAG reviewed the map location latitude and longitude coordinates and compared the location to the reported addresses and landmarks using Google Maps. Surveys with missing or inaccurate mapping information were tagged for follow-up or were thrown out. WestGroup Research, Inc. evaluated each question without a refusal option to check for completeness. Missing responses were removed from the database. Reported flight numbers were verified against *Official Airline Guide* schedules and schedules published on www.flightstats.com and www.flightaware.com. For missing or incomplete flight number information, MAG staff used the following methods:

- Look at the surveys completed before and after the one in question to pin down the location within the terminal. Cross referencing this information with gate locations can provide most missing numbers.
- Look for transposed and missing digits. The numbers 8 and 3 were frequently incorrect, and the number 0 was frequently dropped.
- Search the airline's website for the destination and estimated departure (typically plus or minus 1 hour from the survey time) to find the flight number then check it against OAG, a provider of aviation information (www.oag.com). This method was more successful with smaller airlines.

Figure 3-1. Data collection flow



Completes and Response Rates

Interviewers approached over 10,000 air passengers during the data collection period. Approximately 47 percent refused to participate or terminated during the interview. For the short-form survey, the average completion time was just under 5 minutes. The average long-form trip diary survey duration was 8.5 minutes.

Proposed sample size targets discussed in the previous section were further stratified into "low" and "high" targets. Because the data modeling relies on some assumptions and the initial surveys indicated that some time period--terminal combinations would be difficult to achieve when collecting data, low and high targets were set that ensured enough samples would be collected for the expansion of different strata. The individual cell targets are 50 percent (low) and 150 percent (high) of the modeled estimates. Additionally, minimum targets were set for terminal locations (across all time periods) and time periods (across all terminal locations).

Table 3-1 shows a summary of collected surveys versus targets set for each population group and strata.

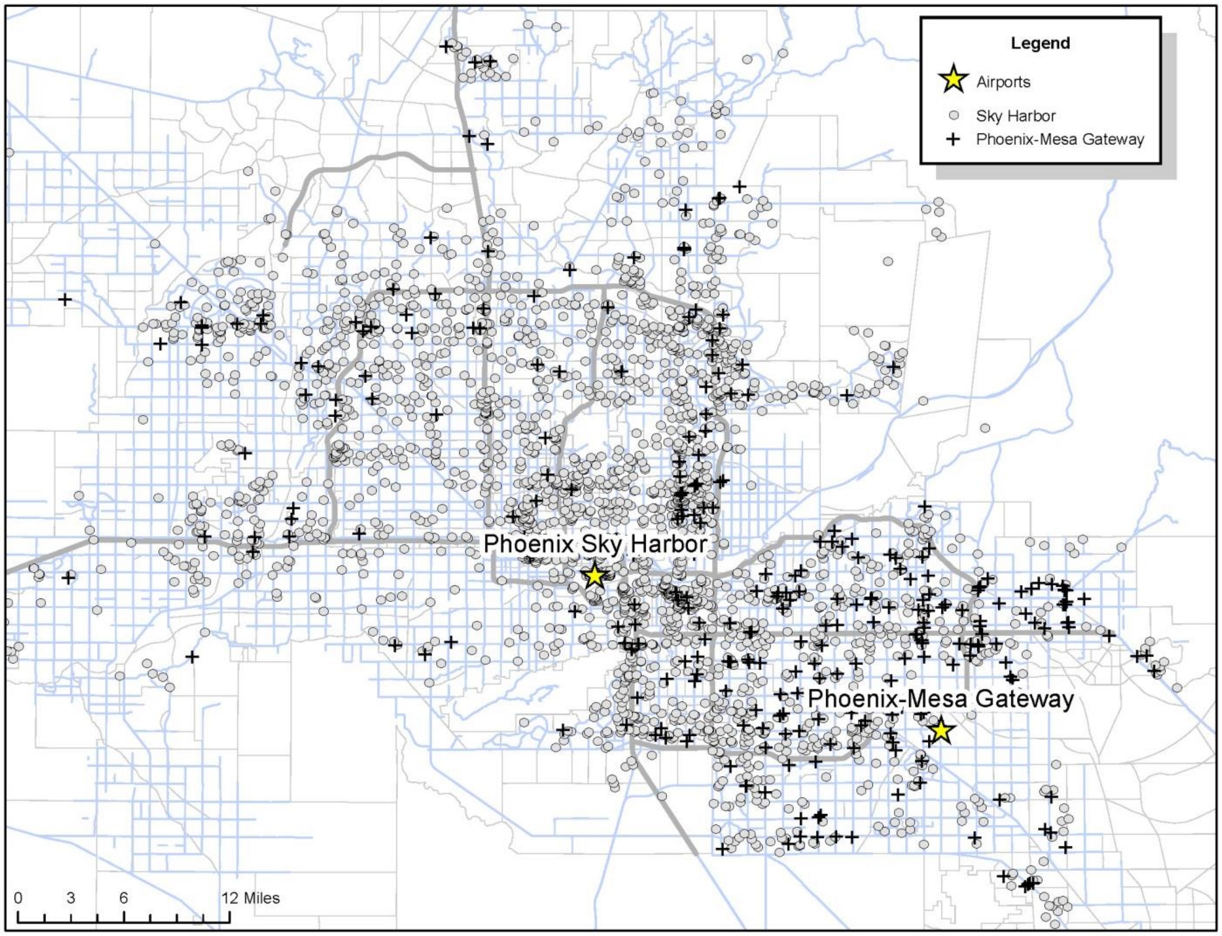
Table 3-1. Airport survey sampling plan targets and completed surveys

Location	Time period	Short-form survey			Long-form survey			
					Resident		Visitor	
		Low target	High target	Com-plete	Target	Com-plete	Target	Com-plete
Air passengers								
PHX Terminal 2	Morning	95	285	191	27	27	157	157
	Midday	130	391	296				
	Evening	47	142	79				
	Nighttime	20	59	37				
	Total for Terminal 2	**292**	**877**	**603**	**27**	**27**	**157**	**157**
PHX Terminal 3	Morning	140	421	283	42	66	201	201
	Midday	207	621	472				
	Evening	71	214	141				
	Nighttime	50	151	87				
	Total for Terminal 3	**468**	**1,407**	**983**	**42**	**66**	**201**	**201**
PHX Terminal 4	Morning	270	811	548	181	198	583	610
	Midday	617	1,852	1,225				
	Evening	122	653	481				
	Nighttime	218	366	262				
	Total for Terminal 4	**1,227**	**3,682**	**2,516**	**181**	**198**	**583**	**610**
	Total for PHX	**1,987**	**5,966**	**4,102**	**250**	**291**	**941**	**968**
AZA	Morning	88	88	100	33	35	33	37
	Midday	126	126	135				
	Evening	60	60	60				
	Nighttime	35	35	35				
	Total for AZA	**309**	**309**	**330**	**33**	**35**	**33**	**37**
	Total for air passengers	**2,296**	**6,275**	**4,432**	**283**	**326**	**974**	**1,005**
Airport employees								
PHX employees		392		419				
AZA employees		94		69				
	Total for airport employees	**486**		**488**				
Meeters/Greeters								
PHX meeters/greeters		715		1,094	Include 738 one-question completed surveys			
AZA meeters/greeters		51		117	Include 57 one-question completed surveys			
	Total for meeters/greeters	**766**		**1,211**				

[a] morning = 5 a.m. to 9 a.m.; midday = 9 a.m. to 4 p.m.; evening = 4 p.m. to 8 p.m.; nighttime = 8 p.m. to midnight

Figure 3-2 shows the geographic distribution of the location of air passengers in the MAG region prior to going to the airport. Including pretests, 5,247 usable air passenger intercept surveys were collected at PHX. This includes 1,644 long-form trip diary surveys and 3,603 short-form surveys. Out of 424 AZA usable air passenger surveys, 78 long-form surveys and 346 short-form surveys were collected.

Figure 3-2. Air passenger location prior to airport arrival



Challenges during Data Collection

The air passenger survey data collection effort presented a number of unique challenges.

- **Agency Coordination**: Multiagency coordination was the biggest challenge during the survey planning and execution stages. The creation of a multiagency technical advisory group was a critical factor to the survey's success. The simultaneous data collection activities required significant coordination with airport staff. Multiple permits from local jurisdictions, airports, and the Federal Aviation Administration were required for a variety of project-related activities.
- **Badging**: While background checks were built into the initial project schedule, the Transportation Security Clearinghouse underwent a massive data migration during the survey

that delayed processing of criminal history records checks and security threat assessment checks for a number of weeks. The length of time required to obtain security clearances limited the team's ability to have a large pool of interviewers available. The loss of an interviewer because of the failure to pass the security check or because of personal circumstances reduced the number of individuals available to conduct surveys.

- **Internet Access**: The mapping software used for the intercept surveys required a constant Internet connection. Spotty wireless Internet access caused connection issues at some airport terminals. Intermittent connections sometimes left the software unusable, resulting in lost surveys. This connectivity issue was resolved using tablets with cellular data service, which incurred additional costs.
- **Mapping**: Some interviewers required additional training to master basic mapping skills needed to use tablet mapping functions to find addresses or landmarks identified by the respondent. Some interviewers had difficulty with ordinal directions and placing map pins with accuracy. When this behavior was discovered, the study team closely monitored the individual and corrected points as possible.
- **Survey Versions**: Programming changes during data collection meant that new survey versions had to be reloaded and verified on all tablets and online sites. Changes in the order of questions between versions meant extra care in matching databases.
- **Flight Schedules**: Actual airline activity often varied compared with published monthly flight schedules provided by the airports. This created a challenge in verifying surveys from flights whose numbers were not included, or whose scheduled departure time varied from the pre-published monthly schedules. Flight schedules had to be manually verified and updated.

Meeter/Greeter Data Collection

During pretests, a postcard was distributed to drivers of vehicles meeting arriving air passengers. These postcards provided an address to the online survey instrument and offered entry to a gift card drawing as an incentive. Postcards were distributed to drivers waiting in the cell phone lots and to drivers loading passengers at the terminal arrival curbs. While drivers met at the cell phone lot responded at a higher rate than drivers met at the curbside areas, the overall response rate was less than 5 percent. Because of the low response rate, the team began supplementing the postcards. When distributing postcards, interviewers asked one question about the meeter/greeter's next stop after the airport. A tablet-based intercept survey was also used in the cell phone lot and airport waiting areas outside of security checkpoints. This more intensive effort improved the response rate, allowing sampling targets to be met.

It was noted that drivers who were approached at curbside would frequently pull away as they were being approached by survey team members. It is believed that these drivers thought they were going to be asked to move or were going to be ticketed. This problem was not reported at cell phone lots.

Employee Data Collection

Airport employees were asked to participate in an online survey about their travel to the airport. Emails with links to the survey were distributed by airport officials to employers and employees. Postcards with the survey link were also distributed to airport employees who do not have computer access as part of their daily job. Government employees, including Transportation Security Administration and Federal Aviation Administration employees, had the highest response rates. Despite repeated follow-up efforts, some of the airlines—the largest employers at PHX—did not have any employee responses. This low response rate was attributed to a lack of distribution accountability, limited computer access, and not enough time to complete the survey. Airport employees provided 418 responses.

Traffic Data Collection

To support the development and calibration of the new airport ground access sub-model, a variety of data such as traffic counts, travel time and origin-destination data, and vehicle occupancy counts were collected at key locations at each airport. These datasets were used in expanding, balancing, and validating the new sub-model.

Anonymous Wireless Address Matching (AWAM), or Bluetooth tracking technology, was used to investigate airport ground traffic travel time and origin-destination characteristics by time of day and by day of week. The selection of this technology was based on consideration of the airport roadway network's complexity and available resources. The AWAM data collection lasted for 7 consecutive days at both PHX and AZA. Understanding that one Bluetooth reader is capable of detecting Bluetooth signals within a 300-foot range, every Bluetooth reader location was adapted to each airport's infrastructure and roadway layouts. The reader locations were chosen to allow only signals from the target traffic to be picked up. Concurrent traffic volume data were collected for determining the Bluetooth sample rate and expanding and cross-referencing the results.

AWAM Data Processing

Compared with a typical freeway or arterial street AWAM application, PHX's unique east-to-west access and complex roadway design required a specific data processing procedure:

- **Step 1**: Data (anonymous wireless ID, time, and location) from all locations were put together for the entire course of data collection.
- **Step 2**: Data records showing the same ID, same location, and same time (time difference less than 2 seconds) were treated as idling records. In this case, only the first and the last reads were kept (dwell time = last read time – first read time), and the rest of the records were filtered out.
- **Step 3**: For each ID, sort its time of the appearance at all possible airport locations, and then obtain trip chaining of this ID (trip).
- **Step 4**: Identify a trip's origin and destination and calculate travel time between any pair of locations within this trip.

Initial findings from the weeklong Bluetooth data include:

- The average Bluetooth penetration rate (Bluetooth reads/traffic volume) of 15 percent at airports was found to be significantly higher than on freeway and arterial streets in the Phoenix region. Additionally, Bluetooth signal read pattern by time of day looked similar to and consistent with traffic volumes in all airport locations.
- At PHX, two-thirds of airport ground trips would enter and exit the airport from the same side, while one-third of airport ground trips would enter and exit the airport from the different side. Out of the one-third that made the cut-through movement, about 25 percent had a travel time less than 4.5 minutes. This time was used to benchmark free-flow travel time at PHX airport if no stop was made. These cut-through trips occurred more frequently during morning and evening weekday peak periods.
- At PHX, it is feasible to monitor cut-through and other traffic movement long-term by AWAM technology if power and communication to Bluetooth devices can be provided.

At AZA, for all trips accessing the airport using the intersection of Ray and Sossaman roads, the trips split east to west at a 1:4 ratio. Meaning that for every westbound car turning left onto Sossaman from Ray road, four eastbound cars turned right onto Sossaman road.

4.0 Data Expansion

With surveys collected and processed, the next step was expanding the data to represent the true population of air passengers, airport employees, and meeters/greeters. The approach for this step was laid out in the sampling plan to develop weights, or expansion factors, by different stratifications. A different weight, or expansion factor, must be assigned to each quota or sample size so that the survey data were expanded appropriately to represent the true universe of airport travelers that includes air passengers, airport employees, and meeters/greeters.

This section describes the expansion procedure to weight the air passenger surveys. After the surveys were collected, cleaned, and processed, the data were expanded to represent the true population of air passengers who access/egress the airport facilities. This was done by developing weights or expansion factors by different stratifications as laid out in the sampling plan. A different weight or expansion factor was assigned to each quota or sample size such that the survey data were expanded appropriately to represent the true universe of air passengers at PHX and AZA.

Phoenix Sky Harbor International Airport

The completed air passenger surveys consist of a set of random samples of air passengers at terminal departure locations, plus mode oversamples from the rental car, long-term parking lot, and LRT shuttle intercept surveys. The first step in the expansion procedure was to expand the random sample of surveys that were conducted throughout each terminal to match the total number of daily air passengers departing from PHX.

Gate Survey Expansion Procedure

Expansion targets were developed from three data sources:

- Monthly enplanements by terminal for April 2012 obtained from the PHX website
- Flight schedule data for April 2012. These data include airline, departure day, scheduled departure time, departure terminal, destination location, and number of seats for each flight departing from PHX in April 2012. These data were obtained from PHX.
- U.S. Department of Transportation 10 percent ticket sample database for domestic departures for the second quarter (April to June) of 2011. This dataset included information on the number of passengers departing from PHX by next airport location and final airport destination.

The above three data sources were used to develop expansion targets along four market segments:

- **Day of week**: weekday, Saturday, Sunday
- **Time of day** (based on scheduled flight departure time): morning (5 a.m. to 9 a.m.), midday (9 a.m. to 4 p.m.), evening (4 p.m. to 8 p.m.), nighttime (8 p.m. to 5 a.m.)

- **Flight segment destination**: short domestic (California, Arizona, Nevada, Utah, Colorado, New Mexico, and El Paso, Texas), long domestic (all other domestic trips), nonstop international
- **Terminal**: Terminal 2, Terminal 3, Terminal 4 – Southwest flights, Terminal 4 – US Airways flights, Terminal 4 – international flights

The following procedure was undertaken to develop expansion targets by day of week, time of day, flight destination, and terminal:

- The flight schedule data were summarized by total monthly number of seats by airline, next airport, weekday, Saturday, Sunday, and departure hour.
- Some differences were found with the coding of the carrier name and airport code between the ticket sample data file and the flight schedule data table. These differences were checked and made consistent, where needed, to facilitate further data processing. Phoenix departures were selected and assigned to next airport location. Each of the ticket samples were classified as originating or connecting at PHX. The data were summarized by airline, next airport, originating versus connecting, and long-domestic versus short-domestic trip.
- Based on the number of seats provided in the flight schedule data, the ticket sample data were further classified by day of week and departure hour.
- The ticket sample data were then factored to match April 2012 total enplanements by terminal.
- The final expansion targets were developed by removing connecting passengers from the dataset and converting the total number of passengers to average weekday, Saturday, and Sunday totals. The expansion targets by market segment are shown in Table 4-1.

The next step in the expansion procedure was to classify the survey records by day of week, scheduled departure time of day, destination location, and terminal. The survey database contained information on day of week, terminal, and flight number. It also contained the final destination of travelers if they were connecting in another airport. The flight number was used to attached scheduled flight departure times and flight destination locations to the dataset. Since the 10 percent ticket sample data contained only domestic traveler data and the scheduled departure data indicated only the next airport, surveyed individuals who indicated that they were connecting to another airport with a final International destination were classified by their next airport location into short-domestic or long-domestic trip. Only those individuals who traveled directly from PHX to an international destination were classified as international and Terminal 4 – International.

Once the surveys were classified by market, the number of surveys by market segment combination was calculated to determine if there were missing or low numbers of surveys for each combination. Table 4-2 shows the number of survey records by market segment combination. Given low survey records for short-distance trips in the nighttime period in Terminals 2 and 3, short- and long-distance trips were combined for the nighttime period in these terminals.[2] Also, Saturdays and Sundays were missing survey records for many destination location and terminal combinations. Thus, destination location and terminal were combined so that Saturday and Sundays were stratified only by time of day.

Table 4-1. PHX daily departing passengers, by market segment

Time of day	Long-distance travel				Short-distance travel				International
	Terminal 2	Terminal 3	Terminal 4: Southwest	Terminal 4: US Airways	Terminal 2	Terminal 3	Terminal 4: Southwest	Terminal 4: US Airways	Terminal 4: International
Weekday									
Morning	1,065	1,828	1,355	1,447	96	191	2,050	478	424
Midday	1,683	2,840	2,829	2,742	306	377	1,890	1,074	1,456
Evening	579	919	1,480	804	126	267	1,400	607	1,816
Nighttime	195	695	555	432	0	0	1,166	483	215
Sunday									
Morning	1,448	1,706	1,140	1,340	117	168	894	379	312
Midday	1,736	2,634	2,681	2,546	313	327	1,812	993	1,199
Evening	528	810	1,551	767	124	186	1,558	560	2,040
Nighttime	182	671	500	437	0	0	665	509	201
Saturday									
Morning	1,631	1,706	753	1,331	131	189	1,007	427	395
Midday	1,669	2,091	2,670	2,548	301	314	1,743	955	1,399
Evening	452	651	1,823	730	106	160	1,333	479	1,839
Nighttime	141	671	19	440	0	0	517	396	0

[2] The nighttime period in Terminal 3 contained a population of 1 for short-distance travel. This is a case where the 10 percent ticket sample data indicated that a person traveling directly to a long-distance location (such as Seattle, Washington) transfers and has a final destination at a short-distance location (such as San Francisco, California). Thus, all other passengers on the flight would have been characterized as long-distance travel. This example supports the need to combine short- and long-distance trips for the nighttime period for Terminals 2 and 3.

Table 4-2. PHX gate survey records, by market segment[3]

Time of day	Long-distance travel				Short-distance travel				International
	Terminal 2	Terminal 3	Terminal 4: Southwest	Terminal 4: US Airways	Terminal 2	Terminal 3	Terminal 4: Southwest	Terminal 4: US Airways	Terminal 4: International
Weekday									
Morning	217	274	138	132	54	17	226	49	9
Midday	284	436	211	380	68	74	224	225	126
Evening	77	63	135	101	24	33	140	127	29
Nighttime	52	118	48	39	1	0	124	18	15
Sunday									
Morning	0	16	28	6	0	1	12	2	1
Midday	0	47	51	19	0	2	45	6	3
Evening	0	24	4	3	0	7	5	12	1
Nighttime	0	5	1	21	0	0	5	7	0
Saturday									
Morning	0	50	21	24	0	11	10	22	11
Midday	2	36	83	35	0	12	62	37	48
Evening	15	13	14	13	4	15	8	2	4
Nighttime	0	0	0	18	0	0	0	10	9

The final expansion value was calculated by weighting the expansion target by party size, since all individuals traveling together have identical travel characteristics. Therefore, if an individual traveled alone, then the survey record would have a party size weight of 1, while if an individual traveled in a group of three, the survey would have a party size weight of 3 to represent all three individuals in the group. Note that party size was compared with vehicle occupancy of departing passengers, and it was found that party size matched up closely with this number even if the traveling party was composed of different households. Thus, party size, irrespective of whether the party was composed of the same household or different households, was used as the weighting variable. Appendix A contains figures showing the weekday, Saturday, and Sunday distribution of the unweighted surveys, control totals, and weighted surveys by time of day, flight destination, and terminal.

[3] Seven additional surveys were eliminated from the dataset provided by MAG. These seven surveys were either missing vital access mode information or responded with a mode of walking or bicycling.

Expansion Procedure for Additional Non-Gate Surveys

Once final weights were determined for the random sample of passenger surveys collected at gates, the weighted surveys were analyzed and used as control totals for weighting the oversampled data collected on the LRT shuttles, rental car shuttles, and economy parking shuttles.

The first step in weighting the oversampled data was to compare selected market segment variable descriptive statistics of the weighted gate survey data to the shuttle survey data for each mode. The market segments analyzed included: day of week, time of day of start of trip to airport, resident status, trip purpose, previous location, household income, household size, and vehicle availability. Common characteristics across shuttle surveys for each mode were identified, as shown in Table 4-3. The highlighted rows in Table 4-3 identify the number of survey records of each survey location and mode that were included in the final database.

Survey records that reported main modes that did not match the survey location were eliminated from the database. As shown in Table 4-3, eight survey records met this criterion. This included LRT shuttle surveys reporting main mode of private car, parking shuttle surveys reporting main mode of rental car, and rental car shuttle surveys reporting main mode of private car. An additional five surveys from the parking shuttle survey reported nonresident status, and one survey had a travel start time in the nighttime period. These surveys were eliminated from the database to simplify the expansion process and to avoid reweighting the data for a very small percentage of the survey records.

Table 4-3. Oversampled survey records, by mode and market segmentation characteristics

Survey location	Mode	Market segmentation characteristics	Number of surveys
LRT shuttle	LRT	Weekday, non-hotel	23
	Private car	Not available	3
	City bus	Weekday, nonbusiness, private home	3
Parking shuttle	Private car	Weekday, resident, non-hotel, morning and midday start times	43
	Private car	Nonresident	5
	Private car	Nighttime start time	1
	Rental car	Not available	2
Rental car shuttle	Private car	Not available	3
	Rental car	Weekday, visitors, no evening start times	76
Outside security	Private car	Not available	1

Gate surveys with mode and market segmentation characteristics matching the oversampled survey records were selected and the weighted time of day distributions of each set of survey records were identified as the control totals. The gate surveys and shuttle surveys for LRT, parking, and rental car were then reweighted, controlling for party size, to match the time of day distributions. An exception to this process was the city bus surveys conducted at LRT shuttles. Given the low sample size of both the shuttle and gate surveys, the city bus surveys were expanded, controlling for party size, to the city bus weighted survey total for the market segmentation combination only.

Phoenix-Mesa Gateway Airport

An analysis of the survey records for AZA indicated that no surveys were collected on Saturday, and surveys were collected on Sunday for only two time periods. This was attributable to the limited number of flights available on these days. Given the size of AZA, it did not make sense to classify individuals by destination location and terminal as was done for PHX. Thus, the expansion procedure for AZA focused on obtaining expansion targets by time of day only for weekdays and total number of passengers for Sunday. Table 4-4 shows the number of survey records by time of day for AZA.

Table 4-4. AZA survey records, by time of day

Time of day	Weekday	Sunday
Morning	51	53
Midday	128	50
Evening	96	0
Nighttime	45	0

Expansion targets were developed from two data sources:

- Flight schedule data for April 2012, which include airline, departure day, scheduled departure time, departure terminal, destination location, and number of seats for each flight departing from AZA in April 2012. These data were obtained from AZA.
- U.S. Department of Transportation 10 percent ticket sample database for domestic departures for the second quarter (April to June) of 2011. This dataset includes information on number of passengers departing from AZA by next airport location and final airport destination.

The following procedure was undertaken to develop expansion targets by day of week, time of day, flight destination, and terminal:

- The flight schedule data were summarized by total monthly number of seats by next airport, weekday, Saturday, Sunday, and departure hour.
- Based on the number of seats provided in the flight schedule data, the ticket sample data were further classified by day of week and departure hour.
- The ticket sample data were then factored to match April 2012 flight schedule data by next airport, weekday, Saturday, Sunday, and departure hour.
- The final expansion targets were developed by converting the total number of passengers to average totals for each time of day. The expansion targets by time of day are shown in Table 4-5.

- The final expansion value was calculated by weighting the expansion target by party size for each survey record.

Table 4-5. AZA daily departing passengers, by time of day

Time of day	Weekday	Saturday	Sunday
Morning	479	330	578
Midday	605	338	770
Evening	159	0	424
Nighttime	195	200	200

Appendix B provides a descriptive analysis of the unweighted survey records for PHX and AZA air passengers combined.

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5.0 Model System Overview

The airport travel model is consistent with the MAG 2011 base year model system and includes both PHX and AZA. The model uses the new expanded MAG zone system and socioeconomic information, MAG highway access networks and level of service (LOS), and LOS offered by transit modes providing airport access.

The model system incorporates the important role of traveler perception in the choice of airport or access mode. This gives airport planners and demand modelers a tool to test different scenarios related to ground access to the two airports, regional socioeconomic environment and geographic distribution, and air service changes related to size of the airports.

The airport model system will be integrated with the current MAG four-step model, but can also be run as a stand-alone model. The model allows MAG to quantify the flow of ground transportation to and from the two existing airports in the region for the base year and under a variety of future-year scenarios. It will enable them to assess policies aimed at improving access to the two airports, including both highway and transit connectivity.

As described in the following sections, and shown in Figure 5-1, the model system has several components (or steps) that are connected. These model components represent relationships among airport-related travel behavior, socioeconomic characteristics, land use and employment variables, and airport/airline service.

