2021 Transportation Conformity

Appendix 12.4

Travel Model Validation

Alamo Area Travel Demand Model

2015 Base Year Technical Documentation

Technical Report

prepared for

Alamo Area MPO

prepared by

Cambridge Systematics, Inc.

January 28, 2019

report

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January 28, 2019

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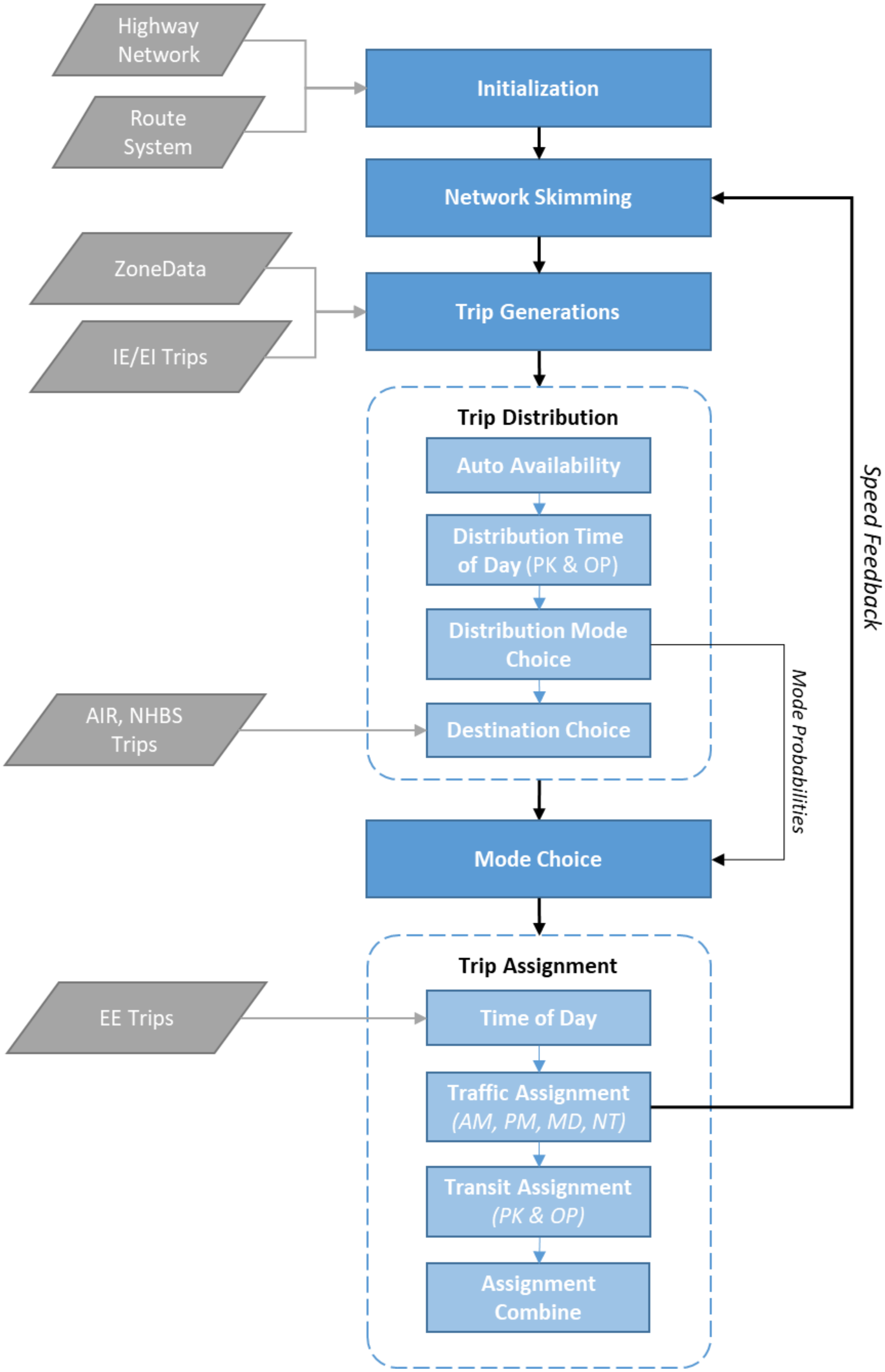
1.0 Introduction

This technical report provides a description of the San Antonio Multimodal Model Version 4 (SAMMV4) developed for the Alamo Area Metropolitan Planning Organization (AAMPO). The model estimates person, vehicle, and transit trips in the region utilizing a trip-based model with the following components: trip generation, trip distribution, mode choice, time-of-day, and assignment. The report discusses the estimation and calibration of each models, and then furnishes traffic and transit assignment validation results.