Airport Trip Generation Model for Air Passenger Trips

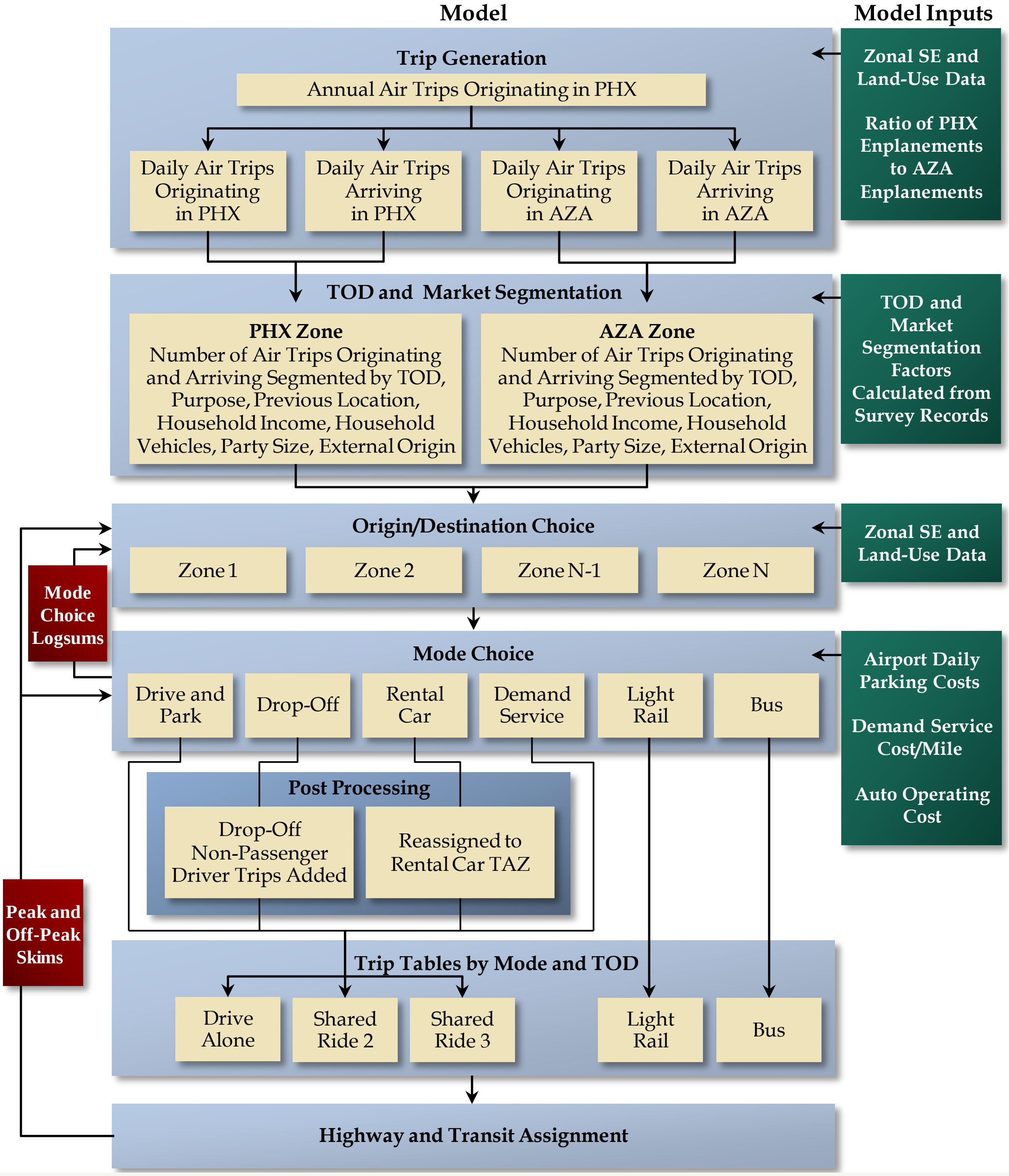
Forecasting the total number of average weekday air passenger trips originating at each of the two airports is based on developing a significant relationship between annual regional socioeconomic indicators and total number of air passengers per year originating at PHX and AZA.

First, a time-series regression model was estimated to explore the relationship between regional-level socioeconomic indicators and annual air passenger trips originating in the MAG region. An association between the zonal-level socioeconomic data and average weekday, Saturday, and Sunday air passenger trips for both airports combined was developed based on the relationship between the base year's zonal-level data and the weighted survey air passenger trip totals. Symmetry was assumed between number of trips produced and attracted to the airport each day.

Second, the PHX and AZA master plans were examined to develop yearly forecasts of market capture rates for each airport. The percentage of market capture for the base year was developed from the expanded survey dataset, which is based on observed air passenger trip totals for each airport. The market capture rates were developed for each forecast year, but the user will have the flexibility to test various policy scenarios (for example, AZA expansion) in forecast years by directly inputting an alternative ratio of trips originating at AZA.

The annual air passenger person trips can be converted into average daily weekday air passenger trips for each airport based on the relationship between the expanded survey numbers developed for the base year and reported annual air passenger trips originating in PHX and AZA.

Figure 5-1. Airport model flow chart



External Trips, Market Segmentation, and Time-of-Day Factors

External Trips

Immediately after trip generation, the number of air passenger trips with origins and destinations outside of the MAG region can be separated from the internal trips. Time-of-day and party size distributions for external trips can be allocated based on the weighted survey data. All air passengers who travel from outside of the region are assumed to travel by auto mode.

Time-of-Day

Air passenger trip time-of-day profiles are not a choice model but a simple derivation of fixed factors from observed trends in flying patterns for the two airports. For air passenger trips traveling to the airport, this was developed directly from the distribution of start times of trips in the expanded survey data. For air passenger trips traveling from the airport, this was developed from scheduled flight data and seat capacity of arriving flights.

Time-of-day factors for forecast years will not change for PHX and will remain the same as the base year. Given that AZA will go through significant expansion in the future, it is expected that AZA's time-of-day profiles will resemble those of PHX over time. In the model, as the market capture of AZA increases, the time-of-day profile for AZA will become closer to that of PHX.

Market Segmentation

This model segments the total number of air passengers into a number of market groups and assigns household-level characteristics, including trip purpose (business versus nonbusiness), resident status (Arizona resident versus visitor), household income, number of household vehicles, previous location before traveling to airport, and party size.

The model assigns market segments and household-level characteristics to each air passenger based on a set of factors developed from the expanded survey data by airport and time of day. The model assigns factors in the following order so that previously assigned characteristics can be used to factor later characteristics: (1) trip purpose and resident status, (2) household income quintile and vehicle ownership, (3) previous/next location, (4) party size.

Origin Choice Model

This model distributes airport travel demand between the airports and MAG regional traffic analysis zones (TAZs). The origin/destination choice model is used to predict the probability of an airport trip originating or ending in a zone. These models determine the distribution of all airport trips among all potential origins and destinations within the MAG region. The utility of each zone reflects the major drivers behind the number of produced or attracted trips. The model is a multinomial logit model in which the traveler is assigned a zone among all potential choices in the study area as the actual origin or destination.

The principal data sources for the model development were the air passenger survey and the MAG databases of socioeconomic and LOS information. Given the nature of such a model, which treats zones as choice alternatives, the explanatory variables are zonal attributes and LOS information. The variables that were tested in model estimation include, but are not limited to, socioeconomic and demographic information of the travelers, travel or distance skims, and area type indicator variables such as rural, urban, or central business district.

Origin choice is fully segmented across location type. These include home, hotel, and other location types. In other words, three origin choice models were estimated, one for each location type. Origin choices from PHX and AZA were estimated in the same model, since it is expected that LOS to each airport will capture the key differences among airports. Segmentation was also explored across residency and trip purpose, although this segmentation was examined only for key variables (rather than wholly separate models).

Mode Choice Model

The airport mode choice model determines the appropriate mode shares of airport travelers from their origin within the Phoenix region to the airport, or airport to their destination within the Phoenix region. This model assigns each trip a main mode from the following alternatives:

- drive and park
- dropped off/picked up
- rental car
- demand service
- shuttle
- walk to light rail
- drive to light rail
- walk to local bus

The model is a nested multinomial logit model with transit in a separate nest.

In application, if an air passenger trip is assigned to mode "dropped off," then an additional airport trip will be generated that represents the driver's trip from the airport after dropping off the airport passenger. Similarly, an additional trip will be generated if a passenger is picked up from the airport. For those trips assigned to rental car, the trip will be reassigned to the rental car TAZ from the airport TAZ.

Using assigned mode and party size information, the air passenger trips are reclassified into the modes supported by MAG's regional model including: drive alone, shared ride 2, shared ride 3, walk to light rail, drive to light rail, and walk to local bus.

Assignment

The trip tables that are produced as output from the airport model will be added to MAG's regional travel demand model for assignment.

6.0 Trip Generation

This section discusses the trip generation of daily air passengers originating at PHX and AZA airports for forecast years. First, the data sources available for forecasting air passenger trips are discussed. Next, a descriptive analysis and time-series regression analysis is presented for forecasting PHX air passenger trips based on regional socioeconomic data. The section concludes with a methodology for calculating AZA annual air passenger trips and for converting from annual to daily trips for both PHX and AZA.

Data Sources

PHX Master Plan – Enplaned Passenger History and Planning Forecast

PHX provided annual enplaned passenger totals for 2000 through 2012 and forecast enplaned passenger totals for 2012 through 2040 for a low, base, and high scenario. The forecasts were published in December 2011. The dataset separated out the enplanement totals based on whether the passengers originated at PHX or connected from another destination. Thus, from this dataset the number of passengers was obtained for those passengers originating in PHX for 2002 to 2011 and for low, base, and high forecasts through 2040.

AZA Master Plan – Enplaned Passenger History

AZA provided a master plan published in December 2009. The methodology for forecasting enplanements at AZA is based on a percentage of PHX's total enplanements. The forecasts included in the report were from a study conducted in 2002. Four scenarios were presented, with percentage of PHX enplanements ranging from 4 percent to 15 percent by 2027. The planned forecast uses a rate of 6.5 percent for 2027.

AZA provided enplaned passenger data for 2008 to 2011. The data showed that AZA enplanements were 2.4 percent of PHX enplanements for 2011.

County-level Socioeconomic Data

Total population, average household income, and total employment for Maricopa and Pinal Counties were obtained for 2002 through 2011 from the American Community Survey, U.S. Census Bureau, Arizona Intercensal Estimates, U.S. Department of Housing and Urban Development, and the Bureau of Labor Statistics. Regional population, as referred to in this section, is total population for Maricopa County plus Pinal County. Regional employment is total employment for Maricopa and Pinal Counties, and regional median household income is a weighted average of median household income for the two counties.

TAZ-level Socioeconomic Data

TAZ forecast socioeconomic data were available for 2005, 2008, 2010, 2020, 2025, 2030, and 2035 in the TAZ2003i system. The forecasts were produced in January 2009. TAZ socioeconomic data were also available for 2008 and 2010 in the TAZ2012 system that was produced in the summer of 2012.

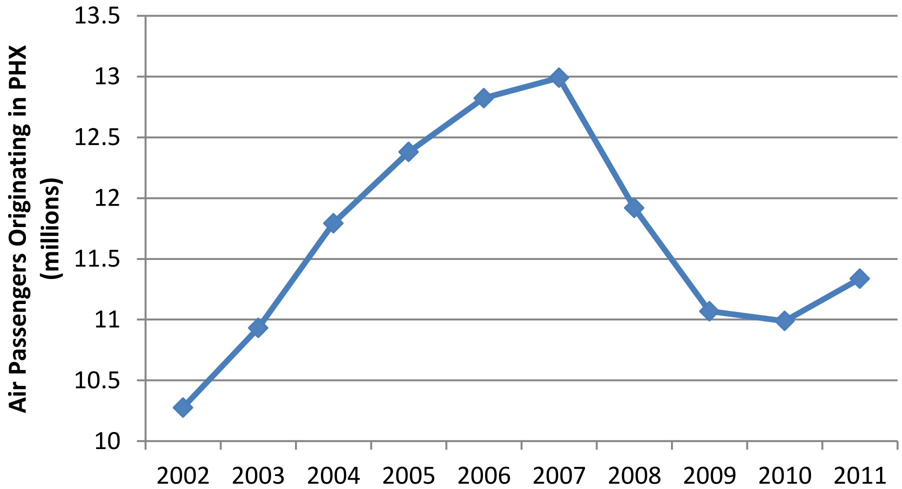
Time-Series Model

AZA historical data are available only for 2008 to 2011, so there are not enough data to estimate AZA enplanements using a regression model. Since the AZA master plan forecasts are based directly on PHX enplanement forecasts, the focus of the time-series model was to find a relationship between regional socioeconomic indicators and number of passengers originating in PHX for 2002 to 2011.

Descriptive Analysis

Figure 6-1 shows the number of passengers originating in PHX for 2002 to 2011 as detailed in PHX's master plan data worksheet. Air passengers increased steadily from 2002 through 2007 and then dropped significantly in 2008 and 2009. Air passenger growth did not resume until 2011.

Figure 6-1. Number of air passengers originating in PHX



Figures 6-2 to 6-4 show regional population, regional median household income, and regional employment versus air passengers originating in PHX, respectively. From the figures, it is clear that the financial crisis of 2008 and subsequent recession caused a shift in the relationship between population, employment, and average income and the demand for air trips. Leading up to 2007, the number of air passengers was generally increasing along with population, income, and employment. The drop in air passengers in 2008 seems to represent a leading indicator of the recession. Over the next 4 years, the number of air passengers sharply declined, but the population, employment, and income statistics declined less sharply.

Figure 6-2. Regional population versus air passengers originating in PHX for 2002 to 2011

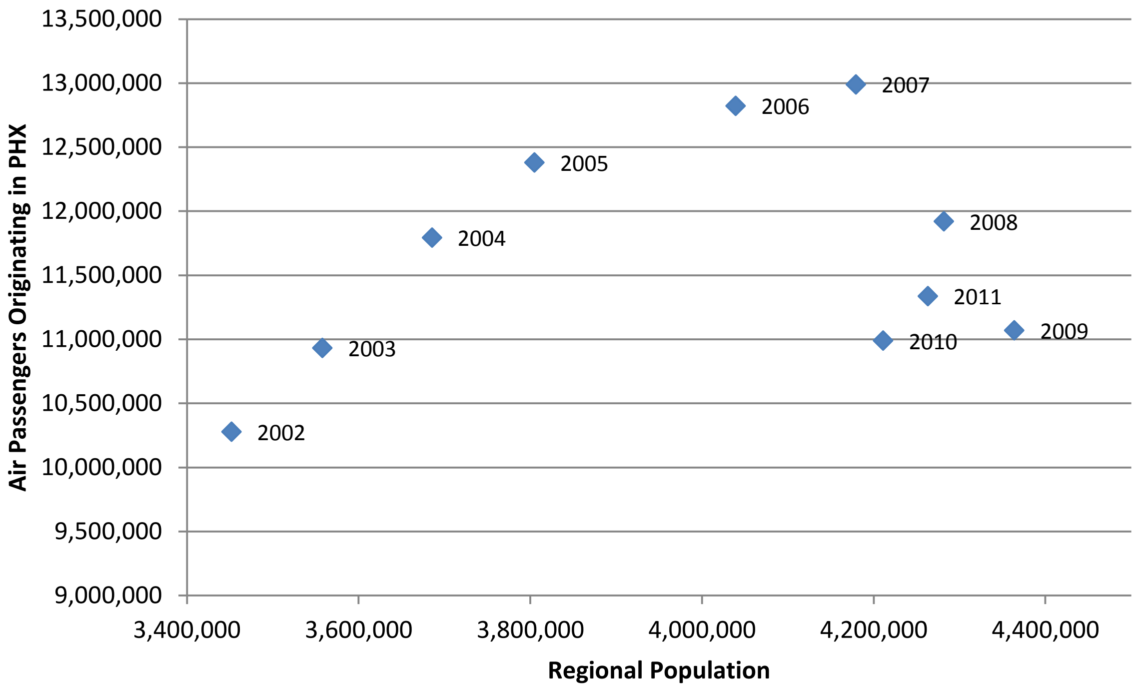


Figure 6-3. Regional median household income versus air passengers originating in PHX for 2002 to 2011

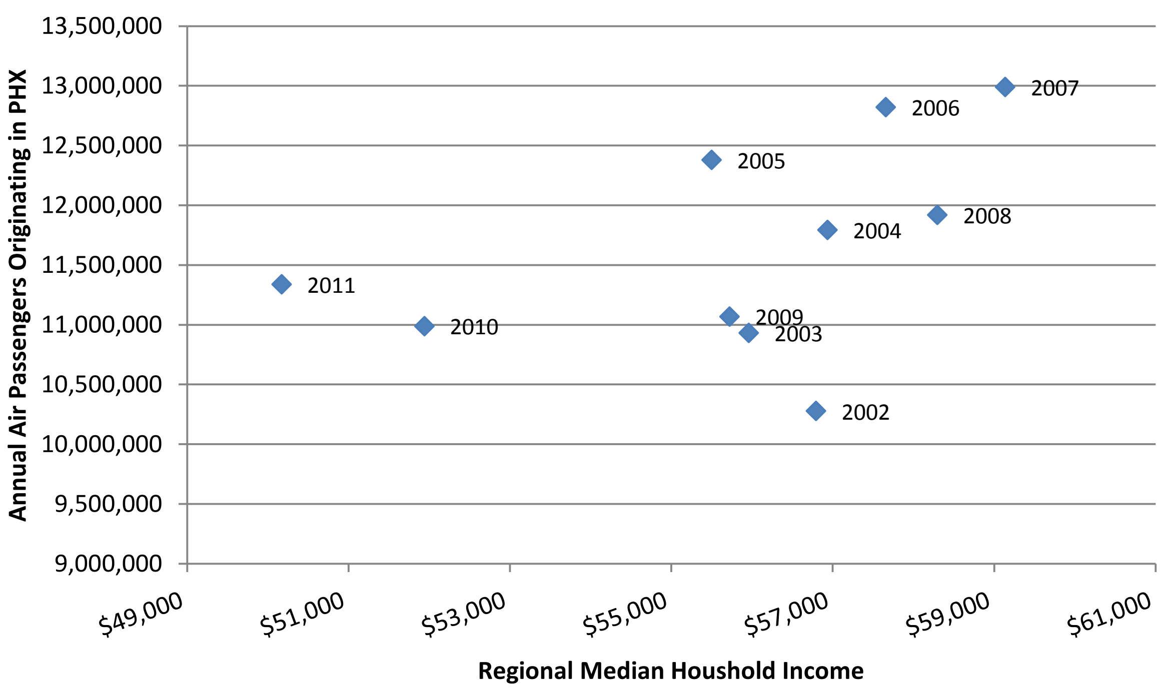
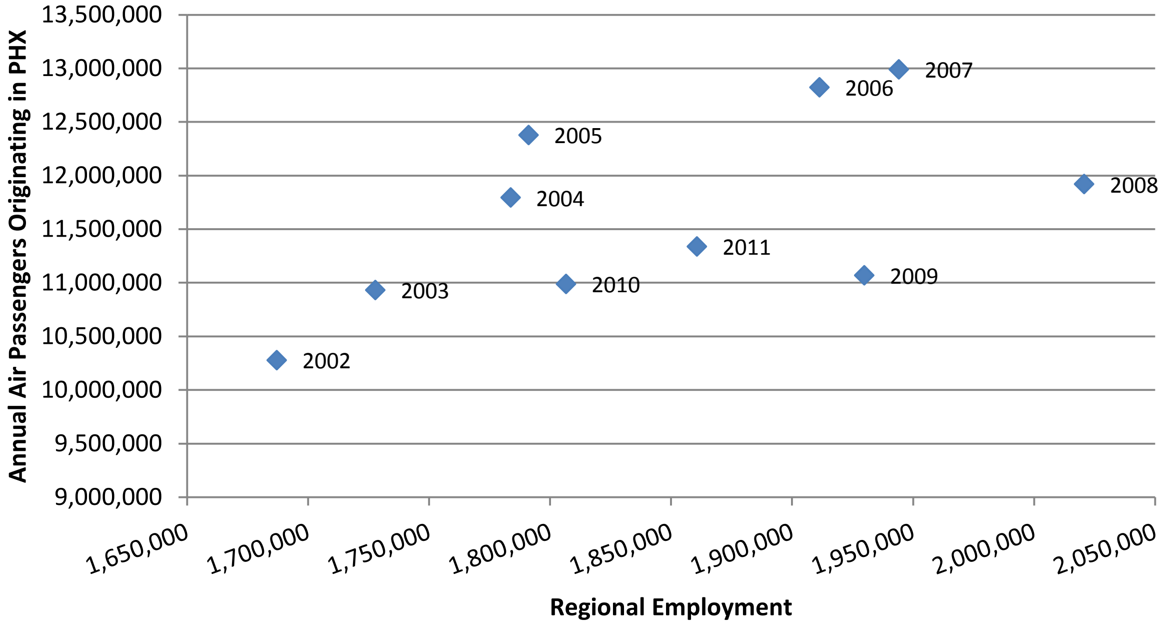


Figure 6-4. Regional employment versus air passengers originating in PHX for 2002 to 2011



A correlation analysis, as shown in Table 6-1, indicated that regional population and regional employment are well correlated with each other across the years (0.85 correlation). Given the drop in air passengers during the recession, a correlation analysis was also conducted separately for 2002 to 2007 and from 2008 to 2011, as shown in Tables 6-2 and 6-3. Prerecession years also showed a strong correlation between median household income and population and employment (0.71 to 0.76 correlation). Thus, a multivariate model is unlikely to produce significant coefficients for all variables. The prerecession years showed a very strong correlation (0.94 to 0.95) between regional population and regional employment and PHX air passenger trips. The recession and postrecession years showed no correlation between population and air passenger trips (0.03 correlation) while employment remain highly correlated (0.81 correlation) with air passenger trips.

Table 6-1. Correlation between PHX air passengers, population, income, and employment for 2002 to 2011

	PHX air passengers	Regional population	Average household income	Total employment
PHX air passengers	1.00	0.31	0.46	0.58
Regional population	0.31	1.00	–0.22	0.85
Average household income	0.46	–0.22	1.00	0.27
Total employment	0.58	0.85	0.27	1.00

Table 6-2. Correlation between PHX air passengers, population, income, and employment for 2002 to 2007

	PHX air passengers	Regional population	Average household income	Total employment
PHX air passengers	1.00	0.95	0.51	0.94
Regional population	0.95	1.00	0.71	0.99
Average household income	0.51	0.71	1.00	0.76
Total employment	0.94	0.99	0.76	1.00

Table 6-3. Correlation between PHX air passengers, population, income, and employment for 2008 to 2011

	PHX air passengers	Regional population	Average household income	Total employment
PHX air passengers	1.00	0.03	0.60	0.81
Regional population	0.03	1.00	0.51	0.56
Average household income	0.60	0.51	1.00	0.90
Total employment	0.81	0.56	0.90	1.00

Model

Separate time-series models were estimated for natural log of regional population, regional median household income (adjusted for inflation), and regional employment against log of annual air passengers originating in PHX. Preliminary estimation indicated that serial correlation was evident in the data, which is common in time-series regressions. To account for serial correlation, the generalized least squares method was used to estimate the models assuming an AR1 correlation structure.[4] Tables 6-4 and 6-5 give the results of the model estimation for 2002 to 2011 and for 2002 to 2007 only.

[4] AR1 correlation structure accounts for the assumption that the previous year is correlated with the current year.

Table 6-4. Natural Log of population, income, and employment regressed against log of PHX air passengers for 2002 to 2011

	Regional population		Average household income		Total employment	
	est	t-stat	est	t-stat	est	t-stat
int	7.860	1.03	11.784	2.08	7.585	1.24
ln(pop)	0.551	1.09				
ln(inc)			0.405	0.78		
ln(emp)					0.600	1.41
Ln Likelihood	14.214		13.914		14.345	
Pseudo R2	0.342		0.302		0.359	
N	10		10		10	

Table 6-5. Natural Log of population, income, and employment regressed against Natural Log of PHX air passengers for 2002 to 2007

	Regional population		Average household income		Total employment	
	est	t-stat	est	t-stat	est	t-stat
int	–0.281	0.00	13.463	0.01	0.707	0.00
ln(pop)	1.092	3.11				
ln(inc)			0.255	0.25		
ln(emp)					1.080	2.14
Ln Likelihood	10.610		8.628		9.811	
Pseudo R2	0.764		0.543		0.692	
N	6		6		6	

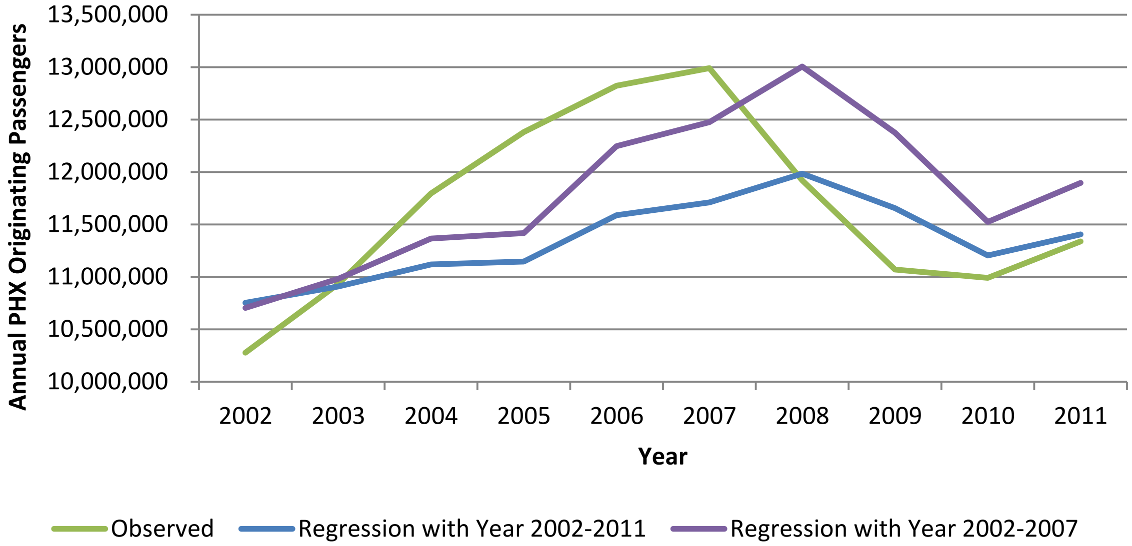
Not surprisingly, the models that include only prerecession years are stronger models compared with models that include all years. Median income is the weakest predictor of PHX air passenger trips for 2002 to 2011 and for the prerecession period of 2002 to 2007. Total population is the best predictor of air trips for the prerecession years, while total employment is the best predictor of air trips for all years. Since employment has a strong correlation with population but also fluctuates depending on the strength of the regional economy, employment is the best variable to use for predicting air passengers.

Forecast Comparison

Figure 6-5 shows observed air passenger trips versus the predicted air passengers for the regional employment regressions for all years and for 2002 to 2007 only. The regression with all years under-forecasts the prerecession values but matches closely to the postrecession totals. The regression that models only prerecession years slightly under-forecasts the prerecession years, but over-forecasts the recession and postrecession years.

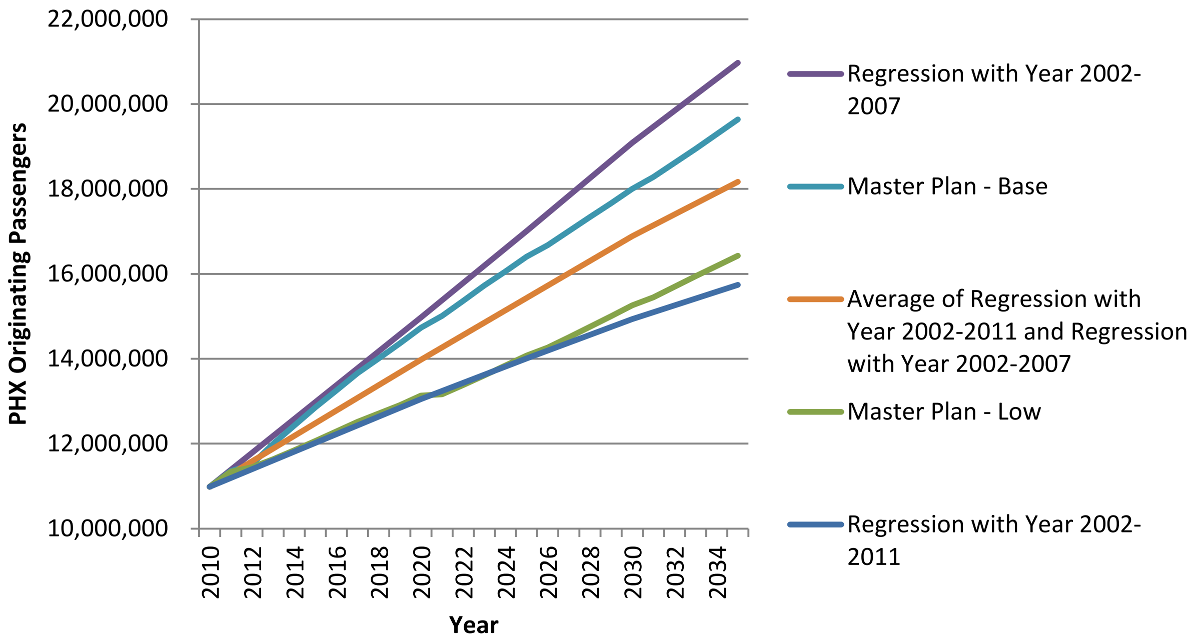
The PHX master plan provides forecasts through 2040, and TAZ-level total employment forecasts for 2020 through 2035 in 5-year increments were produced in December 2010. TAZ-level total employment for 2010 (that corresponds with the forecast year data) is 23 percent higher than the total county-level regional employment used in estimation. Before applying the regression models directly to the total employment forecasts, the constants were calibrated so that the regression models match 2010 air passenger trips exactly. Figure 6-6 shows the calibrated regression model forecasts compared with the PHX master plan low and base forecasts for 2010 through 2035.[5]

Figure 6-5. Observed and predicted annual air passenger trips originating in PHX



[5] The PHX master plan high forecast is identical to the base forecast for trips originating in PHX and, thus, it is not included in the graph.

Figure 6-6. Calibrated regression forecasts versus PHX master plan



The regression with 2002 to 2011 matches up very well to the PHX master plan low forecasts. The regression with 2002 to 2007 predicts a higher number of air passenger trips than the PHX master plan base forecasts. The figure includes an average of these two regressions that falls between the two master plan forecasts. The rationality behind averaging the regressions is that 2002 to 2007 represents a period of unsustainable high growth, while 2008 to 2011 represents an overcorrection to this period.

MAG can limit the external inputs into the airport model and not rely on PHX master plan forecasts by estimating air passengers using the average of regression with 2002 to 2011 and regression with 2002 to 2007 calibrated to the socioeconomic data for 2010. Table 6-6 shows the relationship between natural log of total employment and natural log of air passenger trips calibrated to 2010 for the TAZ2010 and TAZ2012 socioeconomic data. The benefit of using the socioeconomic data directly is that MAG can easily test alternative forecast year socioeconomic scenarios.

Table 6-6. Relationship between natural log of total employment and natural log of air passenger trips originating in PHX

	TAZ2010	TAZ2012
int	3.94	4.13
ln(emp)	0.84	0.84

As detailed in the PHX master plan, there were 19,225,050 annual enplaned passengers in 2010. Since there were 10,988,231 passengers that originated in PHX in 2010, the ratio of enplaned to originating passengers is 1.75. This ratio is assumed to remain constant over time.

A second trip generation alternative is to use the PHX master plan forecasts directly in the model. The forecasts were developed by a consulting firm specializing in airport forecasts (Leigh Fisher Associates) and are based on additional information besides total employment. There is an option in the model that gives MAG the option of choosing one of the three master plan forecasts (low, base, or high) in forecast year alternative analysis.

One important note about the regression model is that the dependent variable is log of air passenger trips, not air passenger trips. Forecasting log of air passenger trips can be done as normal, by applying the regression coefficients shown in Table 6-6. However, the expectation of air passenger trips is not equal to the exponent of the expectation of log of air passenger trips. Instead, the expectation of air passenger trips can be computed using the following equation:

$$E(AP) = exp(E(logAP) + SSR)$$

Here, SSR is the sum of squared residuals computed directly from the regression equation. The value of this term was 0.00375.

$$AP_{forecast} = \exp(4.13 + 0.84 * \ln(emp_{total}) + 0.00375)$$

AZA Forecasts

Forecasts for AZA are based directly on PHX air passenger forecasts. Currently, AZA enplanements are 2.08 percent of PHX total enplanements. This is closest to the AZA master plan middle scenario (Scenario II), which predicts that AZA enplanements will be 2 percent in 2012, 4.3 percent in 2017, and 9 percent of PHX enplanements by 2027. The AZA master plan currently uses a planning forecast of 1.5 percent in 2012 and 6.5 percent in 2027. Based on data from 2011 and 2012 the values used in the model have been adjusted to reflect real world data from the airports. The default value in the model will increase from 2.08 percent in 2010 to 7.27 percent in 2027 and remain at 7.27 percent after 2027, as shown in Table 6-7. However, MAG can change these percentages based on new information on AZA's expansion plans or to test alternative scenarios.

Table 6-7. Percentage of annual PHX enplanements used to calculate AZA annual enplanements

Year	Percent of PHX enplanements	Year	Percent of PHX enplanements
2010	2.08	2020	5.47
2011	2.38	2021	5.73
2012	3.41	2022	5.98
2013	3.67	2023	6.24
2014	3.92	2024	6.50
2015	4.18	2025	6.76
2016	4.44	2026	7.01
2017	4.70	2027	7.27
2018	4.95	2027+	7.27
2019	5.21	—	—

Annual to Daily Forecasts

The annual air passenger person trips originating in PHX and AZA are converted into average daily weekday, Saturday, and Sunday air passenger trips for each airport based on the relationship between the expanded survey numbers developed for the base year and reported annual air passenger trips originating in PHX and total enplanements for AZA. This relationship will not change for forecast years. Table 6-8 shows the annual total enplanements at PHX, annual total enplanements at AZA, average number of daily trips originating in PHX and AZA for 2011, and the calculated daily originating trips to total annual enplanements at each airport.

Table 6-8. 2011 annual enplanements and daily trips originating in PHX and AZA

Day of week	Annual total PHX enplanements	Daily trips originating in PHX	Daily/Annual ratio for PHX	Annual total AZA enplanements	Daily trips originating in AZA	Daily/Annual ratio for AZA
Weekday	19,994,434	35,868	0.0018	475,918	1,438	0.0030
Saturday	19,994,434	33,033	0.0017	475,918	868	0.0018
Sunday	19,994,434	31,018	0.0016	475,918	1,972	0.0041

The relationship between PHX daily originating passengers and the number of annual air passengers originating in PHX, as estimated from the time-series model, can be represented by the following formula:

PHX daily originating passengers = 1.75 x annual passengers originating in PHX x daily to annual ratio for PHX
Where:
1.75 is the ratio of PHX annual enplaned passengers to annual passengers originating in PHX
Annual passengers originating in PHX are estimated by the time-series model using forecast total employment in MAG's transportation analysis area
Daily to annual ratio for PHX differs by day of week as shown in Table 6-8

The relationship between AZA daily originating passengers and the number of air passengers originating in PHX, as estimated from the time-series model, can be represented by the following formula:

AZA daily originating passengers = % of PHX enplanements x 1.75 x annual passengers originating in PHX x daily to annual ratio for AZA
Where:
% of PHX enplanement corresponds to a value in Table 6-7
1.75 is the ratio of PHX annual enplaned passengers to annual passengers originating in PHX
Annual passengers originating in PHX is estimated by the time-series model using forecast total employment in MAG's transportation analysis area
Daily to annual ratio for AZA differs by day of week as shown in Table 6-8

The final trip generation equations for forecasting PHX daily originating passengers are as follows:

$$\text{PHX weekday} = 1.75\ x\ \exp(4.13 + 0.84 * \ln(emp_{total}) + 0.00375)\ x\ 0.0018$$

$$\text{PHX saturday} = 1.75\ x\ \exp(4.13 + 0.84 * \ln(emp_{total}) + 0.00375)\ x\ 0.0017$$

$$\text{PHX sunday} = 1.75\ x\ \exp(4.13 + 0.84 * \ln(emp_{total}) + 0.00375)\ x\ 0.0016$$

The final trip generation equations for forecasting AZA daily originating passengers are as follows:

$$\text{AZA weekday} = \text{\% of PHX enplanement x } 1.75\ x\ \exp(4.13 + 0.84 * \ln(emp_{total}) + 0.00375)\ x\ 0.0030$$

$$\text{AZA saturday} = \text{\% of PHX enplanement x } 1.75\ x\ \exp(4.13 + 0.84 * \ln(emp_{total}) + 0.00375)\ x\ 0.0018$$

$$\text{AZA sunday} = \text{\% of PHX enplanement x } 1.75\ x\ \exp(4.13 + 0.84 * \ln(emp_{total}) + 0.00375)\ x\ 0.0041$$

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7.0 External Trips, Time-of-Day, and Market Segmentation

This section discusses the methodology for allocating air passenger trips to external stations, distributing trips across time of day, and assigning air passenger trips to market segmentation categories.

External Trips

Immediately after trip generation, the number of air passenger trips with origins and destinations outside of the MAG region are separated from the internal trips. The percentages of trips that are assigned to external zones from each of the airports were calculated from the weighted survey data and are shown in Tables 7-1 and 7-2.

Table 7-1. Percentage of PHX air passenger trips originating in internal and external TAZs

Day of week	Internal TAZ	External TAZ
Weekday	93.1%	6.9%
Saturday	89.0%	11.0%
Sunday	93.0%	7.0%

Table 7-2. Percentage of AZA air passenger trips originating in internal and external TAZs

Day of week	Internal TAZ	External TAZ
Weekday	92.5%	7.5%
Saturday[1]	95.0%	5.0%
Sunday	95.0%	5.0%

Time-of-day distributions for external trips are assumed to be identical to internal trips and are discussed in more detail in the next section. The party size distribution for external trips was calculated from the combined weighted survey data for PHX and AZA, as shown in Table 7-3. Average party size for 3+ external trips was calculated as 3.6 people.

Table 7-3. Distribution of PHX and AZA external trips, by day of week and party size

Day of week	1 person	2 people	3+ people
Weekday	37.1%	33.6%	29.2%
Saturday	31.0%	28.6%	40.3%
Sunday	42.8%	41.5%	15.7%

All external trips are assigned to the auto mode. Party size is used to assign the trips as drive alone, shared ride 2, or shared ride 3.

[1] AZA Saturday distributions are borrowed from Sunday survey record results.

Using the geographic information obtained in the survey, external locations were mapped and assigned to a specific external zone. However, since the additional travel beyond an external zone will not be modeled (for example, from the MAG boundary to Flagstaff), network skims are less meaningful for external trips and are, therefore, not used in the estimation dataset. Instead, external zone trip origins are assigned in the model based on the observed distribution in the dataset. The weighted and unweighted external zone distributions are shown in Table 7-4. (Note that three external observations had insufficient geographic information to be mapped or assigned to a specific external station and, thus, were not included in the results shown in Table 7-3.)

Table 7-4. Air passenger survey of external trips, by station

External station ID	External station name	Percentage of external trips		Weighted Trips*		Unweighted Trips	
		PHX	AZA	PHX	AZA	PHX	AZA
1	SR 85	2	0	663	0	5	0
2	I-10 East	30	49	10,960	101	117	16
3	SR 77 (Oracle Road)	0	0	0	0	0	0
4	SR 77 (Winkelman)	0	0	0	0	0	0
5	US 60 East	1	0	421	0	9	0
6	SR 188	0	0	0	0	0	0
7	SR 87	4	1	1,331	3	21	1
8	I-17	58	36	20,882	75	217	10
9	SR 89	0	0	22	0	1	0
10	SR 71	0	0	42	0	1	0
11	US 60 West	0	0	0	0	0	0
12	I-10 West	1	2	401	5	5	1
13	I-8	3	11	1,234	22	17	4
			Total	**35,957**	**206**	**393**	**32**

*Monthly trips, see section 4.0.

Time of Day

Air passenger trip time-of-day profiles will not be a choice model but a simple derivation of fixed factors from observed trends in flying patterns for the two airports. For air passenger trips traveling to the airport, this was developed directly from the distribution of start times of trips in the expanded survey data for internal trips.

For air passenger trips traveling from the airport, the total number of passenger seats arriving on each flight in March 2012 for PHX and April 2012 for AZA was summarized by time of day and day of week. Trip departure from the airport was assumed to be 45 minutes after the flight arrival time for PHX and 15 minutes after the flight arrival time for AZA.

Tables 7-5 and 7-6 show these distributions for PHX and AZA, respectively, broken down by modeling time periods.

Note that these splits by time of day are based on the reported time of day that a traveler or meeter/greeter began his or her journey to the airport. As such, it does not correlate with the time of day tables that reflect the schedule flight departure or arrival time, such as Table 2-2...

Table 7-5. Distribution of trips to and from PHX by day of week and start time

	Morning	Midday	Afternoon	Nighttime
Day of week	**6 a.m. to 9 a.m.**	**9 a.m. to 2 p.m.**	**2 p.m. to 6 p.m.**	**6 p.m. to 6 a.m.**
Weekday	4.3%	29.8%	25.9%	40.0%
Saturday	3.9%	34.2%	24.8%	37.1%
Sunday	3.4%	28.9%	25.7%	42.0%

Table 7-6. Distribution of trips to and from AZA by day of week and start time[1]

	Morning	Midday	Afternoon	Nighttime
Day of week	**6 a.m. to 9 a.m.**	**9 a.m. to 2 p.m.**	**2 p.m. to 6 p.m.**	**6 p.m. to 6 a.m.**
Weekday	0.0%	26.1%	29.0%	44.9%
Saturday	0.0%	21.9%	33.2%	44.9%

Time-of-day factors for forecast years will not change for PHX and will remain the same as the base year. Given that AZA will go through significant expansion in the future, it is expected that AZA's time-of-day profiles will resemble PHX's profiles over time. In the model, as the market capture of AZA increases, the time-of-day profile for AZA will become closer to that of PHX.

Market Segmentation

This model segments the total number of air passengers into a number of market groups and assigns household-level characteristics including trip purpose (business versus nonbusiness), resident status (Arizona resident versus visitor), household income, number of household vehicles, previous location before traveling to airport, and party size.

The model assigns market segments and household-level characteristics to each air passenger based on a set of factors developed from the expanded survey data by airport and time of day. The model assigns factors in the following order so that previously assigned characteristics can be used to factor later characteristics: (1) trip purpose and resident status, (2) household income quintile and vehicle ownership, (3) previous/next location, (4) party size. The distributions for each market segmentation category are shown in Appendix B.

[1] Given the high number of early morning flights at AZA, the nighttime percentage of trips is heavily inflated while the morning time period had no trips.

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8.0 Mode Choice

This section outlines the air passenger access/egress mode choice model data preparation, input assumptions, and proposed model specification, including market segmentation and available alternatives. Additionally, the necessary model constraints, estimation results and mode insertions are presented.

Survey Dataset

The model was estimated from the air passenger survey data, which contained 5,779 observations. Four hundred twenty-eight of these observations were coded to an external zone. Since no skim can be joined to these observations, they were removed from the estimation dataset. External zone trip modes were assigned in the model based on the observed distribution in the dataset. The weighted and unweighted mode distributions for access trips originating in internal and external zones are shown in Table 8-1.

Table 8-1. Mode Distribution of Trips to Aiport by Origin

		Internal trips				External trips			
		Unweighted		Weighted*		Unweighted		Weighted*	
Mode		**Obs.**	**%**	**Obs.**	**%**	**Obs.**	**%**	**Obs.**	**%**
Drive and park	DA	544	10.2	24,285	6.0	50	11.7	1,313	3.6
	SR2	326	6.1	28,310	7.0	39	9.1	5,171	14.2
	SR3+	125	2.3	19,937	4.9	21	4.9	3,926	10.8
Dropped off/ Picked up	SR2	1,145	21.4	54,613	13.5	50	11.7	2,166	6.0
	SR3+	1,028	19.2	88,313	21.8	50	11.7	6,549	18.0
Rental car		1,200	22.4	111,049	27.4	125	29.3	12,205	33.6
Taxi		302	5.6	19,325	4.8	3	0.7	566	1.6
Shared ride van		213	4.0	16,367	4.0	83	19.4	3,984	11.0
Limo/car service		184	3.4	17,129	4.2	4	0.9	370	1.0
LRT		55	1.0	1,566	0.4	0	0.0	0	0.0
Hotel shuttle		208	3.9	17,666	4.4	1	0.2	37	0.1
City bus		12	0.2	704	0.2	0	0.0	0	0.0
Charter bus		10	0.2	6,722	1.7	1	0.2	16	0.0
Total		**5,352**	**—**	**405,985**	**—**	**427**	**—**	**36,302**	—

*Monthly trips, see section 4.0.

Market Segmentation

The mode choice model was segmented according to the trip purpose (business or other), traveler residency (resident or visitor), and income group (low and high). The mode choice for both PHX and AZA were estimated in the same model. While it was expected that the skim data will capture the different LOS to each airport, an airport dummy variable was introduced during model development to test for a significant difference in the unobserved attributes of each airport.

Trip purpose segmentation is important to identify any difference in sensitivity to travel costs; for example, a traveler may be less sensitive to costs when traveling for business. The residency segmentation determines the available modes. A detailed review of modes available to residents and visitors is presented in the next section.

Income segmentation is based on the assumption that decision makers have a different set of underlying preferences based on their income (that is, wealthier travelers may be more willing to rent a car) and different value of time (that is, wealthier travelers are willing to pay more to get to their destination more quickly). The income segments must balance using a low enough income split such that the mode preferences within the groups is significant while not segmenting the data so fine that there are too few observations. The amount of $80,000 was chosen as a segmentation point because the income is grouped into $20,000 segments and approximately 30 percent of the respondents reported an income less than $80,000. In other words, the income variable was segmented into low and high groups. The derivation of input data for these two groups will be explained in the value of time discussion in the model constraints section that follows.

Choice Set Definition

Modal Availability

The visitor and resident designation determines what modes are available. Specifically, access by rental cars should only be an option for visitors. Residents are not likely to be returning cars rented at the airport. Conversely, a visitor cannot drive and park at the airport; otherwise, they would not be able to retrieve their cars. Table 8-2 shows the distribution of weighted trips by mode and segment. Trips with invalid market-mode combinations are highlighted.

Table 8-2. Weighted trips, by market segment

Mode		Trips byResidents				Trips by Visitors			
		Other Trips		Business Trips		Other Trips		Business Trips	
		Weighted trips	%	Weighted trips	%	Weighted trips	%	Weighted trips	%
Drive and park	DA	7,920	10.3	10,735	27.6	1,823	0.8	3,807	5.3
	SR2	11,242	14.6	3,640	9.4	11,612	5.3	1,816	2.5
	SR3+	5,654	7.3	1,368	3.5	12,536	5.7	379	0.5
Dropped off/ Picked up	SR2	16,517	21.4	11,751	30.2	20,828	9.5	5,517	7.7
	SR3+	24,068	31.2	4,854	12.5	55,292	25.3	4,100	5.7
Rental car		2,028	2.6	1,303	3.4	79,586	36.4	28,112	39.3
Taxi		1,638	2.1	2,464	6.3	6,696	3.1	8,527	11.9
Shared ride van		4,522	5.9	1,789	4.6	6,230	2.9	3,827	5.3
Limo		1,500	1.9	502	1.3	7,538	3.5	7,589	10.6
LRT		1,008	1.3	72	0.2	358	0.2	128	0.2

Shuttle	1,004	1.3	410	1.1	9,067	4.2	7,185	10.0
Bus	23	0.0	0	0.0	204	0.1	478	0.7
Charter bus	0	0.0	0	0.0	6,589	3.0	133	0.2
Total	**77,124**	**—**	**38,888**	**—**	**218,359**	**—**	**71,598**	**—**

MAG reviewed the observations reporting private vehicle drive and park by visitors and found that many should be categorized as rental car. Visitor drive and park observations that reported parking in an off-airport lot were recategorized as rental car. All other visitor drive and park observations were removed from the estimation dataset. In future surveys, it is advisable to explicitly list private vehicles as not being rental cars.

It is unclear why resident trips were reported with rental cars. It may be because of miscoded responses in the dataset or a misunderstanding of the resident/visitor designation (for example, one potential explanation for residents who chose rental car is that the residency question asks if the individual is a resident of Arizona; therefore, a resident of Flagstaff would be coded as a resident, even if he or she was visiting Phoenix and flying home). These observations were excluded from the estimation dataset. This methodology is consistent with other airport models as described in ACRP Synthesis 5.

Alternative Grouping

The taxi, shared ride van, limo, and charter bus are similar types of modes in that they are an on-demand fee service. Thus these modes were combined for estimation into a common "demand service" alternative.

Although there are very few transit observations in the overall dataset, it is useful to estimate separate LRT and bus alternatives to support future transit expansions.

The occupancy level for drive and park and dropped off/picked up modes is highly correlated to the air trip party size. Air trip party size is assumed to be determined prior to the airport access/egress mode choice and is exogenous to the mode choice model. Thus the occupancy specific alternatives were combined into a single alternative for all occupancies. The input cost for that alternative varies based on the expected occupancy rate for each party size.

The proposed mode choice alternatives for estimation and the corresponding number of weighted survey observations are shown in Table 8-3.

Table 8-3. Weighted trips, by mode choice alternatives

Mode	Trips by Residents				Trips by Visitors			
	Other Trips		Business Trips		Other Trips		Business Trips	
	Weighted trips	%	Weighted trips	%	Weighted trips	%	Weighted trips	%
Drive and park	24,816	48.6	15,743	48.1	—	—	—	—
Dropped off/ Picked up	16,517	32.4	11,751	35.9	76,120	36.1	9,617	13.7
Rental car	—	—	—	—	97,945	46.5	32,682	46.6
Demand service	7,660	15.0	4,754	14.5	27,052	12.8	20,076	28.6
LRT	1,008	2.0	72	0.2	358	0.2	128	0.2
Shuttle	1,004	2.0	410	1.3	9,067	4.3	7,185	10.2
Bus	23	0.0	0	0.0	204	0.1	478	0.7
Total	**51,027**	**—**	**32,731**	**—**	**210,745**	**—**	**70,165**	**—**

Skims

Highway and transit skims were associated with each observation to provide travel distance, time, and cost values for each alternative. The skims are categorized by peak and off-peak and by high-occupancy vehicle/low-occupancy vehicle for highway and by both access mode (walk, kiss-and-ride, park-and-ride) and mode for transit. This section describes the methodology by which skims were appended to the survey records.

Peak/Off-peak

Peak and off-peak skims were associated with the survey data according to the trip travel time and day of week as defined in Table 8-4.

Table 8-4. Association between Travel Times and Time of Day/Dayof Week.[8]

Day of week	Morning	Midday	Afternoon	Nighttime
Weekday	Peak	Off-peak	Peak	Off-peak
Saturday	Off-peak	Off-peak	Off-peak	Off-peak
Sunday	Off-peak	Off-peak	Off-peak	Off-peak

[8] This table refers to the model time periods, not the data collection time periods.

High-occupancy Vehicle/Low-occupancy Vehicle

Low-occupancy vehicle skims will be associated with drive-and-park when the air trip party size equals one. The high-occupancy vehicle skims were associated with all other auto modes, excluding rental car, which do not have any LOS variables in the utility function.

Transit Access Mode

The transit access mode affects the transit availability and path in the skims. Walk access restricts transit availability to within a walking-distance buffer around each station. Park-and-ride access must use a station with a parking lot. Kiss-and-ride access can use any station. The survey data includes the access mode to transit only if light rail is used. If the previous mode reported is bus, the transit access mode is not reported. Table 8-5 shows the distribution of access modes to transit in the dataset.

Table 8-5. Transit access mode

Mode	Weighted trips	%
Walk	998	63.7
Park-and-ride	29	1.8
Kiss-and-ride	314	20.0
Bus	226	14.4
Total	**1,566**	**100.0**

Transit Mode

Five transit skims are available that represent different levels of transit mode availability. The skims labeled "URB" will be used for the LRT alternative while the skims labeled "LOC" will be used for the local bus alternative. The paths skimmed in the URB matrix, however, are not guaranteed to use LRT service. Instead, the shortest path using any transit mode LOS attributes are skimmed. In estimation, the LRT alternative was only considered available when the skim path includes non-zero LRT in-vehicle travel time. The bus alternative was considered available when there is non-zero in-vehicle travel time on local bus in the "LOC" skims.

Previous Location

All airport access trips using hotel shuttles are expected to originate at a hotel. However, nine observations reported hotel shuttle as the access mode, but had a previous location that was not a hotel (two – private home, seven – other). MAG reviewed the long-form survey on the nine observations and found that the previous location on four of them was misidentified and should be a hotel. In application, the hotel shuttle is only available when a trip end is at a hotel; therefore, the remaining five observations were removed from the estimation dataset. During estimation, the "previous location = private home" and "previous location = hotel" variables were tested across all market segments.

Utility Formulation

Transit Time Formulation

Transit trips involve several different components of time: waiting time, transfer time, access time (walk or drive), and in-vehicle time of different modes. Given the small number of transit observations, the model was not likely to estimate significant parameters for each of these components. Thus, an in-vehicle time to out-of-vehicle time ratio of 2.0 was applied to generate a generalized time variable, which is consistent with the MAG special event model. Generic time and cost coefficients were estimated in the model to be consistent with Federal Transit Administration recommendations.

Auto Occupancy

The average auto occupancy size for each air trip party size was needed to compute the cost component. The air trip party size was aggregated into 1, 2, and 3+ groups with an average auto occupancy of 1, 2, and 3.6, respectively.

Demand Service Rates

The demand service alternative includes taxi, limo, shared-ride van (for example, super shuttle), and charter bus. The survey reported the fare paid for the taxi and limo modes. Interestingly, the cost per mile per passenger for both taxi and limo was similar (approximately $3/mile/passenger). The average distance used by limo service was also longer than taxi. This implies that the limo rates, which are typically by time, are better for longer trips than taxi rates, which are typically calculated by distance. The average shared ride van rates reported on the super-shuttle website are less $3/mile/passenger, but shared-ride van service includes a potentially large time delay depending on how the passenger pick ups and drop offs are sequenced. The time delay information is not available, so the higher cost rate calculated from taxi/limo service serves as a proxy.