SAMMV4 consists of 1317 internal traffic analysis zones (TAZs) and 42 external TAZs covering the five-county region consisting of: Bexar, Comal, Guadalupe, Kendall, and Wilson Counties. It runs in TransCAD version 6.0.

The San Antonio Multimodal Model (SAMM) follows the traditional 4-step modeling approach: Trip Generation, Trip Distribution, Mode Choice, and Route Assignment, as described in Figure 1.1.

Figure 1.1 SAMM Flowchart



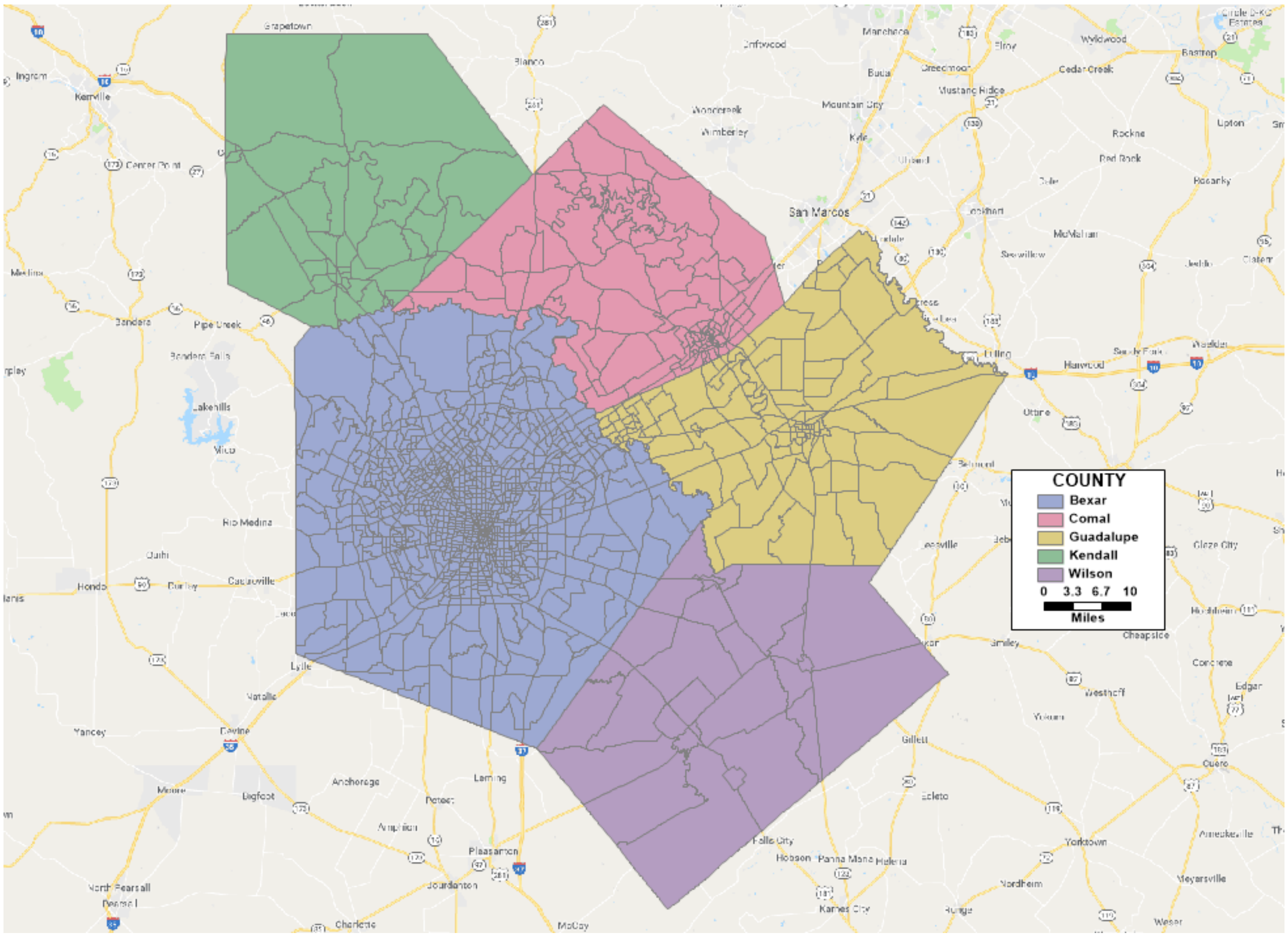
2.0 Review and Preparation of Model Data

2.1 Overview of Model Data

2.1.1 Geographic Areas

SAMM consists of 1317 internal traffic analysis zones (TAZs) and 42 external TAZs covering the five-county region consisting of: Bexar, Comal, Guadalupe, Kendall, and Wilson Counties (Figure 2.1).