Drive and Park Airport Out-of-Vehicle Time

The out-of-vehicle time from airport parking to the terminal at PHX depends on the terminal and parking location. Two economy lots are located on either end of the airport; they are served by shuttles with a 10-minute headway. There are also terminal garages with direct walk access. Travelers can also park in privately managed off-airport lots.

Table 8-6 shows the weighted number of observations by each parking lot used. The travel times from the east and west economy lots are calculated using the average shuttle travel time across all terminals. The off-airport lot travel time is the average of the economy lot travel times. The wait time is calculated as half the headway of the shuttle. An average 5-minute walk is assumed for parking in the terminal garage. Finally, the weighted average out-of-vehicle time is calculated across all parking locations to get an average out-of-vehicle time for PHX of 12.74 minutes.

Table 8-6. PHX parking lot use and estimated terminal travel times

Lot	Weighted observations	%	Wait time	Travel time
Off-airport	153	22.7	5.00	11.78
East lot	216	32.0	5.00	12.33
West lot	71	10.5	5.00	10.67
Garage	235	34.8	0.00	5.00
Average			3.26	9.48
			Total	**12.74**

AZA has a mix of local parking at the terminal and a remote lot with a shuttle service. The AZA website recommends that travelers allow for 15 to 20 minutes to access the terminal from the parking lot. An average out-of-vehicle time of 17.5 minutes is assumed for AZA.

Cost Formulation

Table 8-7 shows the cost calculation for each mode.

Table 8-7. Cost formulation for each mode

Mode	Cost calculation
Drive and park	(CPM + DailyParkingRate* AvgTripDur / 2) / (AvgAutoOcc | AvgGroupSize)
Dropped off/Picked up	CPM / (AvgAutoOcc | AvgGroupSize)
Rental car	None
Demand service	Cost / Mile / Person calculated from survey
Hotel shuttle	None
LRT	Fare (from skims)
Local bus	Fare (from skims)

Notes on the cost calculations follow:

- CPM – Operating cost per mile, set at $0.19/mile.
- DailyParkingRate – An average parking rate per day will be assumed at PHX and AZA. A $6/day parking rate will be used for AZA, as published on its website. The parking lot transaction data from PHX parking rates revealed that a $10/day parking rate is most appropriate based on the distribution of garage and economy lot usage. The total parking costs are only realized as part of a round trip. Therefore, the daily parking rate is divided by 2 to associate half of the parking costs with this leg of the trip.

- AvgTripDur – Average number of days spent traveling. Trip duration will differ based on trip purpose. The parking lot transaction data, however, only shows the average trip length for trips that decided to park. The length of the air trip is expected to be correlated with the decision to park, that is, parking is more likely on shorter trips. Trip lengths of 4 days for business purposes and 6 days for other purposes will be used, which is consistent with the trip length values reported in ACRP Synthesis 5.
- Rental Car Cost – If a visitor has rented a car from the airport to use during his or her stay in Phoenix, it must be returned to the airport regardless of the operating costs or travel times. Therefore, the costs will not factor into the mode choice decision and are not included in the cost calculation. There is insufficient data to estimate the initial choice to rent a car during a visitor's stay in Phoenix.

Model Structure

There is likely correlation between the transit modes that warrants implementing a nested logit model (see Figures 8-1 and 8-2). During calibration, the LRT mode alternative was split into two separate modes: drive access LRT and walk access LRT, which resulted in a change to the nesting structure. This is described in more detail in the validation section.

Figure 8-1. Resident market nest structure

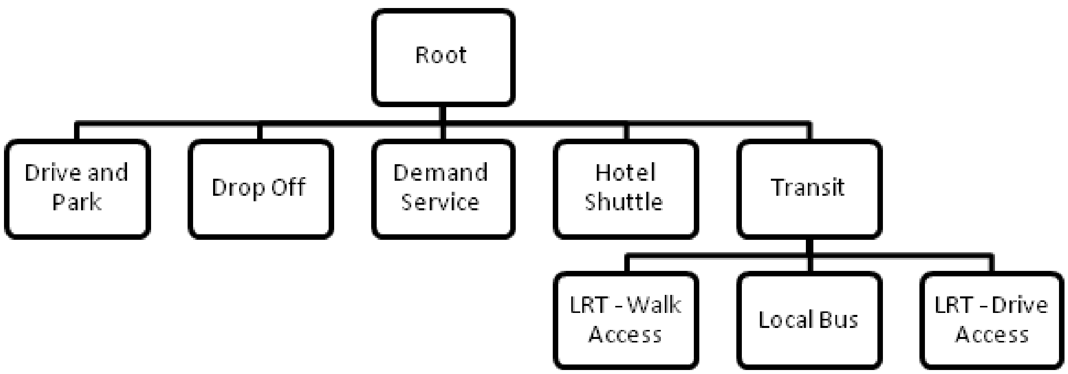
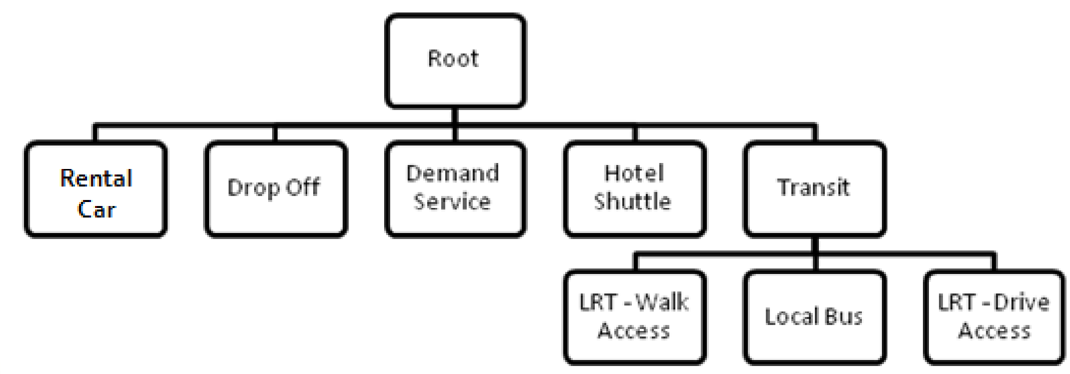


Figure 8-2. Visitor market nest structure



Model Estimation Process

The model process proceeded through the four major rounds of estimation, discussed below.

Initial Round: Multinomial Logit Models for Exploratory Analysis

This round included four sets of models specified as multinomial logit models:

- resident business
- resident other
- nonresident business
- nonresident other

The first round of models resulted in very high values of times ranging from $100 to $500 for most of the models. This was computed using the estimated time and cost coefficients.

Second Round: Nested Model Structure

The second round involved models that were specified as nested logit models. The results were not very different in terms of magnitude and direction of most of the coefficients. The values of times were also in the same range as the first round of models.

Based on a review of the ACRP Synthesis report, it was found that the values of times ranged from $20 to $125 based on the purpose (business or other) and resident or nonresident.

Third Round: Constrained LOS Coefficients

For the third round of models, both multinomial logit and nested logit models were estimated by constraining the time and cost coefficients to certain values of times. The value of time constraints are based on the ranges in other airport models reported in the ACRP Synthesis 5. These models generally followed the following value of time assumptions:

- Value of time of business travelers is about twice that of other purpose travelers.
- The value of time of low- and high-income segments is relative to the median income of each segment. In this dataset, the high-income median is approximately 2.5 times the low-income median with an $80,000 income segmentation.
- The relationship of resident and nonresident values of time is calculated from the ratio of the regional median income for Phoenix (approximately $44,000) and the median income for the rest of the United States (approximately $51,000). This relationship is applied only to the higher income group because the lower income group is fixed. The result is that the nonresident high-income group value of time is 15 percent higher than the resident high-income group with the same trip purpose.

Based on these assumptions and the $20 to $125 value of time range from similar regions, the following values of time were developed for this model:

- resident other – $20 to $50 for low- to high-income groups
- resident business – $40 to $100 for low- to high-income groups

- nonresident other – $20 to $57.50 for low- to high-income groups
- nonresident business – $40 to $115 for low- to high-income groups

The in-vehicle time coefficient was constrained to a value within Federal Transit Administration specifications:

- Business purpose trips: –0.030
- Other purpose trips: –0.015

Final Round: Nest Coefficients

In the fourth round of models, the nesting coefficients were constrained to 0.6. Nest coefficients represent the degree of correlation between alternatives and must be between 0 and 1, but typically range between 0.2 and 0.8.

The nest coefficient scales each coefficient within the nest; therefore, the nest coefficient must be constrained if there are constrained coefficients within the nest. Otherwise, the nest coefficient in estimation would relax the constrained LOS coefficients. The two transit modes are likely to be well-correlated, so a coefficient of 0.6 is asserted for this nest.

Estimation Results

The final model estimation results are shown in Table 8-8.

Table 8-8. Mode choice estimation results

		Resident business		Resident other		Visitor business		Visitor other	
	Mode	**Coeff**	**t-stat**	**Coeff**	**t-stat**	**Coeff**	**t-stat**	**Coeff**	**t-stat**
Alternative specific constants	Drive and park (DP)	Base		Base		N/A		N/A	
	Drop off/Pick up (DO)	–2.837	–5.0	–1.206	–1.9	–0.653	–1.4	1.145	2.3
	Hotel shuttle (SHTL)	–0.562	–0.5	–0.417	–0.6	–2.367	–7.5	–4.128	–3.7
	Rental car (RC)	N/A		N/A		Base		Base	
	Demand service (DS)	–3.537	–3.1	–2.403	–3.1	–0.031	0.0	0.402	0.7
	LRT	–5.379	–3.0	–21.205	–2.5	–3.283	–3.6	–15.242	–1.9
	Bus	–10.000	const	–23.574	–2.7	–3.833	–3.3	–15.738	–2.0
LOS variables									
Time cost		–0.050	const	–0.025	const	–0.050	const	–0.025	const
In-vehicle travel time (min)	DP, DO, SHTL, DS, LRT, BUS	–0.030*	const	–0.015*	const	–0.030*	const	–0.015*	const
Out-of-vehicle travel time (min)	DP, DO, SHTL, DS, LRT, BUS	–0.060*	const	–0.030*	const	–0.060*	const	–0.030*	const
Cost – income ≤ $80,000	DP, DO, DS, LRT, BUS	–0.045*	const	–0.045*	const	–0.045*	const	–0.045*	const
Cost – income > $80,000	DP, DO, DS, LRT, BUS	–0.018*	const	–0.018*	const	–0.016*	const	–0.016*	const
Distance (miles)	RC					–0.072	–6.1	–2.97	–4.5
Socioeconomic									
Income >$80,000	DO	–0.603	–1.5	–0.560	–2.2	–1.817	–4.4	–1.745	–8.4
	SHTL							–1.152	–2.7
	DS	–2.025	–3.1	–1.341	–3.0	–1.794	–5.4	–2.576	–9.4
Missing income	DO	–0.306	–0.6	–0.599	–1.8	–0.733	–1.3	–1.064	–4.1
	SHTL							0.471	1.0
	DS	–0.945	–1.1	0.348	0.7	–1.465	–3.2	–1.799	–5.1
Zero or one auto in household	DO			–0.871	–3.0				
	DS			0.782	1.8				

*Effective coefficient at the highest nest level – all other coefficients are the scaled value applied at the alternative level.
Const – Constrained or asserted coefficients

	Mode	Resident business		Resident other		Visitor business		Visitor other	
		Coeff	**t-stat**	**Coeff**	**t-stat**	**Coeff**	**t-stat**	**Coeff**	**t-stat**
Trip Characteristics									
Previous location = home	DO	0.611	1.2	0.999	2.5	2.713	5.7	2.334	8.1
	DS	2.252	2.1	1.904	2.6			2.890	5.8
Previous location = hotel	DO	–2.647	–1.0	–4.312	–1.8	–1.190	–2.8	–2.258	–6.9
	DS	3.535	2.0	1.890	1.6	1.281	4.2	1.177	2.4
Mesa Gateway	SHTL					–2.520	–0.5	–4.791	–2.3
Weekend	DO	1.151	2.4			0.622	1.2		
	SHTL					1.301	2.5		
	DS	1.302	1.8	0.517	1.1	0.428	1.1	0.205	0.8
Nighttime (8 p.m. to 5 a.m.)	SHTL					0.817	2.0	2.496	6.9
Party Size ≥2	DO	0.778	2.2	–1.096	–4.4	–0.720	–1.9	–1.732	–8.5
	DS			–1.003	–2.5			–0.711	–2.5
	LRT, bus			–2.142	–1.7			–2.438	–1.8
Zone characteristics									
Log(Max(Population Density, 1))	DO			0.091	1.4			0.074	1.6
	SHTL							0.172	1.4
	DS					0.137	2.1		
	LRT, bus			2.036	2.1			1.320	1.5
Nest coefficient									
Transit nest	LRT, bus	0.6	const	0.6	const	0.6	const	0.6	const
Value of time ($/hour)									
Income ≤$80,000		40	const	20	const	40	const	20	const
Income >$80,000		100	const	50	const	115	const	57.5	const
Observations			637		1,277		1,197		2,092
Log likelihood at zero			–711.5		–1679.2		–1637.8		–3733.0
Log likelihood convergence			–459.9		–1052.3		–1118.4		–2335.8
Rho-squared			0.354		0.373		0.317		0.374

Some of the counterintuitive model results are discussed below:

- **Large negative LRT and bus alternative specific constant (ASC) for other-purpose segments.** These values need to be considered along with the population density variable, which has a large coefficient. High population density is well-correlated with the choice of transit. For example, the maximum value of log (population density) is 10.53, which adds 10.53 X 2.043 = 21.5 to the LRT utility, effectively balancing the ASC. Also, the magnitude of ASCs should not be interpreted in isolation; all other constants in the utility equation should be included to know the true influence of ASCs.
- **Resident hotel shuttle ASC is less negative than all modes except drive and park**. The hotel shuttle alternative is only available when the previous location is a hotel. DS and DO have variables for previous location = hotel. When the previous location is a hotel, the effective ASCs for each of these alternatives are shown in the following table. Furthermore, it is reasonable that DO is less attractive when the previous location is hotel.

Table 8-9. Alternative specific constants when previous location is a hotel

Mode	Base ASC	Hotel variable	Total hotel
DO	–3.000	–2.595	–5.595
SHTL	–0.533	0.000	–0.533
DS	–4.312	4.048	–0.264

- **Interpretation of the Log(MAX(Population Density,1)) function.** Employment density and population density were both tested and population density was found to be more consistently significant across alternatives and market segments. A log formulation is used because the effect of increased density is expected to be marginally more important at lower density levels than higher ones. In other words, a unit increase in density should have a larger effect if the base density was 1 as opposed to a base density of 1,000. Also, it is not uncommon to use the logarithmic transformation of variables like employment or population, which are zonal aggregates that relate to quantity of the variable and not much quality. The max(density, 1) function is used to ensure that this variable will always have a positive value and thus a consistent impact on utility.

Final Model with Drive-LRT Mode

As discussed previously, there is insufficient data to estimate LRT access-specific modes. The drive-LRT mode is included in the model prior to calibration with the same utility formulation as the estimated walk-LRT mode. The only difference between the utilities is the ASC value. To approximate the drive-LRT ASC, the relative difference between walk-LRT and drive-LRT in the MAG special event mode choice model is used. The difference in the special event model is translated into in-vehicle time units, and this difference is applied to the estimated walk-LRT mode in the airport access/egress model.

The difference in LRT access ASCs in the special event model is equivalent to 23.81 minutes (see Table 8-10).

Table 8-10. MAG special event mode choice LRT access

	ASC	IVTT	ASC IVTT equivalents
Walk-LRT	–3.300	–0.063	52.38
Drive-LRT	–1.800	–0.063	28.57
		Difference	23.81

Using the IVTT coefficient from the airport access/egress model, the drive-LRT ASC should be 23.81 X -0.050 = -1.19 different from the walk-LRT ASC. The airport access/egress model LRT ASCs are shown in Table 8-11.

Table 8-11. Airport access/egress LRT access-specific ASCs

	Resident business	Resident other	Visitor business	Visitor other
Walk-LRT	–5.379	–21.205	–3.283	–15.242
Drive-LRT	–6.569	–22.395	–4.474	–16.433

Finally, including the LRT access-specific modes warrants adding another nest level to the model. The nest coefficient for this nest is constrained to be 0.4.

9.0 Origin Choice

This section outlines the air passenger access/egress destination choice model data preparation, input assumptions, model specification (including market segmentation), and estimation results. The model was estimated using the air passenger survey data.

Origin Choice Model

Origin choice is fully segmented across location type. These include home, hotel, and other location types. In other words, three origin choice models were estimated, one for each location type. Origin choices from PHX and AZA were estimated in the same model, since it is expected that LOS to each airport will capture the key differences among airports. Segmentation was also explored across residency and trip purpose, although this segmentation was examined only for key variables (rather than wholly separate models).

Variables

A key variable that was tested in the origin choice model was LOS to the airport. To account for this, mode choice logsums were computed using the estimated mode choice model coefficients. These mode choice logsums represent an aggregate accessibility measure between zones across all available modes.

Size variables are key for the origin choice models. These variables measure the opportunity in an alternative, rather than the quality of that alternative. In other words, the higher the number of households in a zone, the more likely a person will choose that zone for a home trip type. Variables consistent with the location type modeled and forecast by MAG were explored, such as number of households for home-based trips, various employment types for other-based trips, and hotel employment for hotel-based trips.

Alternatives

All internal zones in the MAG region are available alternatives in the model. External trips are handled separately as described above.

Estimation Results – Home-based Model

The home-based origin choice model predicts location for all trips originating at a home. Key variables to the model include a mode choice logsum, accessibility of transit as a mode alternative, highway distance, and area type. Furthermore, most of these variables affect origin choice differently depending on the market segment of the person. Key market segments were resident travelers, visitor business travelers, and visitor nonbusiness travelers. Some important distinctions were found across household income, but mostly for residents. Table 9-1 shows the estimation results.

Table 9-1. Reults of the Home-based origin choice estimation

Utility variables	Segment	Coef	t-stat
Mode choice logsum	All	0.408	6.4
Transit accessible (0/1)	Low income, resident	0.133	1.1
Transit accessible (0/1)	Low income, visitor, nonbusiness	0.374	3.0
Log (1+highway distance)	AZA	–0.568	–4.8
Rural or suburban zone	High income, resident	0.804	7.0
Urban zone	High income, resident	0.558	5.1
Rural zone	Missing income, resident	0.933	3.1
Suburban or urban zone	Missing income, resident	0.530	3.0
Rural or suburban zone	Visitor, business	0.676	3.2
Rural zone	Visitor, nonbusiness	1.30	10.5
Suburban zone	Visitor, nonbusiness	0.945	11.3
Urban zone	Visitor, nonbusiness	0.465	5.8
Size variables			
Total households	All	0.00	constr
Households in income quintile 1–2	Low income, resident	–2.69	–0.7
Transient households	Visitor, business	0.574	0.7
Transient households	Visitor, nonbusiness	0.613	2.5

Observations	3,042
Log Lik - Zero	–23629.3
Log Lik - Convergence	–21634.1
Rho Squared	0.084

Transit accessibility variable coefficients suggest that, for low-income travelers, the availability of transit service to the home origin is an important characteristic in choosing an origin. In addition, travelers flying out of AZA were typically found to be located closer to that airport.

The base size variable tested here was the total number of households in a zone. Several other size variables were tested, including number of households in a zone by income level and the number of transient households. In general, the number of households by income level did not have powerful effects in the model. Particularly for residents, this variable was expected to be more important. However, small importance of low-income households was found in a zone for the low-income resident segment. Transient households were found to have important impacts on location choice for visitors.

Estimation Results – Hotel-based Model

The hotel-based origin choice model predicts location for all trips originating at a hotel. Key variables to the model include a mode choice logsum, accessibility of transit as a mode alternative, highway distance, whether the hotel is located within 5 miles of the airport (such hotels are likely to have good shuttle service to/from the airport), and employment density in the origin zone. Like the home-based model, most of these variables affect origin choice differently depending on the traveler's market segment. Key market segments were resident business travelers, resident nonbusiness travelers, visitor business travelers, and visitor nonbusiness travelers. Some distinctions were also found across household income. Table 9-2 shows the estimation results.

Table 9-2. Results of the Hotel-based origin choice estimation

Utility variables	Segment	Coef	t-stat
Mode choice logsum	All	0.141	0.6
Transit accessible (0/1)	Visitor, nonbusiness	0.332	2.1
Log (1+highway distance)	Visitor, business	–0.709	–3.9
Log (1+highway distance)	Visitor, nonbusiness	–0.603	–6.2
Log (1+highway distance)	Low income	–0.277	–2.6
Log (1+highway distance)	AZA	–0.769	–3.1
Within 5 miles (0/1)	Resident, business	1.98	4.2
Within 5 miles (0/1)	Resident, nonbusiness	2.96	6.9
Log (1+total employment density)	Resident	–0.221	–2.0
Log (1+total employment density)	Resident, high income	0.389	2.2
Log (1+total employment density)	Visitor, business	0.0881	2.7
Log (1+total employment density)	Visitor, nonbusiness	–0.100	–3.4
Size variables			
Hotel employment	All	0.00	constr

Observations	1,383
Log Lik – Zero	–8899.0
Log Lik – Convergence	–8250.7
Rho Squared	0.073

The highway distance was found to be an important variable for AZA travelers and for visitors, with more distant hotels being less likely to be chosen. Similar results are found for residents, but through a variable indicating whether the hotel is within 5 miles of the airport. The reason for this is that most residents traveling to the airport from a hotel are likely staying at a hotel to make an early flight, rather than staying for leisure or business. Such travelers likely live a relatively long distance from the airport. Employment density has differing impacts depending on market segment. For high-income residents and business visitors, areas of high employment are more likely to be chosen, all else being equal, while for low-income residents and nonbusiness visitors, the opposite is true. This may be a result of more expensive hotels more often locating in areas of high density.

The base size variable for this model was hotel employment. Since no other variables make sense to use as size variables, no other variables were tested.

Estimation Results – Other-based Model

The other-based origin choice model predicts location for all trips originating at a locations that are not home or hotel. Key variables to the model include a mode choice logsum, highway distance, and employment density in the origin zone. Key market segments include resident business travelers, resident nonbusiness travelers, visitor business travelers, and visitor nonbusiness travelers. Table 9-3 shows the estimation results.

Table 9-3. Other-based origin choice estimation results

Utility variables	Segment	Coef	t-stat
Mode choice logsum	All	0.318	2.8
Log (1+highway distance)	Visitor, nonbusiness	–0.839	–7.0
Log (1+highway distance)	AZA	–0.666	–1.6
Log (1+total employment density)	Resident, nonbusiness	0.179	2.0
Log (1+total employment density)	Visitor, nonbusiness	–0.136	–2.3
Size variables			
Total employment	All	0.00	constr
Other employment	Resident, business	0.395	0.4
Public employment	Resident, business	1.44	2.4
Office employment	Resident, business	0.0409	0.0
Other employment	Resident, nonbusiness	0.730	0.8
Public employment	Resident, nonbusiness	0.627	0.6
Retail employment	Resident, nonbusiness	1.02	1.3
Office employment	Resident, nonbusiness	0.782	0.8
Other employment	Visitor, business	0.896	2.0
Public employment	Visitor, business	–1.52	–0.5
Retail employment	Visitor, business	0.115	0.2
Office employment	Visitor, business	0.417	0.8
Other employment	Visitor, nonbusiness	1.22	2.3
Public employment	Visitor, nonbusiness	0.816	1.2
Retail employment	Visitor, nonbusiness	2.68	8.1

Observations	713
Log Lik – Zero	–5565.3
Log Lik – Convergence	–4581.1
Rho Squared	0.177

Highway distance was found to have a negative effect on location choice for AZA travelers (consistent with the other two origin choice models) and for visitor nonbusiness travelers. In addition, nonbusiness residents were found to be more likely to originate in denser areas, while for nonbusiness visitors, the opposite was found.

The base size variable in this model was total employment in the origin zone. Employment by type was also tested using each of the key market segments. In general, retail, public, office, and other employment types were found to have more important impacts on location choices than the other employment types, which include industrial, construction, and nonsite business employment.

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10.0 Meeters and Greeters

One additional airport trip is not currently captured by modeling the air passenger trips to and from the airport. This is the trip from the airport made by the driver of the air passengers who are dropped off at the airport and the trip made by the meeters/greeters before picking up passengers at the airport. In this section, non-air passenger drivers and meeters/greeters are referred to simply as meeters/greeters.

Each meeter/greeter shares one trip with the air passenger(s) being served by the meeter/greeter. These shared trips need not be treated explicitly, since those trips will be handled sufficiently by the air passenger models. However, each meeter/greeter engages in a second trip to or from the airport to pick up or drop off air passengers, as mentioned above. This section outlines the procedure by which these nonshared meeter/greeter trips will be handled in the airport model, including trip generation, location choice, mode choice, and time of day.

Note that in the remainder the section, the term meeter/greeter trip refers to the airport trip that is not shared with the air passenger, unless otherwise noted.

Trip Generation

Since meeter/greeter demand (or trip generation) is induced by the air passengers they serve, the number of meeter/greeter trips need not be generated by a separate model. Instead, the number of meeter/greeter trips can be computed directly from the air passengers choosing the drop-off automobile mode. However, one complication exists. Air passengers are modeled individually (that is, person trips), rather than in groups of individuals traveling together. For each drop-off air passenger group, one can reasonably assume a single corresponding meeter/greeter vehicle trip. In order to generate meeter/greeter vehicle trips, a procedure for converting drop-off air passenger person trips into air passenger groups must be developed.

To compute the generation of meeter/greeter trips from air passenger drop offs, average vehicle trips per passenger trip were computed from the expanded air passenger data, using the party size variable. A party size of 1 corresponds to 1 vehicle trip, while a party size of 2 corresponds to 0.5 vehicle trips. Table 10-1 summarizes the average vehicle trips (that is, meeter/greeter trips) per air passenger trip by air passenger residency and trip purpose (from the air passenger survey).

Table 10-1. Meeter/greeter vehicle trips per drop offs for air passenger

Residency	Trip purpose	Weighted weekly air passengers	Vehicles per air passenger trip
Resident	Business	9,106	0.855
	Nonbusiness	28,690	0.720
Nonresident	Business	5,715	0.791
	Nonbusiness	46,090	0.640

Destination Choice

The meeter/greeter survey is rather limited, consisting of 215 observations, all of which occurred on weekdays, with 6 coded to an external zone. Given the small sample size, external trip origin rate for meeters and greeters will be assigned from the external trip origin rate of air passengers choosing the drop-off car mode. Likewise, the external meeter and greeter stations will be assigned from the distribution of external trip origins of the same set of air passengers. Table 10-2 shows the distribution of external air passenger trips choosing the drop-off car mode by external station, which will be used to distribute external meeter/greeter trips.

Table 10-2. Summary of air passengers who are dropped off by car and come from an external station

External station ID	External station name	Weighted		Unweighted	
		PHX	AZA	PHX	AZA
1	SR 85	448	0	2	0
2	I-10	1,915	34	29	7
3	SR 77	0	0	0	0
4	SR 77	0	0	0	0
5	US 60	374	0	6	0
6	SR 188	0	0	0	0
7	SR 87	613	0	11	0
8	I-17	4,733	1	36	1
9	SR 89	0	0	0	0
10	SR 71	0	0	0	0
11	US 60	0	0	0	0
12	I-10	23	0	1	0
13	I-8	446	3	5	1
	Total	**8,551**	**38**	**90**	**9**
	Percent of all drop-off trips (internal and external)	6.1%	2.4%	4.6%	3.8%

For internal destination choices, the meeter/greeter survey data was examined to determine how closely it resembled the air passenger destination choices from the air passenger survey data. First, the frequency at which meeter/greeters returned to the same location where they started was examined. For meeters/greeters returning to the same location they started, the meeter/greeter destination choice is identical to that of pick up air passengers. As shown in Table 10-3, when a meeter/greeter's previous location is home or hotel, the next location is the same about 90 percent of the time. Not surprisingly, when the previous location is other, the next location is the same only 15 percent of the time. Overall, over 80 percent of meeter/greeters have identical previous and next locations.

Table 10-3. Frequency of meeters/greeters with the same previous and next locations

Destination	Previous location of Air Passengers			
	Home	**Hotel**	**Other**	**Total**
Same as next location	172	2	3	177
Different location	21	0	17	38
Same as next location	89.1%	100.0%	15.0%	82.3%
Different location	10.9%	0.0%	85.0%	17.7%
	Next Location of Air Passengers			
	Home	**Hotel**	**Other**	**Total**
Same as previous location	172	2	3	177
Different location	22	5	11	38
Same as previous location	88.7%	28.6%	21.4%	82.3%
Different location	11.3%	71.4%	78.6%	17.7%

Second, meeter/greeter trip length frequencies were examined and compared with weekday air passengers choosing the drop-off car mode. Figures 10-1 and 10-2 show the comparisons for home- and other-based trips, respectively (there are too few hotel-based meeters/greeters to offer a meaningful comparison). The average trip distance for home-based trips is 21.9 miles for air passengers and 20.6 miles for meeters/greeters. For other-based trips, the average trip distance is 15.9 miles for air passengers and 15 miles for meeters/greeters. As shown in the two figures, the trip lengths are very similar for meeter/greeter trips and drop-off air passengers.

Figure 10-1. Trip length frequency distributions for home-based trips

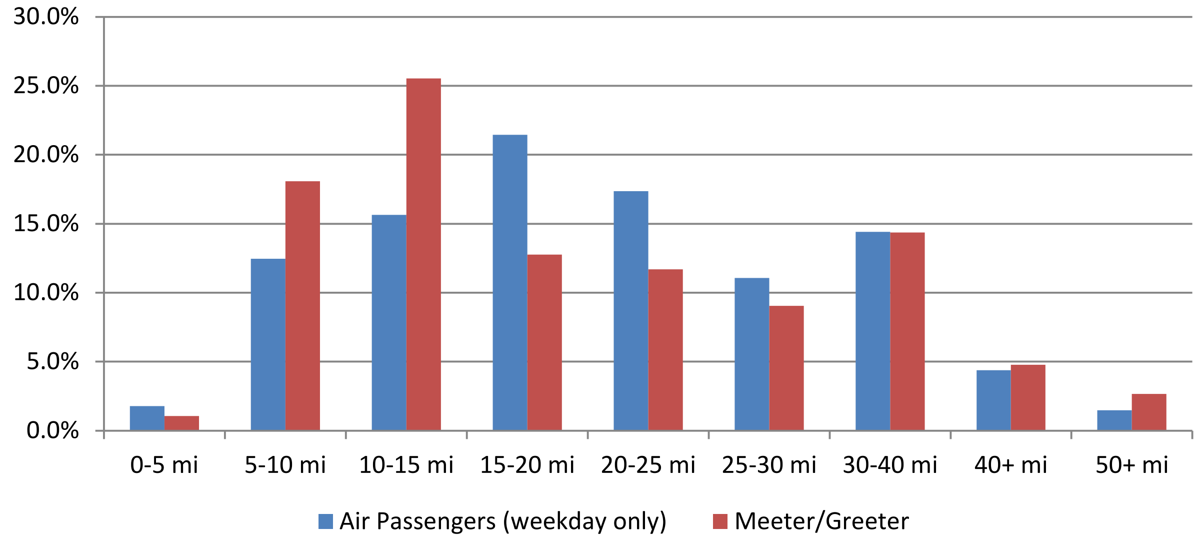
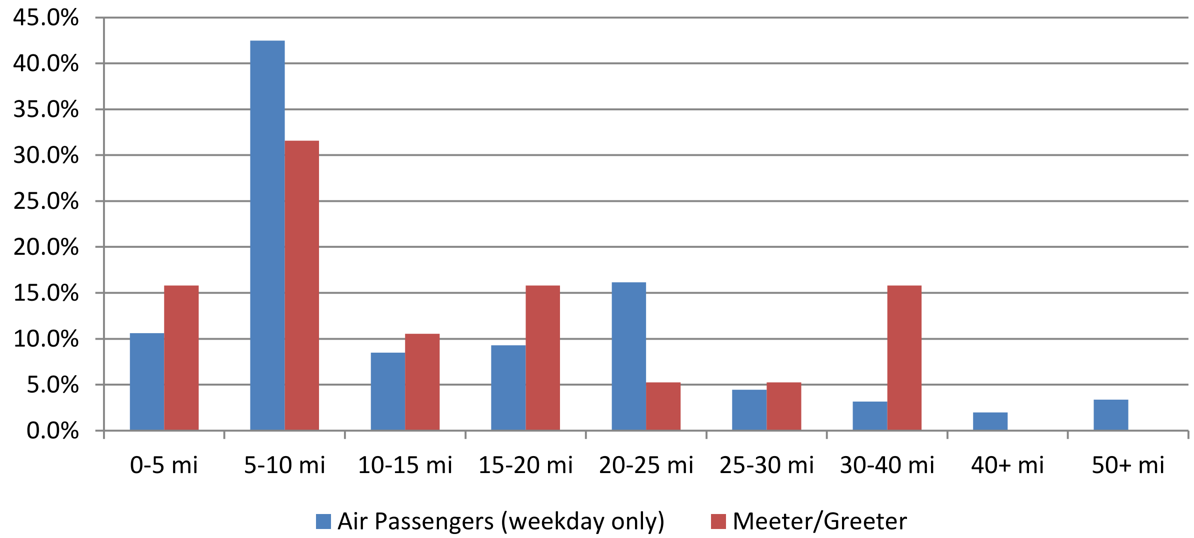


Figure 10-2. Trip length frequency distrubtion for other-based trips.



Based on this analysis, the best option for handling meeter/greeter trip locations is to use the location choice shares modeled for drop-off air passengers. That is, explicit meeter/greeter location choice models will not be estimated. Three main reasons support this conclusion:

- The meeter/greeter data are limited and include only weekday travelers.
- Destination choices of meeters/greeters closely follow the destination choices of drop-off air passengers.
- Eighty percent of meeters/greeters have identical previous and next locations. As a corollary, the drop-off air passenger destination choice distributions should match the meeter/greeter distributions at least 80 percent of the time.

The procedure for predicting meeter/greeter locations will be as follows:

First, trips generated will be aggregated over all segments, except location type (home, hotel, or other).

Second, the distribution of previous location of air passenger drop offs will be assigned to meeters/greeters (since the previous location is the shared trip). The distribution of "nonshared" location types for meeter/greeter trips can then be deduced from the correspondence shown in Table 10-4, developed from the meeter/greeter survey. For instance, of the air passengers destined for a home location type in the shared trip, meeters/greeters serving these passengers came from a home location 92.3 percent of the time, a hotel location 0 percent of the time, and another location 7.7 percent of the time (which corresponds to the nonshared airport trip).

Table 10-4. Summary of surveys by meeter/greeters based on location types

Next location	Previous location		
	Home	**Hotel**	**Other**
Home	179	0	15
Hotel	3	2	2
Other	11	0	3
Home	92.3%	0.0%	7.7%
Hotel	42.9%	28.6%	28.6%
Other	78.6%	0.0%	21.4%

Last, the TAZ destination choice shares predicted by the air passenger destination choice model will be used to predict the destination choices of meeters and greeters by previous location type. The destination choice model of drop-off air passengers destined for a home location will be used for the meeters/greeters coming from a home location. Those coming from a hotel location will use the destination choice model of drop-off air passengers destined for a hotel location, and a similar approach will be used for other trips.

Mode Choice

Since all meeters and greeters are driving to pick up air passengers, mode choice really comes down to vehicle occupancy. Vehicle occupancy for the meeter/greeter trip is expected to be largely uncorrelated to other travel variables, particularly LOS variables. Therefore, fixed vehicle occupancy factors derived from the meeter/greeter survey will be used (as shown in Table 10-5).

Table 10-5. Vehicle occupancy for meter/greeter surveys

Vehicle occupancy	Meeters/greeters	Percentage
1	148	68.8
2	55	25.6
3	11	5.1
4	1	0.5

Time of Day

The meeter/greeter survey data can be used to develop time of day factors for meeter/greeter trips. Since meeter/greeter trips pivot off of drop-off air passengers, the time of day distributions of meeter/greeter trips should pivot off of time of day distributions for drop-off air passengers. The meeter/greeter survey asked for the flight arrival time period of the air passenger(s). However, the time periods did not line up with the time periods used in the MAG model. Instead, 30 minutes was added to the exact arrival time of meeters/greeters at the airport, and this value was assumed to be the departure time of the joined meeter/greeter plus air passenger trip (for which a time of day distribution will be known in the model). Using this information, it is possible to develop a correspondence table between the departure time of the air passenger trip and the departure time period of the meeter/greeter trip, as shown in Table 10-6.

Table 10-6. Meeter/greeter pick up time of day distribution

Air passenger trip departure time of departure	Meeter/greeter time of departure			
	Morning	Midday	Afternoon	Nighttime
Morning	100.0%	0.0%	0.0%	0.0%
Midday	12.5%	87.5%	0.0%	0.0%
Afternoon	0.0%	25.6%	74.4%	0.0%
Nighttime	0.0%	0.0%	23.2%	76.8%

From this table, one can see that for drop-off air passenger trips leaving from the airport in the morning peak period, 100 percent of the meeter/greeter trips to the airport depart during the morning peak period. For drop-off air passengers leaving from the airport in the midday period, 12.5 percent of meeter/greeter trips to the airport depart during the morning peak, with the remaining 87.5 percent departing during the midday period.

To develop a similar distribution for meeter/greeter trips dropping off air passengers (the above distribution applies to meeters/greeters picking up air passengers), the drop-off air passenger survey data can be used. The air passenger survey includes the departure time for the trip to the airport. To obtain airport arrival times, skims were attached to the survey records. Finally, the meeter/greeter trip (leaving the airport after dropping off the air passenger[s]) was assumed to depart 30 minutes after the air passenger trip arrived. The correspondence between air passenger departure time to the airport and meeter/greeter departure time from the airport can then be obtained, as shown in Table 10-7.

Table 10-7. Meeter/greeter drop-off time of day distribution

Air passenger trip departure time of departure	Meeter/greeter time of departure			
	Morning	**Midday**	**Afternoon**	**Nighttime**
Morning	66.0%	34.0%	0.0%	0.0%
Midday	0.0%	80.6%	19.4%	0.0%
Afternoon	0.0%	0.0%	73.2%	26.8%
Nighttime	45.3%	0.0%	0.0%	54.7%

11.0 Model Validation

This section describes the airport model calibration and validation process. It also provides the data used in calibrating and validating the various model components.

Background

The new MAG airport model system was developed as a stand-alone model in TransCAD. This takes advantage of existing data from the MAG TransCAD-based model system such as SED data, skims, networks, and relevant trip tables for assignment purposes. The airport model is designed to run for any base or forecast year as long as model inputs such as socio-demographic data and highway and transit networks are available. This model will provide network assignments by time of day or daily by vehicle class. Highway and transit assignment results will be reported separately.

Model Calibration and Validation

During calibration, the results from each step of the model implementation process should be compared with observed values from various sources including the airport (air passenger, meter/greeter) surveys, traffic counts, and parking lot utilization data.

Trip Generation

The trip generation model predicts the number of airport trips by purpose and market segment based on regional employment and population and on current annual airport enplanement and deplanement data. The model constant and percentage of AZA share of the market should be adjusted until the estimated number of trips by airport is close to the observed number of trips for the base year.

Trip Distribution

The trip distribution step of the airport modeling process is captured by destination choice (or origin choice) models. Results from the model application for both airports are compared with the weighted survey data for the modeled airport(s). The results are summarized as follows:

- Percentage of airport trips by purpose, market segment, and previous location – This verifies that the allocations by purpose (business, other), market segment (resident, nonresident), and previous location (home, hotel, other) are applied correctly in the model.
- Average trip lengths and trip length frequency distributions – The average trip lengths from the airport models are computed and compared with those of the weighted survey average trip lengths by airport for different purposes and market segments. The trip length frequency distributions are also plotted for both modeled and surveyed observations, and the coincidence ratios of these plots indicate how well the destination (or origin) choice models are performing.

During calibration, the parameters of the destination (or origin) choice models are adjusted, including the incorporation of bias constants based on geographical location of origins or destinations and distance-based factors. The updated and final model specifications with adjusted parameters are provided in Table 11-1 by destination (or origin) location type.

Table 11-1. Calibrated destination (or origin) choice model coefficients

Utility variables	Home	Hotel	Other
MC logsum	0.42301	0.31694	0.30552
Highway distance: 0–10 miles	–0.296	0.384	0.228
Highway distance: 10–20 miles	–0.067	0.638	–0.436
Highway distance: 20–30 miles	0.156	0.553	–0.062
Highway distance: 30–40 miles	0.315	0.502	0.334
Highway distance: 40–50 miles	0.015	0	0
Highway distance: 60+ miles	–0.405	0	0
Transit accessible – low-income resident	0.07599	0	0
Transit accessible – low-income visitor, nonbusiness	0.15915	0	0
Within 5 miles of airport – resident business	0	1.86334	0
Within 5 miles of airport – resident nonbusiness	0	2.95649	0
Log (1+highway distance) – AZA	–0.44409	–0.6558	–0.66785
Log (1+highway distance) – visitor business	0	–0.5869	0
Log (1+highway distance) – visitor nonbusiness	0	–0.57866	–0.85614
Log (1+highway distance) – low-income	0	–0.24374	0
Log (1+employment density) – resident high-income	0	0.42965	0
Log (1+employment density) – visitor business	0	0.09148	0
Log (1+employment density) – visitor nonbusiness	0	–0.07667	–0.13784
Log (1+employment density) – resident	0	–0.23406	0
Log (1+employment density) – resident nonbusiness	0	0	0.17885
Rural zone – visitor business	0.60254	0	0
Rural zone – visitor nonbusiness	1.0796	0	0
Suburban zone – visitor nonbusiness	0.51044	0	0
Urban zone – visitor nonbusiness	0.37801	0	0
Size variables			
Total households	0	N/A	N/A
Transient households – visitor business	0.85559	N/A	N/A
Transient households – visitor nonbusiness	0.53466	N/A	N/A
Hotel employment	N/A	0	N/A
Total employment	N/A	N/A	0
Other employment – resident business	N/A	N/A	0.38349
Public employment – resident business	N/A	N/A	1.44329
Office employment – resident business	N/A	N/A	0.0358
Other employment – resident nonbusiness	N/A	N/A	0.74397
Public employment – resident nonbusiness	N/A	N/A	0.64321

Utility variables	Home	Hotel	Other
Retail employment – resident nonbusiness	N/A	N/A	1.04064
Office employment – resident nonbusiness	N/A	N/A	0.79876
Other employment – visitor business	N/A	N/A	0.88657
Public employment – visitor business	N/A	N/A	–1.51018
Retail employment – visitor business	N/A	N/A	0.09341
Office employment – visitor business	N/A	N/A	0.41681
Other employment – visitor nonbusiness	N/A	N/A	1.21655
Public employment – visitor nonbusiness	N/A	N/A	0.80253
Retail employment – visitor nonbusiness	N/A	N/A	2.68218
Households income quintile 4 – high-income resident	0.82392	N/A	N/A
Households income quintile 5 – high-income resident	2.98696	N/A	N/A
Households income quintile 5 – missing income resident	2.17564	N/A	N/A
Households income quintile 5 – visitor business	1.06563	N/A	N/A
Households income quintile 5 – visitor nonbusiness	0.48679	N/A	N/A

Figures 11-1, 11-2, and 11-3 present the trip length distributions for PHX, AZA, and the two airports together. Within each figure, the trip lengths distributions for each trip purpose are also presented. The coincidence ratios are greater than 0.98 for all trip purposes for PHX and for the two airports together. However, for AZA, the coincidence ratios are in the range of 0.65 to 0.70, with the exception of the hotel-based model, which is 0.48. The low coincidence ratio is mostly attributable to the fact that there are very few observations for this trip purpose. This could have been improved with more bias factors, but that would be overwhelming and the model would misrepresent the true behavior.

Figure 11-1. PHX trip length distributions, by trip purpose

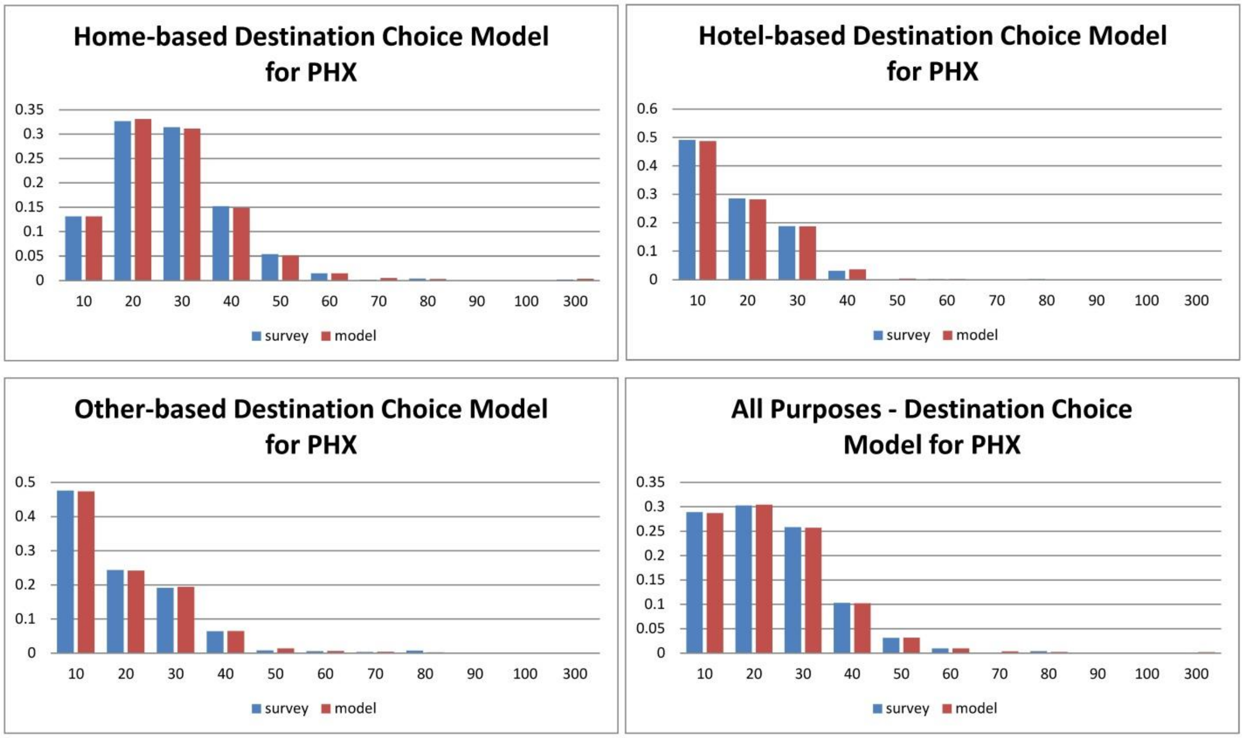


Figure 11-2. AZA trip length distributions, by trip purpose

Figure 11-3. Trip length distributions, by trip purpose, for both airports

Mode Choice

This step determines the modal shares of airport trips to both airports. One major change to the mode choice models was implemented during calibration. This involved splitting the LRT mode by access mode (e.g., LRT-drive access and LRT-walk access). The utility functions for these two modes are largely the same as the original model with only a single LRT mode alternative. The differences between the utility functions appear by way of network travel time and cost variables and ASCs. The nesting structures were also modified to accommodate the new modal alternatives, as shown in Figures 11-4 and 11-5.

Figure 11-4. Resident market nest structure

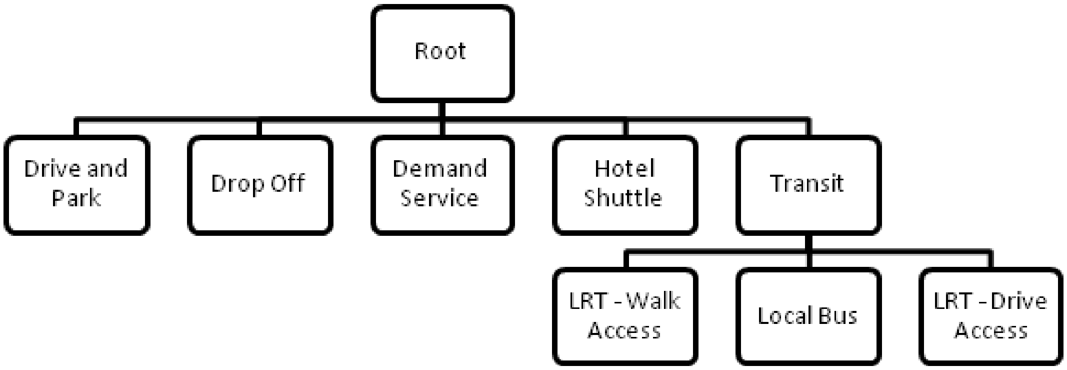
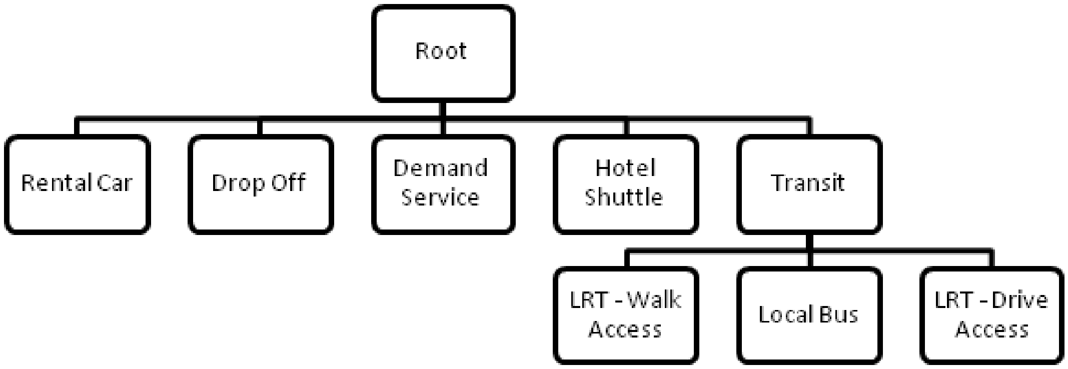


Figure 11-5. Visitor market nest structure



The model calibration involved adjustments of mode choice ASCs in an efficient manner such that the shares from the model, weighted surveys, and observed data are close to each other. This process also involved incorporation of additional bias constants by market segments, if necessary. The observed data was obtained from the weighted airport survey data. The updated and final model specifications with adjusted parameters are provided in Table 11-2 by market segment (trip purpose and resident type).

Table 11-2. Calibrated mode choice model coefficients, by trip purpose and resident type

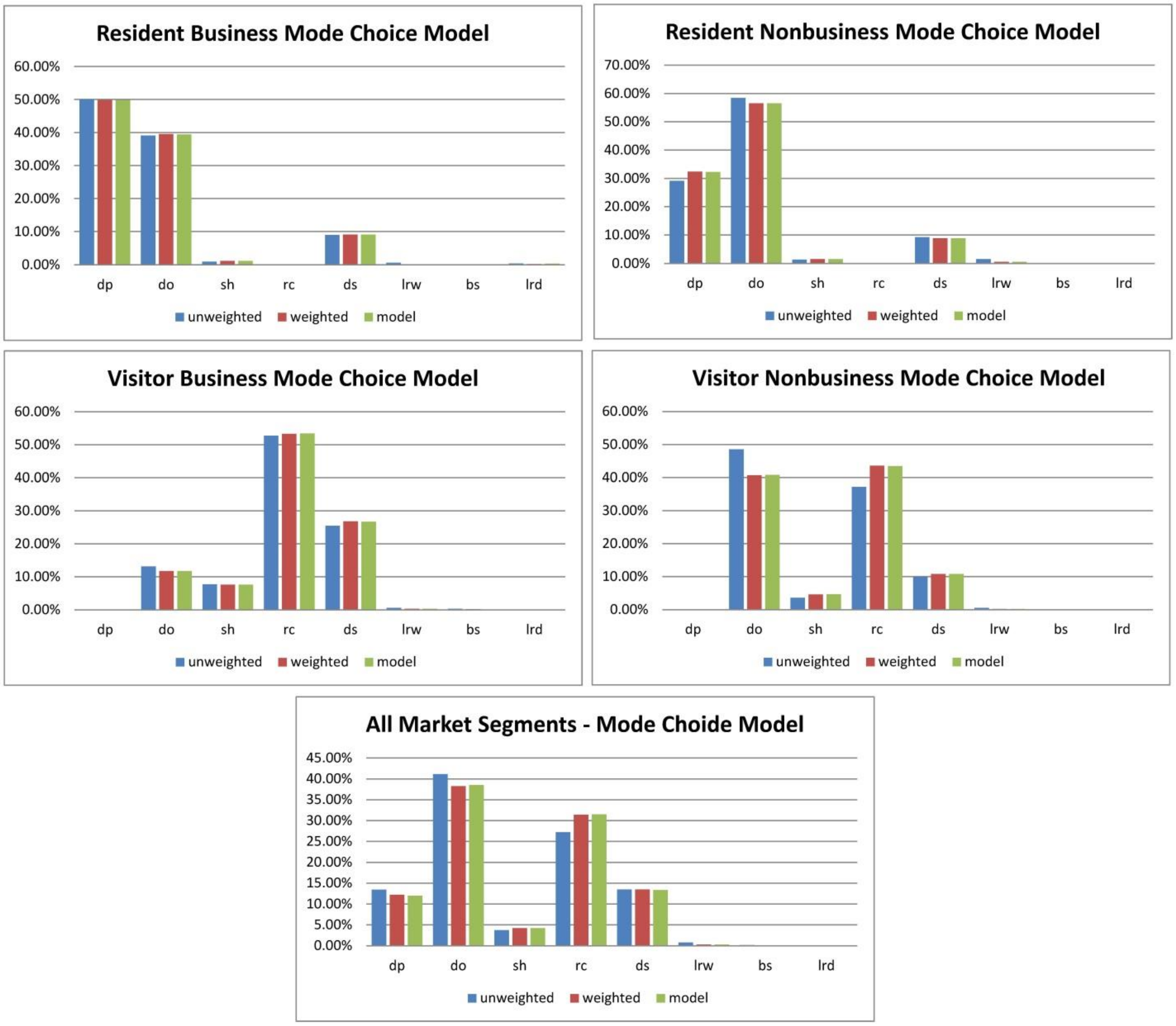
Utility variables	ResBiz	ResOth	VisBiz	VisOth
DP ASC	0	0	0	0
DO ASC	–1.93	–0.54	–1.08	0.8
SH ASC	–2.23	0.98	–2.88	–4.26
RC ASC	0	0	0	0
DS ASC	–3.5	–2.14	–0.91	–0.72
LRW ASC	–6	–4.8	–4.9	–5.6
BS ASC	–7	–7	–5.8	–6.7
LRD ASC	–7	–6.7	–15	–15
IVT	–0.03	–0.015	–0.03	–0.015
OVT	–0.06	–0.03	–0.06	–0.03
Cost – low-income	–0.045	–0.045	–0.045	–0.045
Cost – high-Income	–0.018	–0.018	–0.01565	–0.01565
Highway distance – rental car	0	0	–0.072	–0.02968
DO – high-income	–0.60251	–0.55955	–1.8171	–1.74525
SH – high-income	0	0	0	–1.15211
DS – high-income	–2.02493	–1.34057	–1.79352	–2.57579
DO – 0/1 vehicle HH	0	–0.87105	0	0
DS – 0/1 vehicle HH	0	0.781566	0	0
DO – missing income	–0.30625	–0.59925	–0.73278	–1.06409
SH – missing income	0	0	0	0.471332
DS – missing income	–0.94482	0.347704	–1.46487	–1.79909
DO – home-based trip	0.61128	0.999075	2.712574	2.333504

Utility variables	ResBiz	ResOth	VisBiz	VisOth
DS – home-based trip	2.252155	1.904314	0	2.889723
DO – hotel-based trip	–2.64743	–4.31226	–1.19033	–2.25796
DS – hotel-based trip	3.534915	1.88996	1.280623	1.176547
SH – AZA	0	0	–2.51957	–4.79076
DO – weekend	1.150932	0	0.622131	0
SH – weekend	0	0	1.300654	0
DS – weekend	1.302256	0.516948	0.427833	0.205464
SH – night TOD	0	0	0.816806	2.496478
DO – party size 2+	0.777554	–1.09591	–0.72011	–1.732
DS – party size 2+	0	–1.00269	0	–0.71122
TR – party size 2+	0	–2.14241	0	–2.43775
DO – log pop density	0	0.091084	0	0.073827
SH – log pop density	0	0	0	0.171704
DS – log pop density	0	0	0.136545	0
LRW,BS – log pop density	0	0.2	0	0.15
Nesting coefficient	0.6	0.6	0.6	0.6

Figure 11-6 presents the mode shares by trip purpose and resident type for both the airports. The model estimates modal shares that very closely match with the weighted survey targets derived from the airport passenger surveys.

These results were achieved by adjusting the ASCs in conjunction with the population density parameters. The ASCs are well within reasonable limits, and the magnitudes are also reasonable relative to one another.

Figure 11-6. Mode shares, by market segment (trip purpose and resident type)



Time of Day

The time of day allocations were achieved using fixed factors derived from the weighted survey data. After the model application, these allocations were cross-checked to see whether the time of day factors have been applied correctly.

Assignments

The weighted survey data can be used to develop an origin-destination matrix for the two airports and assign that to the MAG model network. The resulting assignment results (loaded network) on key corridors—highway and transit—can be compared with that of the modeled volumes for the airport(s) to see how well the model is performing.

Appendix C contains summaries of traffic counts at PHX and AZA by average weekday, Saturday, and Sunday.

Appendix A: PHX and AZA Air Passenger Data Expansion

Figure A-1. PHX Resident status, trip purpose, and previous location for weekday travelors

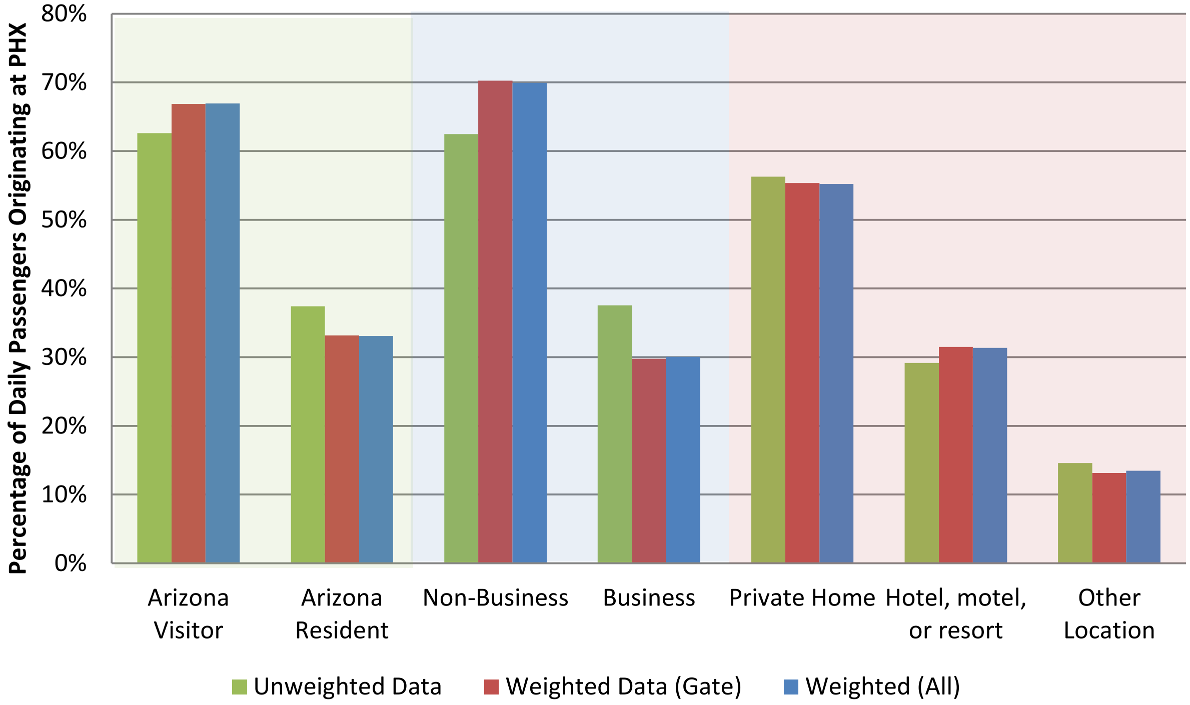


Figure A-2. PHX Saturday resident status, trip purpose, and previous location

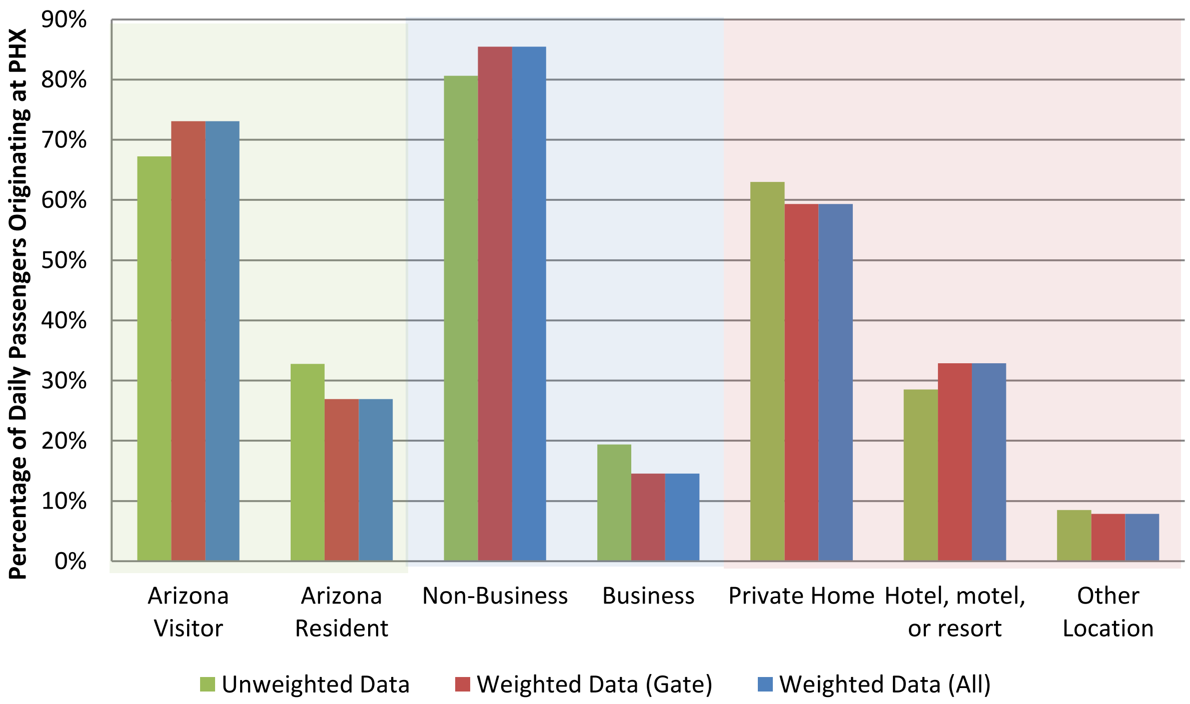


Figure A-3. PHX Sunday resident status, trip purpose, and previous location

Figure A-4. PHX weekday airport trip start time

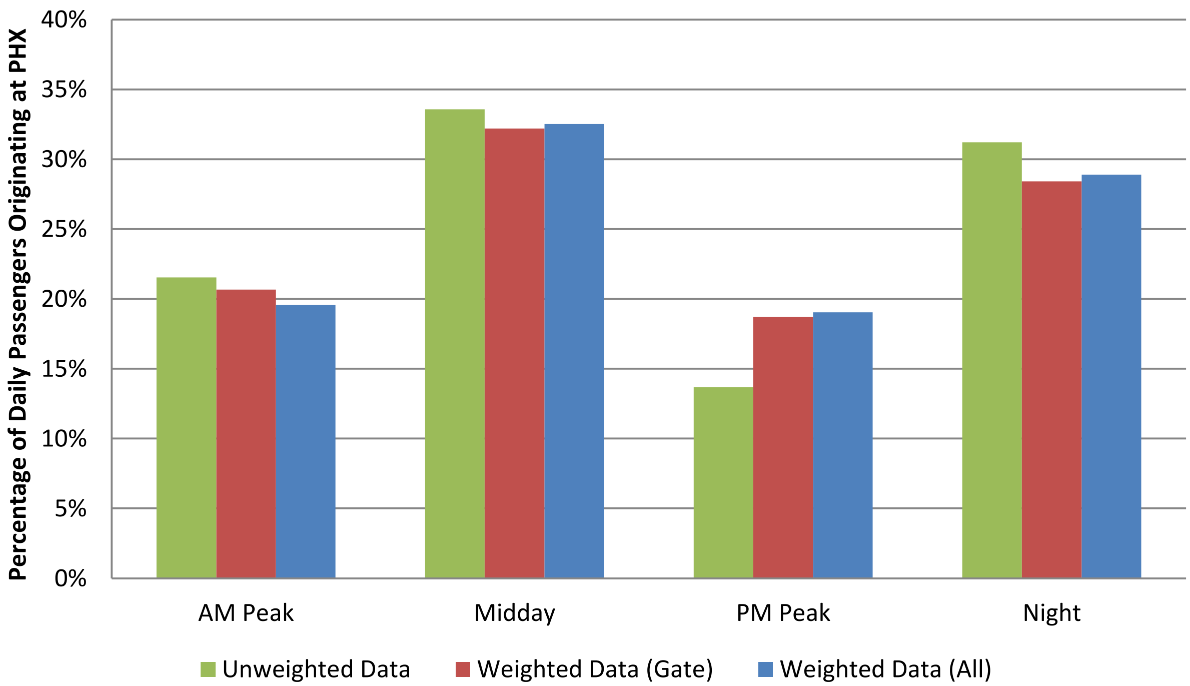


Figure A-5. PHX Start time of trips to airport on Saturdays

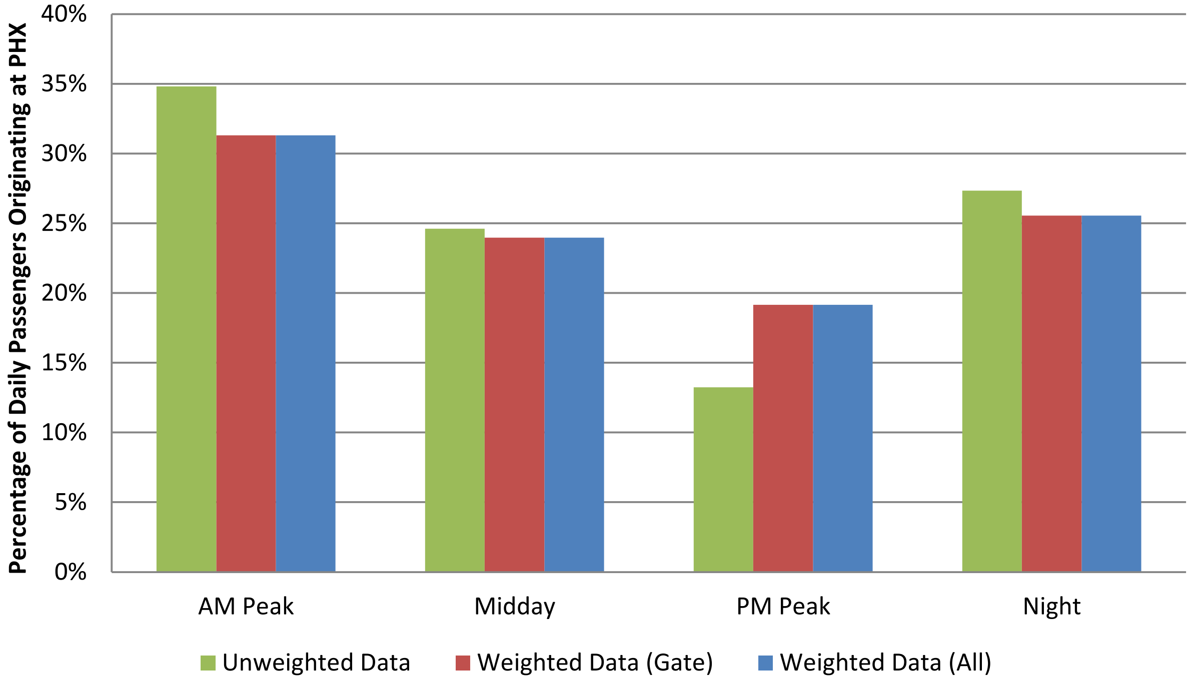


Figure A-6. PHX Sunday airport trip start time

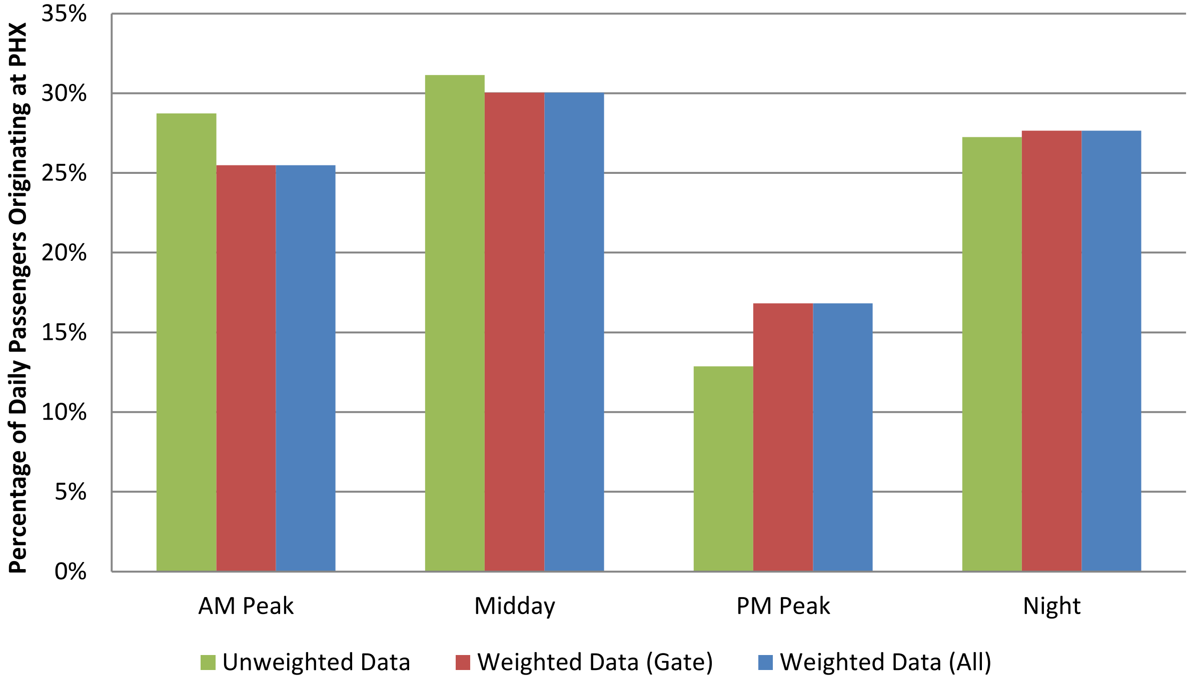


Figure A-7. PHX Main mode of travel to airport on weekdays

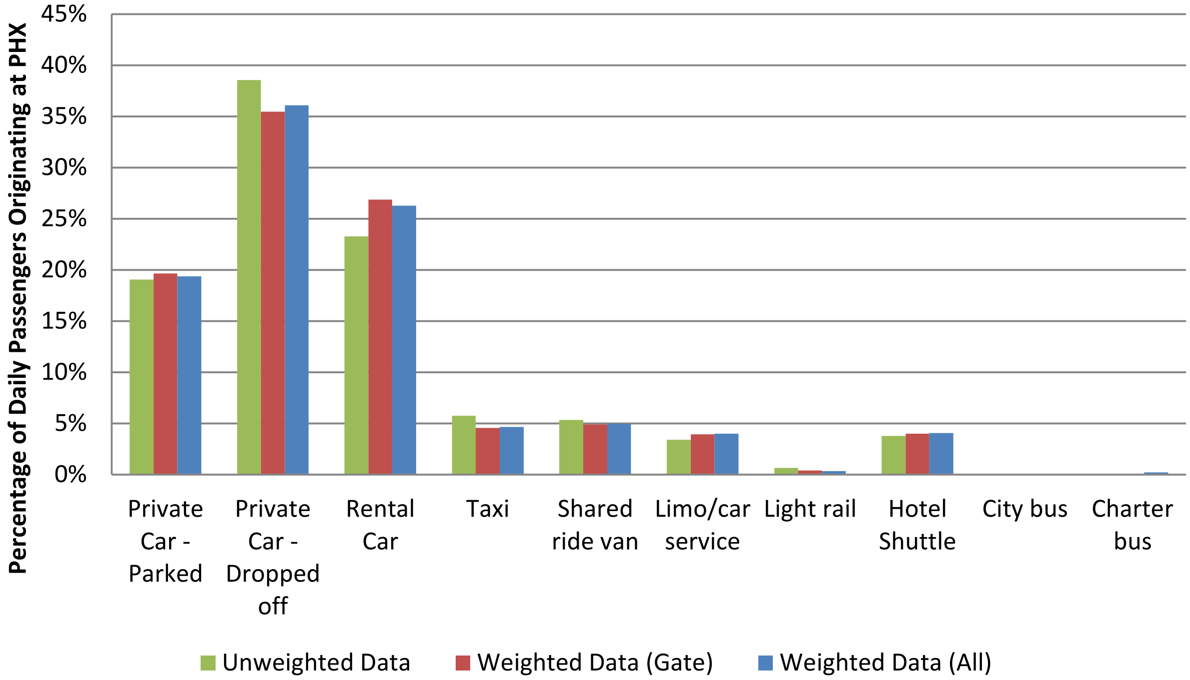


Figure A-8. PHX Saturday main mode to airport

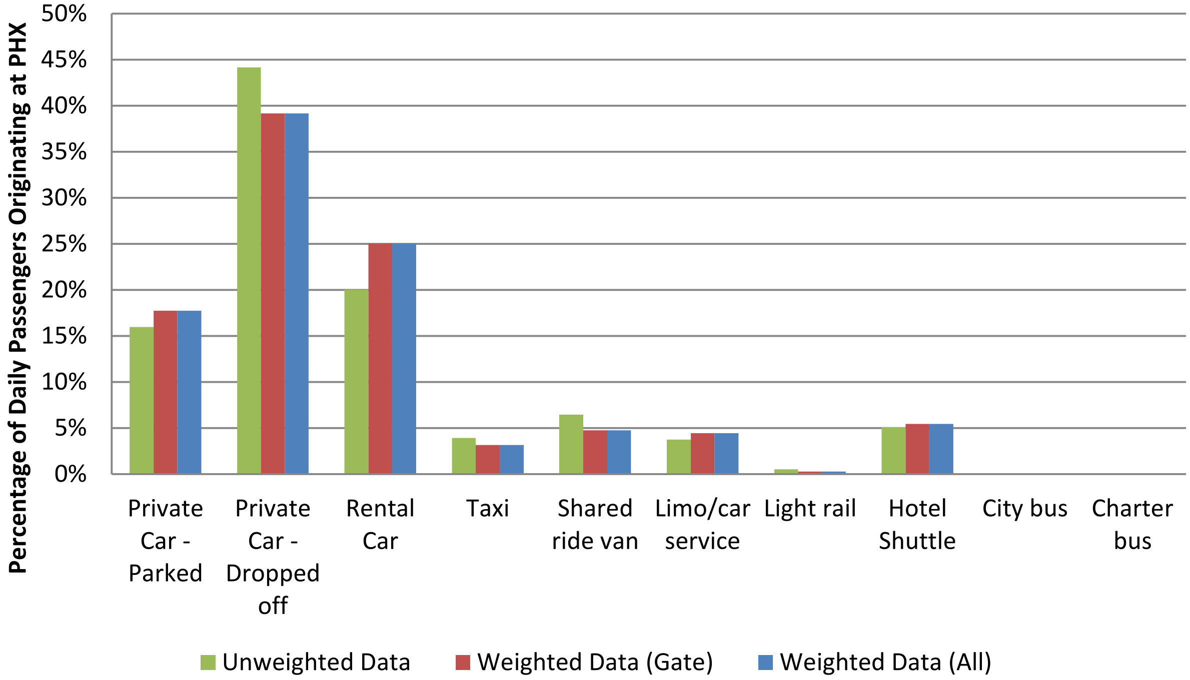


Figure A-9. PHX Sunday main mode to airport

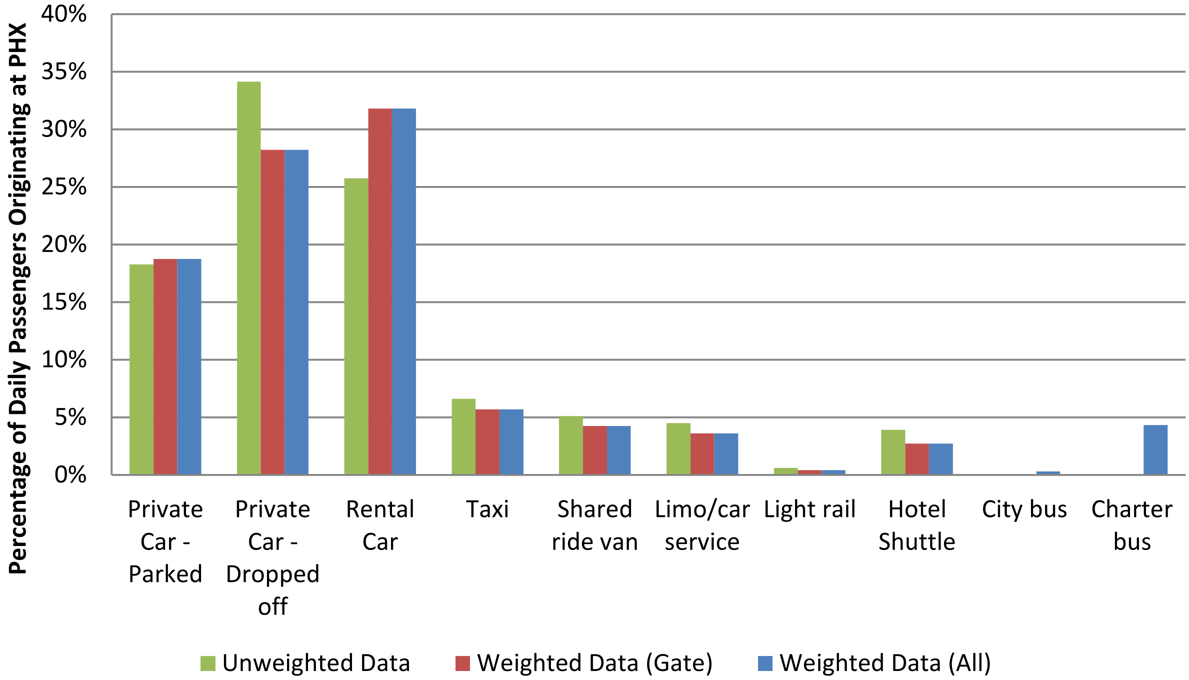


Figure A-10. PHX household income of passengers traveling on weekdays

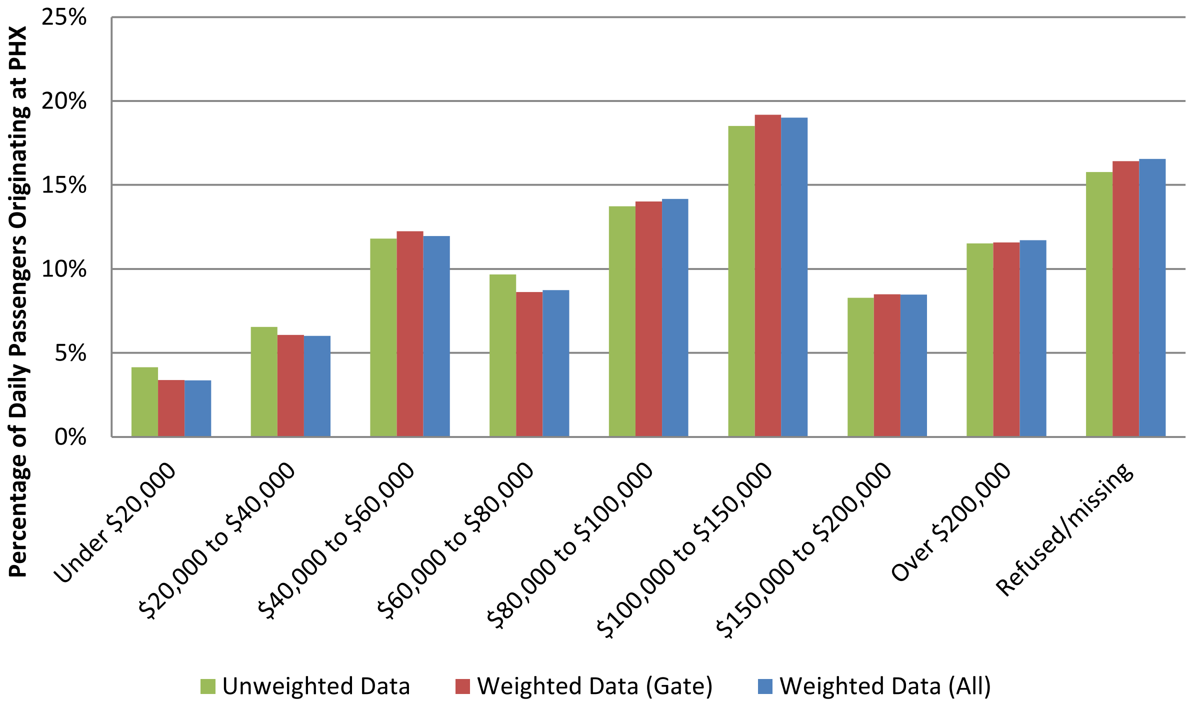


Figure A-11. PHX Saturday household income

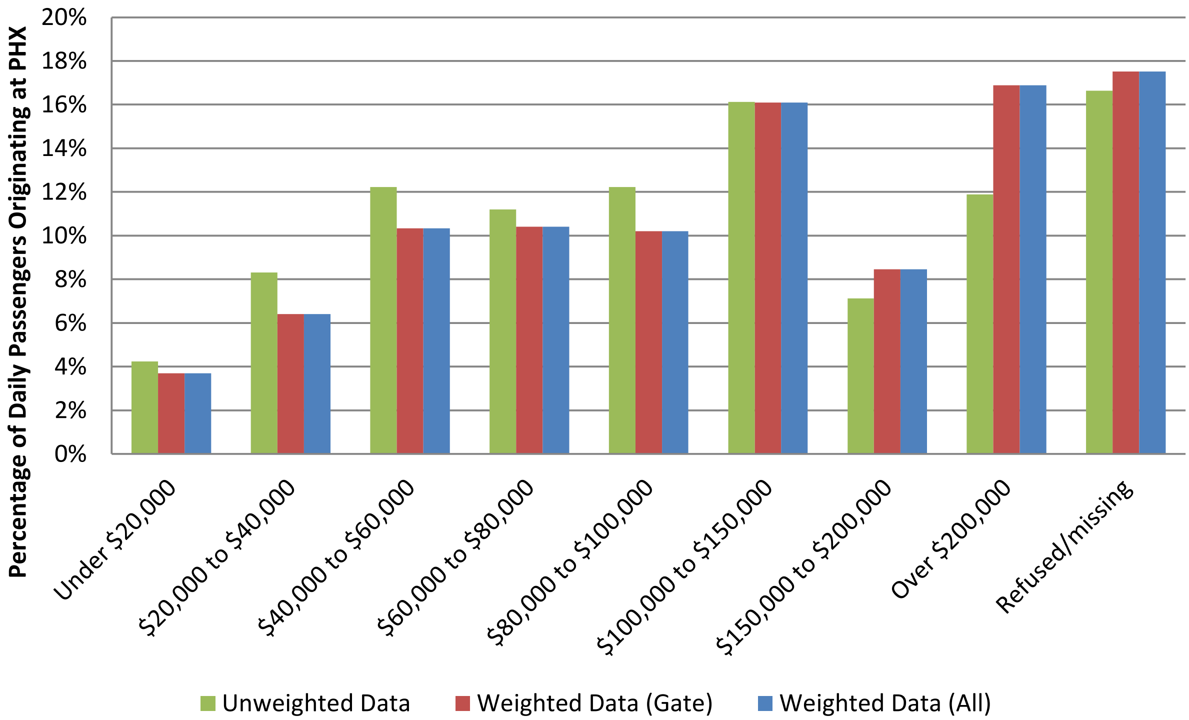


Figure A-12. PHX Sunday household income

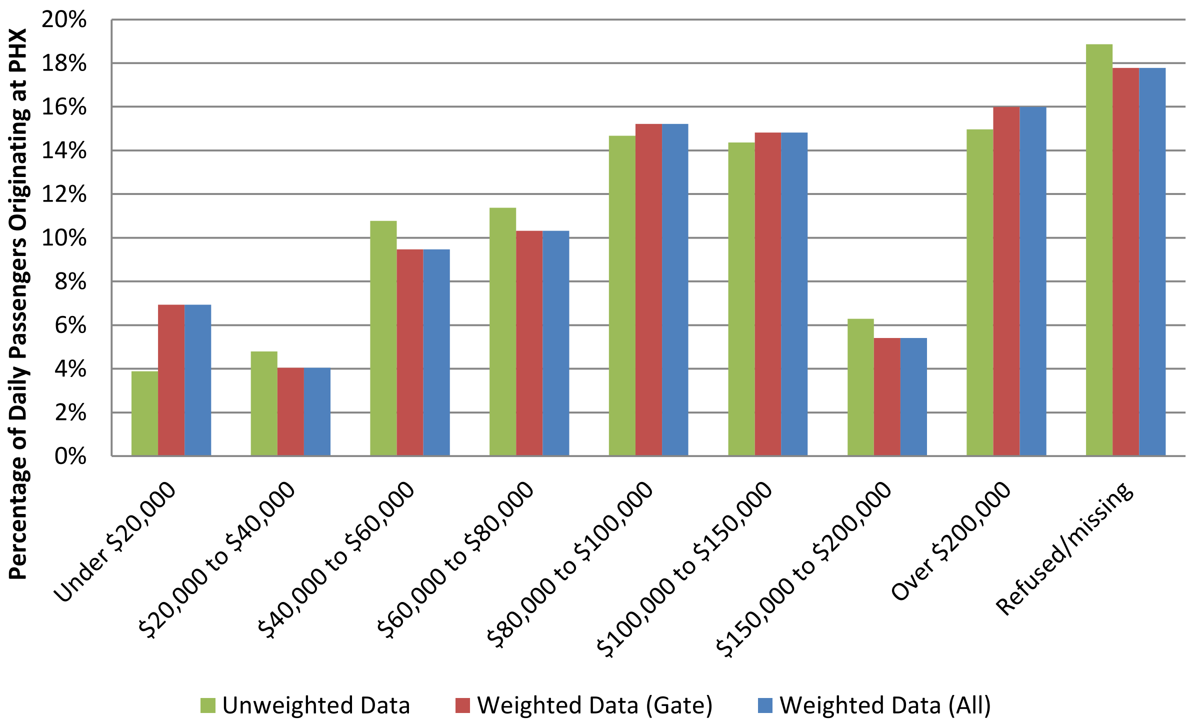


Figure A-13. PHX household size of passengers traveling on weekdays

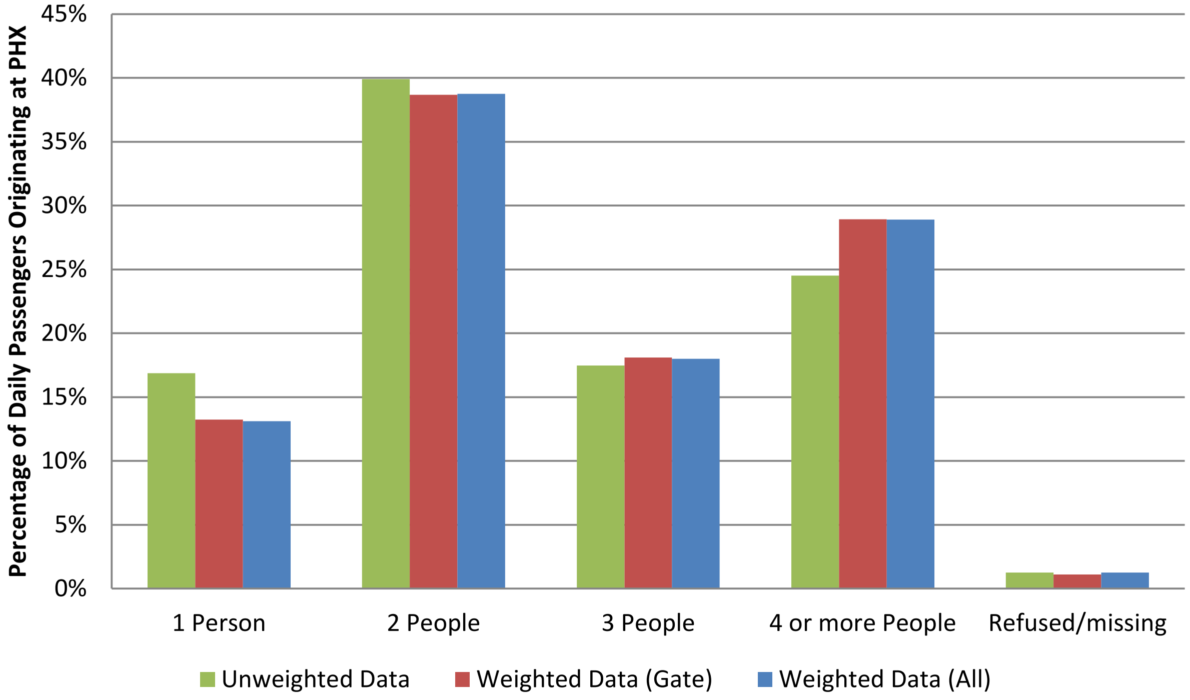


Figure A-14. PHX Saturday household size

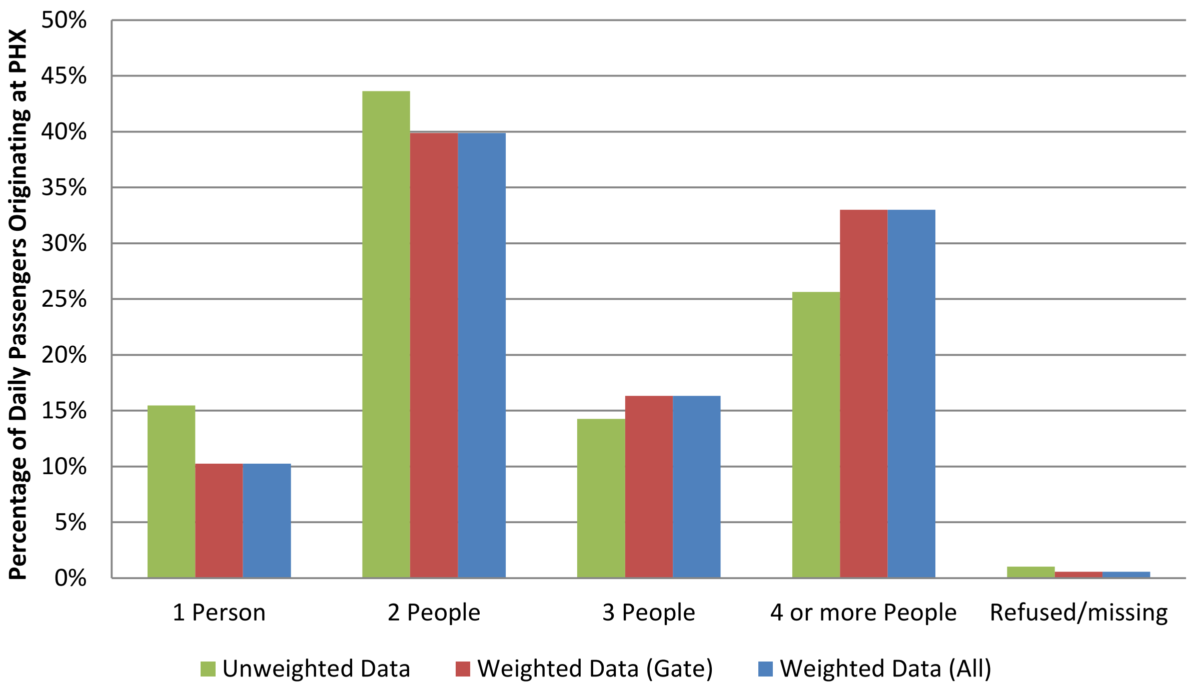


Figure A-15. PHX Sunday household size

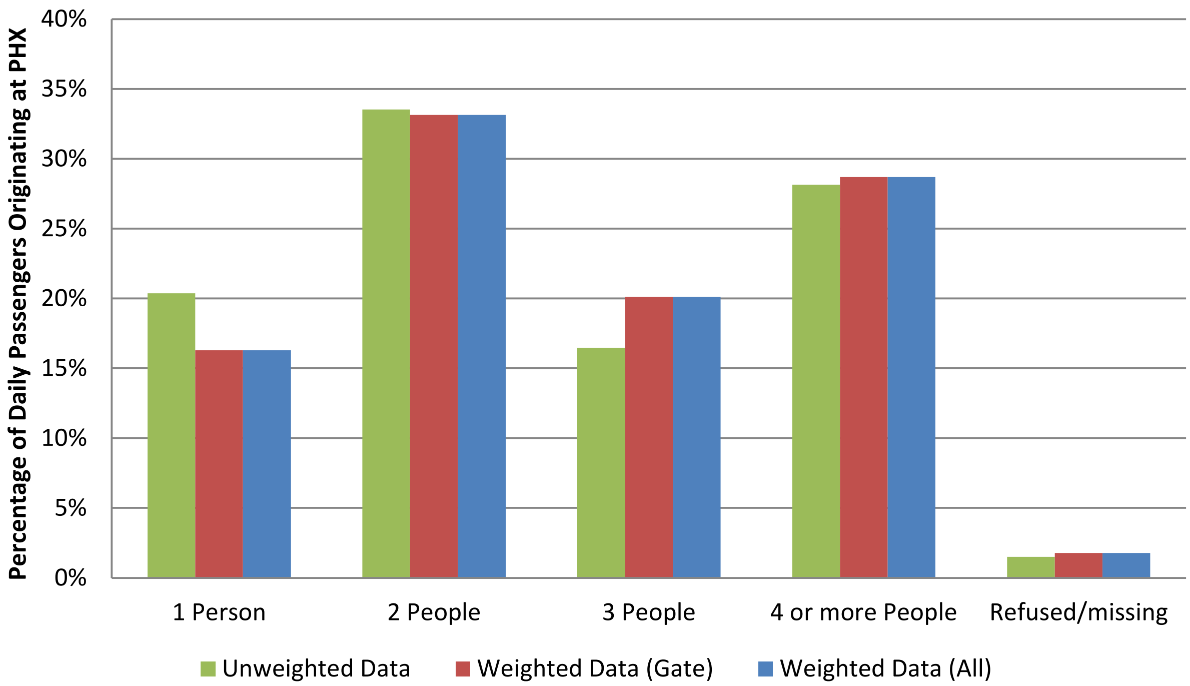


Figure A-16. AZA vehicle availability of households for passengers who travel on weekdays

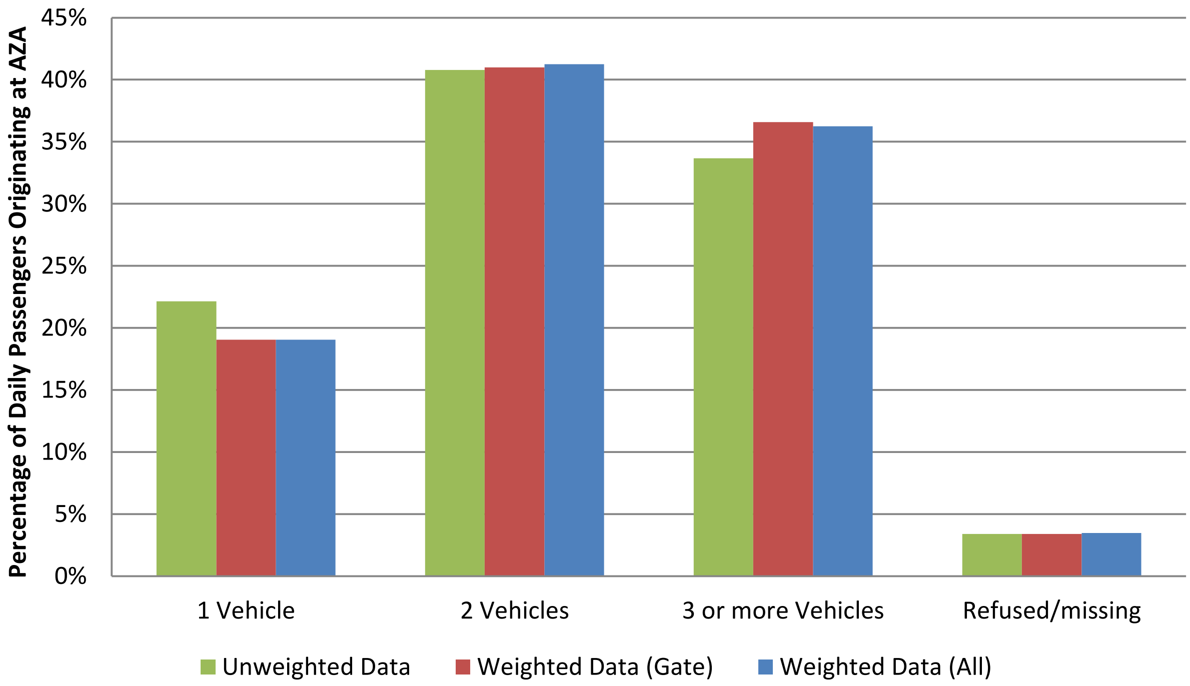


Figure A-17. AZA weekday resident status, trip purpose, and previous location

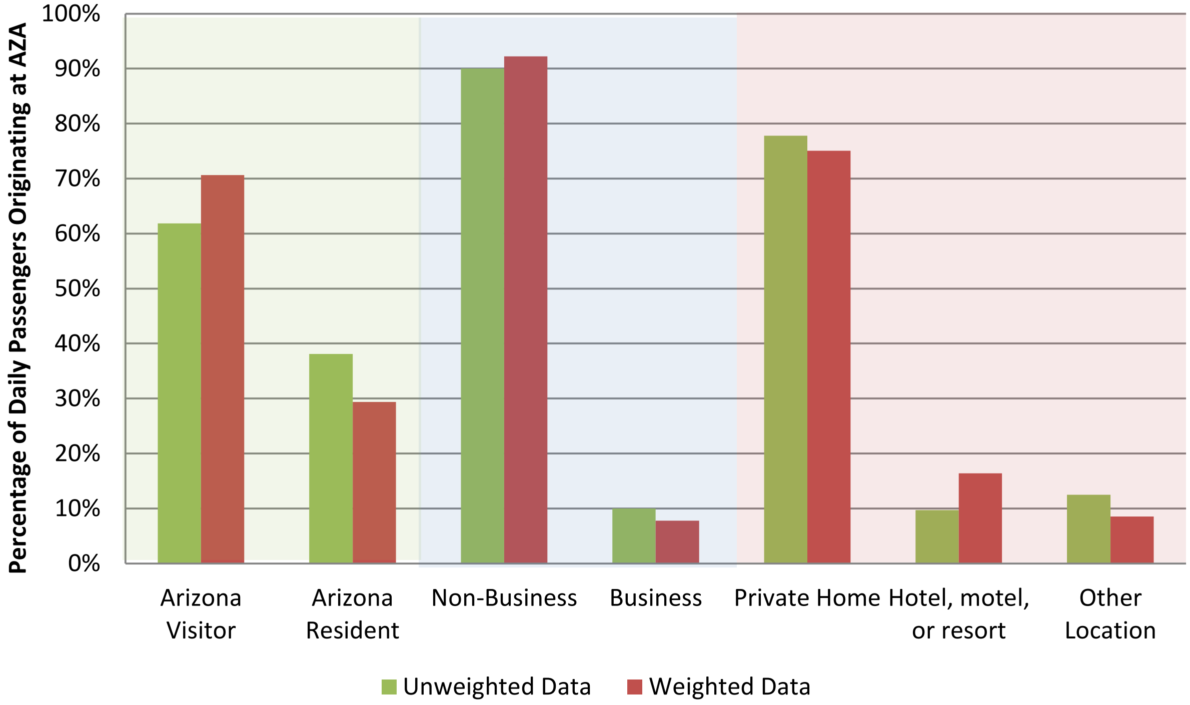


Figure A-18. AZA Sunday resident status, trip purpose, and previous location

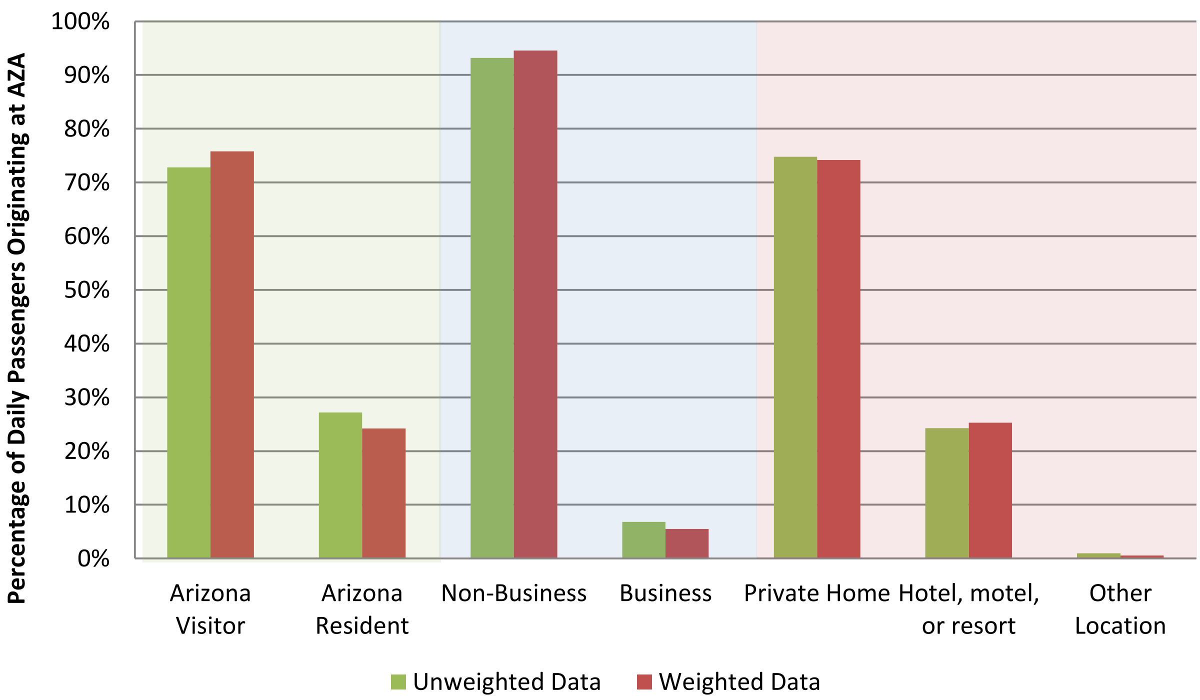


Figure A-19. **AZA weekday start time of trip to airport**

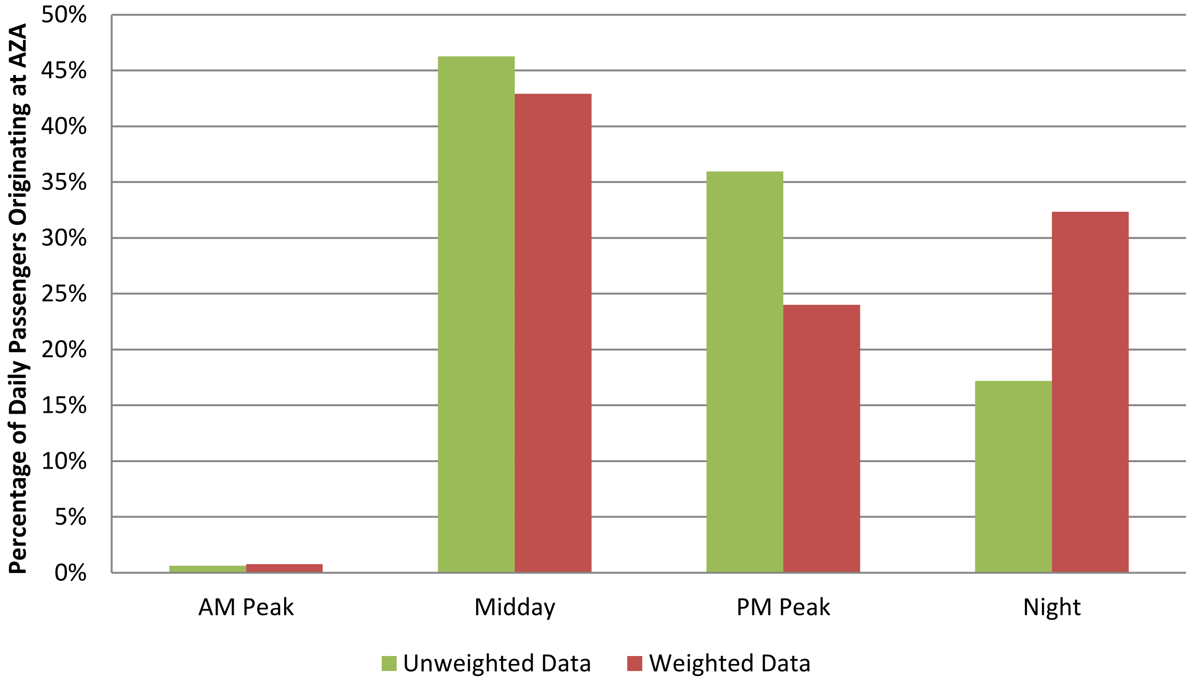


Figure A-20. AZA Sunday start time of trip to airport

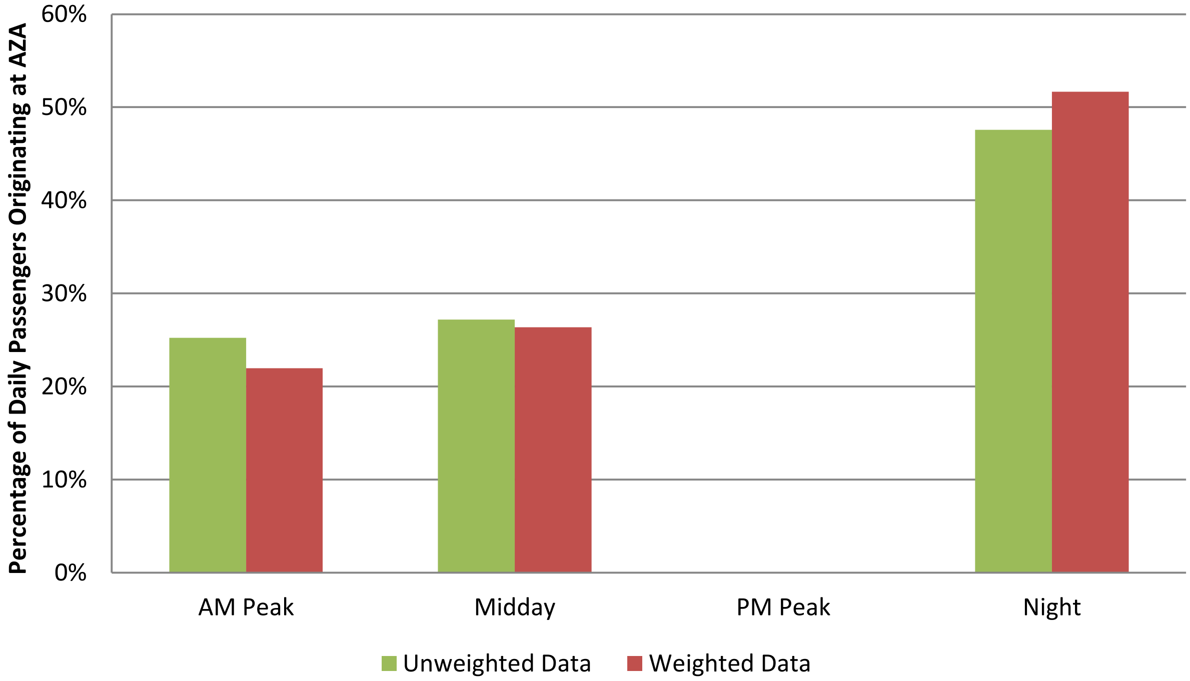


Figure A-21. AZA weekday main mode to airport

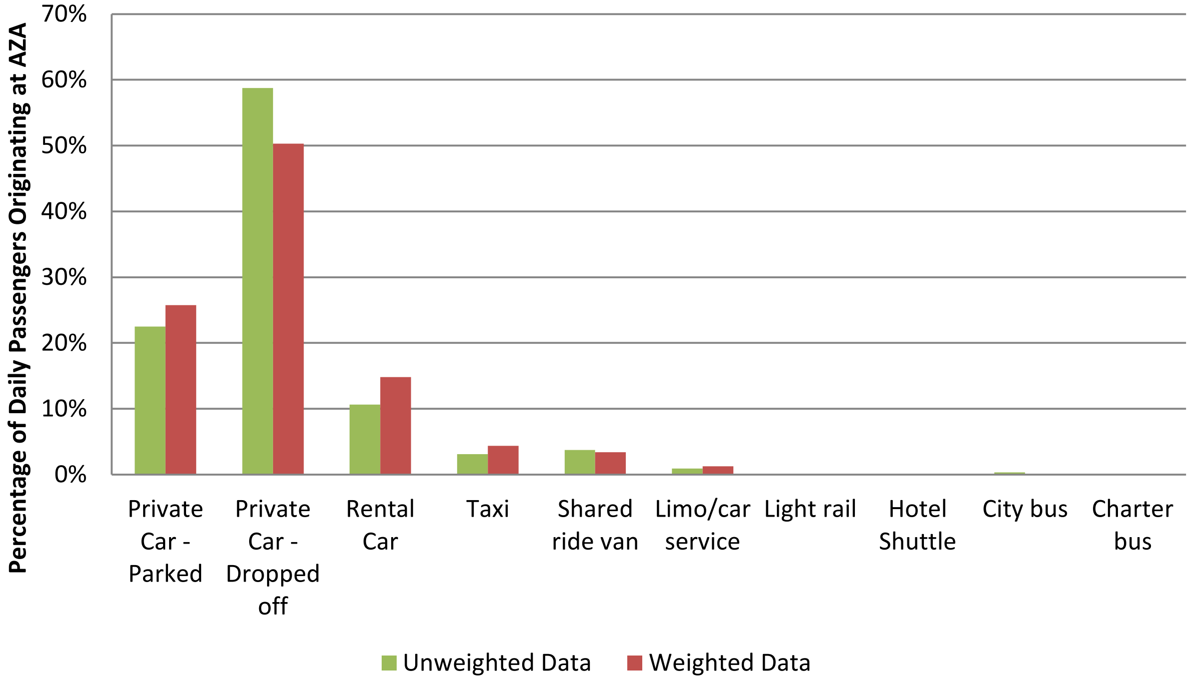


Figure A-22. AZA Sunday main mode to airport

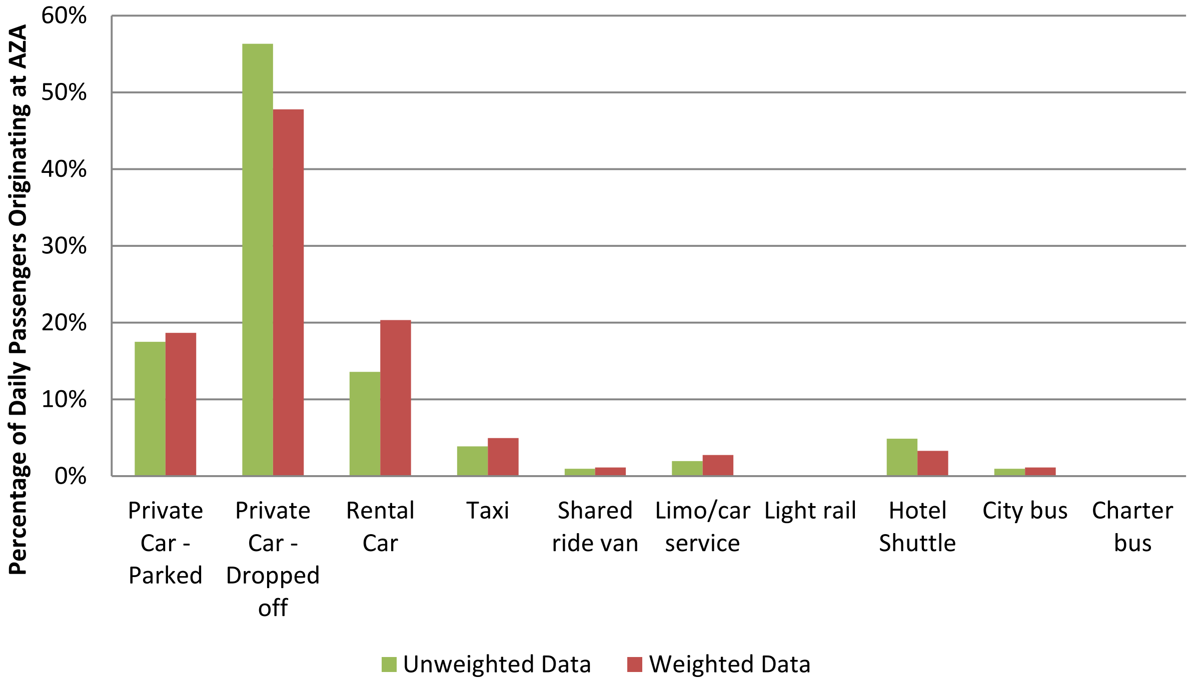


Figure A-23. AZA weekday household income

Figure A-24. AZA Sunday household income

Figure A-25. AZA weekday household size

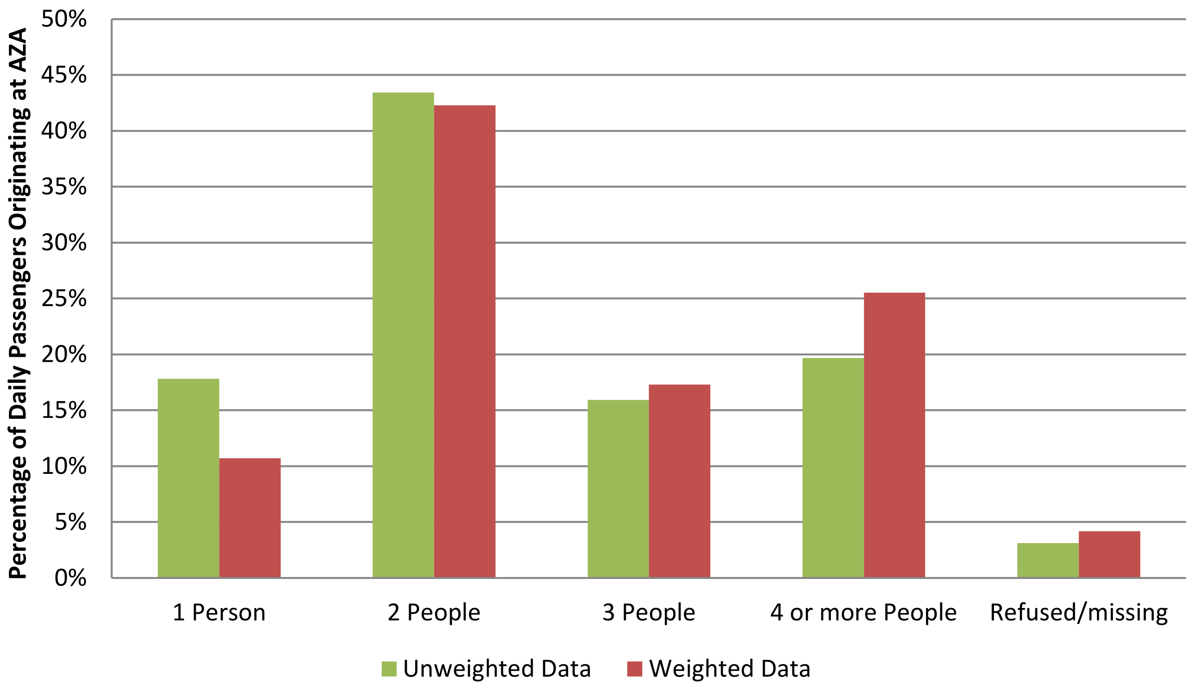


Figure A-26. AZA Sunday household size

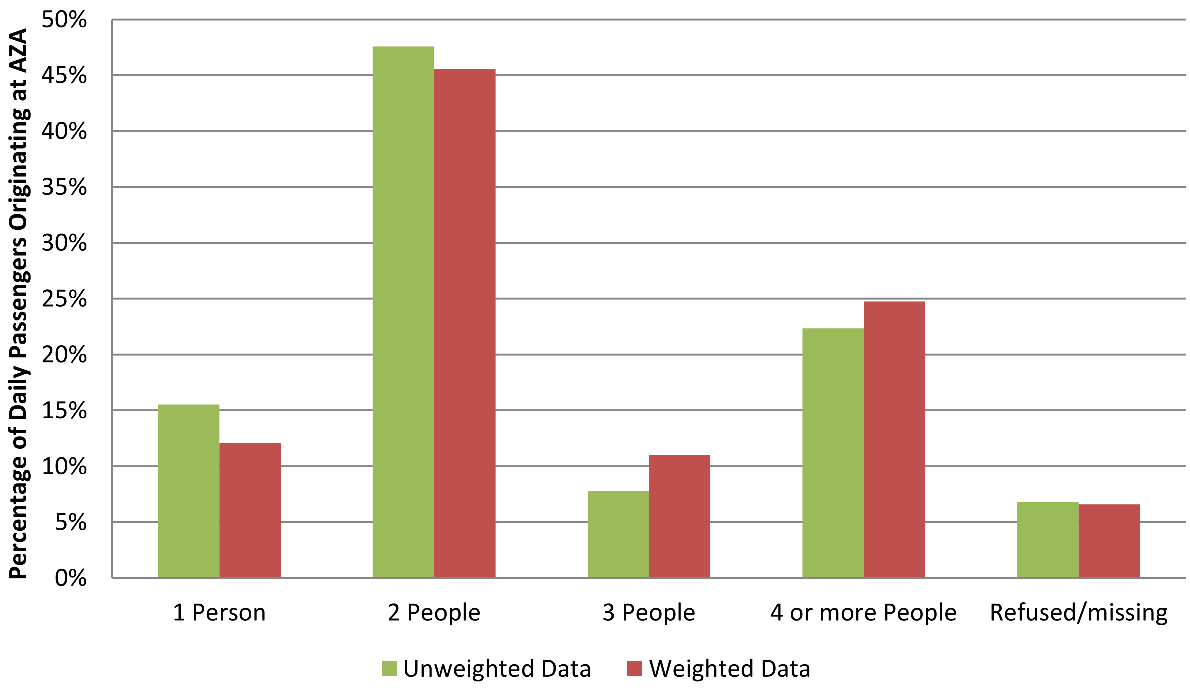


Figure A-27. AZA weekday vehicle availability

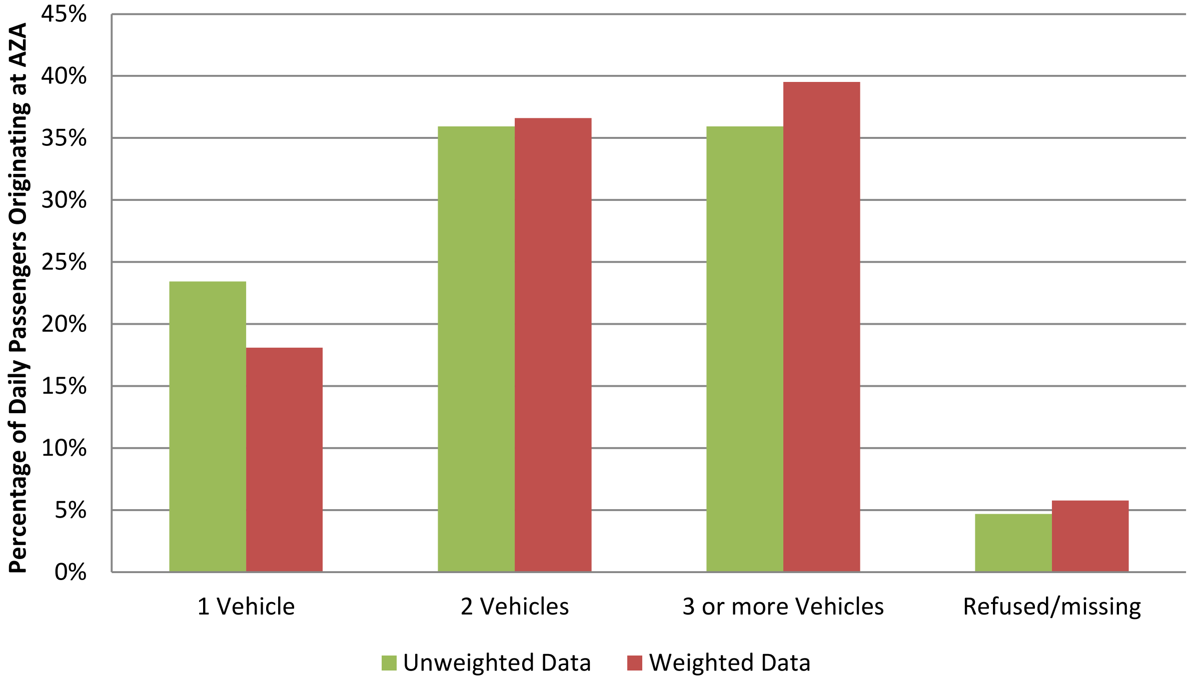
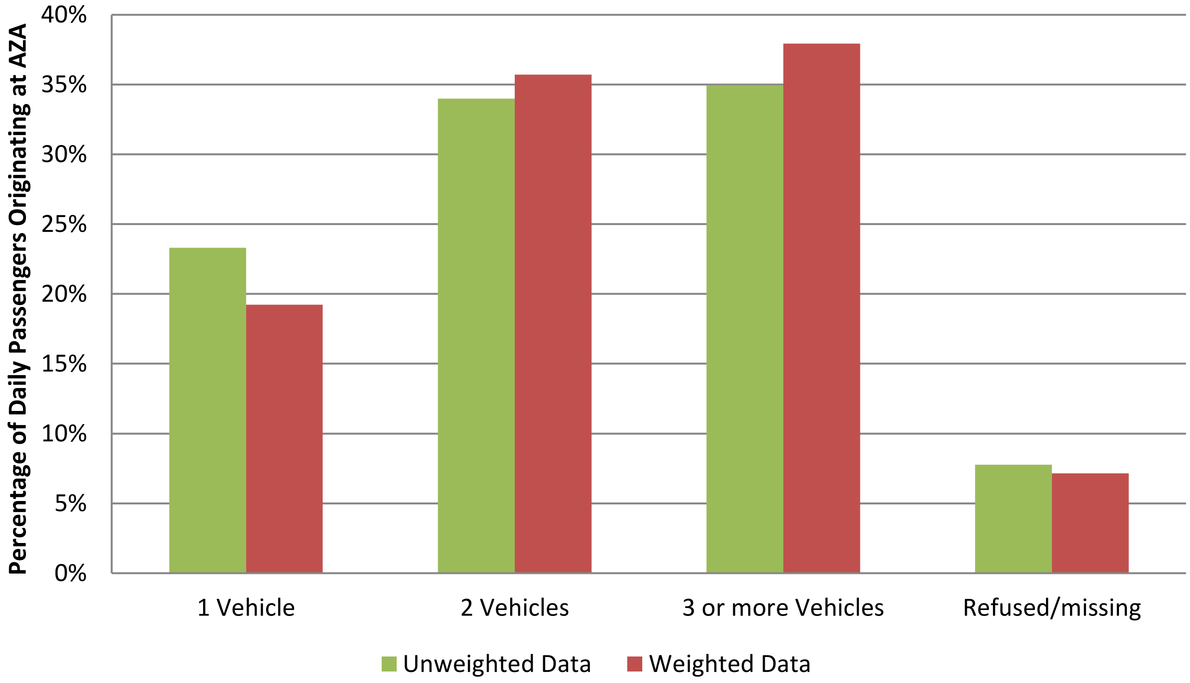


Figure A-28. AZA Sunday vehicle availability



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Appendix B: PHX and AZA Additional Data

Table B-1. PHX and AZA trip purpose and resident status distribution, by day of week

Day of week	Resident business	Resident nonbusiness	Visitor business	Visitor nonbusiness
PHX				
Weekday	9.3%	23.1%	20.4%	47.2%
Saturday	4.1%	18.7%	11.5%	65.7%
Sunday	11.7%	13.2%	22.4%	52.7%
AZA				
Weekday	2.6%	22.4%	5.2%	69.9%
Saturday	1.3%	20.5%	4.0%	74.2%
Sunday	1.3%	20.5%	4.0%	74.2%

Note: Percentages based on weighted air passenger survey data.

Table B-2. PHX and AZA resident business: household income and vehicle segmentation, by day of week

Day of week	Low-income (<$80,000), low vehicle (0–1 vehicle)	High-income (>$80,000), low vehicle (0–1 vehicle)	Low-income (<$80,000), high vehicle (2+ vehicles)	High-income (>$80,000), high vehicle (2+ vehicles)
Weekday	10.6%	9.1%	15.0%	65.4%
Saturday	19.2%	4.8%	15.3%	60.6%
Sunday	5.1%	5.7%	19.6%	69.7%

Note: AZA and PHX were calculated together because of low sample sizes. Percentages based on weighted air passenger survey data.

Table B-3. PHX and AZA resident nonbusiness: household income and vehicle segmentation, by day of week

Day of week	Low-income (<$80,000), low vehicle (0–1 vehicle)	High-income (>$80,000), low vehicle (0–1 vehicle)	Low-income (<$80,000), high vehicle (2+ vehicles)	High-income (>$80,000), high vehicle (2+ vehicles)
PHX				
Weekday	15.5%	6.0%	33.6%	45.0%
Saturday	14.7%	0.5%	39.6%	45.2%
Sunday	17.5%	7.6%	34.1%	40.8%
AZA				
Weekday	15.8%	6.1%	42.8%	35.3%
Saturday	23.4%	0.0%	36.6%	40.0%
Sunday	23.4%	0.0%	36.6%	40.0%

Note: Percentages based on weighted air passenger survey data.

Table B-4. PHX and AZA visitor business: household income and vehicle segmentation, by day of week

Day of week	Low-income (<$80,000), low vehicle (0–1 vehicle)	High-income (>$80,000), low vehicle (0–1 vehicle)	Low-income (<$80,000), high vehicle (2+ vehicles)	High-income (>$80,000), high vehicle (2+ vehicles)
Weekday	9.3%	10.3%	13.1%	67.4%
Saturday	18.0%	11.1%	20.1%	50.8%
Sunday	11.3%	6.0%	22.9%	59.8%

Note: AZA and PHX were calculated together because of low sample sizes. Percentages based on weighted air passenger survey data.

Table B-5. PHX and AZA visitor nonbusiness: household income and vehicle segmentation, by day of week

Day of week	Low-income (<$80,000), low vehicle (0–1 vehicle)	High-income (>$80,000), low vehicle (0–1 vehicle)	Low-income (<$80,000), high vehicle (2+ vehicles)	High-income (>$80,000), high vehicle (2+ vehicles)
PHX				
Weekday	11.0%	6.8%	24.8%	57.4%
Saturday	7.8%	7.3%	21.8%	63.1%
Sunday	7.5%	10.2%	21.8%	60.5%
AZA				
Weekday	17.8%	2.6%	38.9%	40.8%
Saturday	8.4%	3.2%	36.8%	51.6%
Sunday	8.4%	3.2%	36.8%	51.6%

Note: Percentages based on weighted air passenger survey data.

Table B-6. PHX and AZA resident business: previous location, by day of week

Day of week	Private home	Hotel, motel, or resort	Other
PHX			
Weekday	82.1%	4.7%	13.2%
Saturday	68.5%	20.1%	11.4%
Sunday	95.4%	4.6%	0.0%
AZA			
Weekday	82.6%	0.0%	17.4%
Saturday	90.3%	9.7%	0.0%
Sunday	90.3%	9.7%	0.0%

Note: Percentages based on weighted air passenger survey data.

Table B-7. PHX and AZA resident nonbusiness: previous location, by day of week

Day of week	Private home	Hotel, motel, or resort	Other
PHX			
Weekday	88.0%	2.4%	9.6%
Saturday	90.6%	7.1%	2.3%
Sunday	96.0%	2.7%	1.3%
AZA			
Weekday	82.6%	0.0%	17.4%
Saturday	90.3%	9.7%	0.0%
Sunday	90.3%	9.7%	0.0%

Note: Percentages based on weighted air passenger survey data.

Table B-8. PHX and AZA visitor business: previous location, by day of week

Day of week	Private home	Hotel, motel, or resort	Other
PHX			
Weekday	8.4%	65.8%	25.8%
Saturday	10.0%	76.7%	13.3%
Sunday	13.5%	63.1%	23.4%
AZA			
Weekday	57.7%	18.3%	23.9%
Saturday	37.9%	62.1%	0.0%
Sunday	37.9%	62.1%	0.0%

Note: Percentages based on weighted air passenger survey data.

Table B-9. PHX and AZA visitor nonbusiness: previous location, by day of week

Day of week	Private home	Hotel, motel, or resort	Other
PHX			
Weekday	55.0%	35.4%	9.6%
Saturday	60.5%	33.7%	5.8%
Sunday	35.8%	54.1%	10.1%
AZA			
Weekday	73.8%	22.8%	3.4%
Saturday	72.5%	26.6%	0.8%
Sunday	72.5%	26.6%	0.8%

Note: Percentages based on weighted air passenger survey data.

Table B-10. PHX and AZA resident business: party size, by day of week

Day of week	1 person	2 people	3+ people
Weekday	72.4%	19.3%	8.3%
Saturday	54.6%	24.5%	20.8%
Sunday	78.2%	21.8%	0.0%

Note: AZA and PHX were calculated together because of low sample sizes. Percentages based on weighted air passenger survey results.

Table B-11. PHX and AZA resident nonbusiness: party size, by day of week

Day of week	1 person	2 people	3+ people
PHX			
Weekday	43.9%	33.5%	22.6%
Saturday	36.7%	43.9%	19.3%
Sunday	49.7%	40.1%	10.1%
AZA			
Weekday	44.8%	41.8%	13.4%
Saturday	35.9%	30.7%	33.3%
Sunday	35.9%	30.7%	33.3%

Note: Percentages based on weighted air passenger survey data.

Table B-12. PHX and AZA visitor business: party size, by day of week

Day of week	1 person	2 people	3+ people
Weekday	60.0%	22.0%	17.9%
Saturday	45.6%	42.0%	12.4%
Sunday	48.4%	32.1%	19.4%

Note: AZA and PHX were calculated together because of low sample sizes. Percentages based on weighted air passenger survey results.

Table B-13. PHX and AZA visitor nonbusiness: party size, by day of week

Day of week	1 person	2 people	3+ people
PHX			
Weekday	26.7%	38.3%	35.0%
Saturday	22.0%	33.1%	44.8%
Sunday	28.7%	34.4%	36.9%
AZA			
Weekday	20.8%	45.5%	33.8%
Saturday	21.8%	48.4%	29.8%
Sunday	21.8%	48.4%	29.8%
Percentages based on weighted air passenger survey results.			

Appendix C: PHX and AZA Traffic Count Summary

Table C-1. PHX traffic count summary, by day of week, time of day, and direction

Sunday, April 1, 2012		Weekday (April 2–6, 2012)		Saturday, April 7, 2012	
All locations	**EB**	**All locations**	**EB**	**All locations**	**EB**
AM Peak (6 a.m.–9 a.m.)	14,385	AM Peak	18,265	AM Peak	11,870
Midday (9 a.m.–2 p.m.)	29,421	Midday	33,011	Midday	23,408
PM Peak (2 p.m.–6 p.m.)	23,899	PM Peak	31,235	PM Peak	17,146
Night (6 p.m.–6 a.m.)	42,553	Night	42,025	Night	26,056
Total	**110,258**	**Total**	**124,536**	**Total**	**78,480**

Sunday, April 1, 2012		Weekday (April 2–6, 2012)		Saturday, April 7, 2012	
All locations	**WB**	**All locations**	**WB**	**All locations**	**WB**
AM Peak	15,469	AM Peak	19,984	AM Peak	11,232
Midday	31,465	Midday	33,481	Midday	23,987
PM Peak	26,437	PM Peak	28,210	PM Peak	18,062
Night	44,097	Night	40,043	Night	25,741
Total	**117,468**	**Total**	**121,719**	**Total**	**79,022**

Table C-2. AZA traffic count summary, by day of week, time of day, and direction

Sunday, April 22, 2012		Weekday (April 23–27, 2012)		Saturday, April 21, 2012	
All locations	**NB**	**All locations**	**NB**	**All locations**	**NB**
AM Peak (6 a.m.–9 a.m.)	605	AM Peak	1,921	AM Peak	758
Midday (9 a.m.–2 p.m.)	2,741	Midday	3,078	Midday	2,291
PM Peak (2 p.m.–6 p.m.)	1,984	PM Peak	2,345	PM Peak	1,406
Night (6 p.m.–6 a.m.)	2,483	Night	2,555	Night	1,557
Total	**7,813**	**Total**	**9,899**	**Total**	**6,012**

Sunday, April 22, 2012		Weekday (April 23–27, 2012)		Saturday, April 28, 2012	
All locations	**SB**	**All locations**	**SB**	**All locations**	**SB**
AM Peak	507	AM Peak	1,407	AM Peak	381
Midday	2,323	Midday	2,939	Midday	1,845
PM Peak	1,786	PM Peak	2,631	PM Peak	1,244
Night	2,304	Night	2,841	Night	1,526
Total	**6,920**	**Total**	**9,817**	**Total**	**4,996**

Sunday, April 22, 2012		Weekday (April 23–27, 2012)		Saturday, April 28, 2012	
All locations	**EB**	**All locations**	**EB**	**All locations**	**EB**
AM Peak	378	AM Peak	648	AM Peak	351
Midday	2,279	Midday	2,025	Midday	824
PM Peak	1,470	PM Peak	1,387	PM Peak	243
Night	2,824	Night	2,552	Night	977
Total	**6,951**	**Total**	**6,612**	**Total**	**2,395**

Sunday, April 22, 2012		Weekday (April 23–27, 2012)		Saturday, April 28, 2012	
All locations	**WB**	**All locations**	**WB**	**All locations**	**WB**
AM Peak	224	AM Peak	366	AM Peak	201
Midday	1,492	Midday	1,338	Midday	796
PM Peak	1,171	PM Peak	1,075	PM Peak	224
Night	1,870	Night	1,882	Night	919
Total	**4,757**	**Total**	**4,660**	**Total**	**2,140**

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