Figure 2.1 AAMPO Five County Region



2.1.2 Area Types

Area types as defined by TAZ density (along with facility types and number of lanes) are used to set roadway speeds and capacities. Changes in densities and area types over time enable the model networks to properly represent roadway and transit performance within various types of urban settings. Generally, as urban density increases, speeds decline and capacities increase. SAMM considers five different area types:

1. Central business district (CBD)

2. CBD fringe

3. Urban
4. Suburban
5. Rural

2.1.3 Trip Purposes

There are 12 different trip purposes:

1. Home-based work (HBW) person trips: trips that have home and work as trip ends
2. Home-based education K-12 (HBED1) person trips: trips that have home and school as trip ends
3. Home-based college or higher (HBED2) person trips: trips that have home and college as trip ends
4. Home-based shopping (HBSH) person trips: trips that have home and retail centers are trip ends
5. Home-based other (HBO person trips): other non-work trips
6. Non home-based (NHB) person trips: trips that do not have either end at home - includes visitor travel
7. Airport (AIR) person trips: non-work trips to and from the airport
8. Non home-based special (NHBS) person trips: visitor/commuter travel
9. Commercial truck and taxi (TRTX) vehicle trips: commercial vehicles > 8,500 lbs and having six or more tires
10. External-local commercial truck (EXLO-C) vehicle trips: commercial truck trips with one end within the region
11. External-local non-commercial truck (EXLO-NC) vehicle trips: non-commercial truck trips with one end within the region
12. External through (THRU) vehicle trips: trips that are crossing through the region with no trips ends within the region

2.1.4 Income Groups

Households are divided into five income groups in 2015$:

1. $0 to $19,999 (Low income)
2. $20,000 to $34,999 (Low-medium income)
3. $35,000 to $49,999 (Medium income)
4. $50,000 to $74,999 (High-medium income)

5. $75,000 and above (High income)

2.1.5 Household Size

Households are segmented by five household size groups:

1. Household size 1
2. Household size 2
3. Household size 3
4. Household size 4
5. Household size 5+

2.1.6 Number of Workers

The market segmentation for the HBW trip purpose also includes the number of workers dimension:

1. 0 Workers
2. 1 Worker
3. 2+ Workers

2.1.7 Vehicle Sufficiency

Three vehicle sufficiency segments were derived based on auto availability with respect to household size:

1. No vehicles
2. Number of vehicles < household size
3. Number of vehicles ≥ household size

2.1.8 Travel Modes

The model includes thirteen different travel modes, including three auto modes, two non-motorized modes, and eight transit modes which are characterized by their mode of access:

1. Single-occupancy vehicle (SOV)
2. Two person sharing a ride (SR2)
3. Three or more persons sharing a ride (SR3)
4. Walk
5. Bike

6. Walk to Local bus
7. Walk to express bus
8. Walk to bus rapid transit (BRT) – not used in base model
9. Walk to light rail transit (LRT) – not used in base model
10. Drive to local bus
11. Drive to express bus
12. Drive to BRT – not used in base model
13. Drive to LRT – not used in base model

2.1.9 Socioeconomic and Demographic Data

SAMM requires the following socioeconomic and demographic data at the TAZ level:

- Area size
- Area type
- County
- Population
- Households
- Household size
- Median household income
- Distribution of households by number of workers
- Urban/rural indicator
- Total employment
- Basic employment
- Retail employment
- Service employment
- Education 1 (school) employment
- Education 2 (college/university) employment

- Special generator employment

2.2 Household Travel Survey

2.2.1 Expansion of the 2005 Household Travel Survey

The 2005 household travel survey (HTS) was expanded to match AAMPO's 2015 socioeconomic population at the regional level[1] using a univariate expansion that controlled for household size, number of vehicles, number of household workers, income level, and aggregate sectors, but capping weights to eliminate extreme weights.

Control totals for household size, number of vehicles, number of household workers, and income level were obtained from the 2011-2015 ACS data scaled to match total households from the 2015 AAMPO socioeconomic data. Control totals by aggregate geographic sector were obtained directly from the 2015 AAMPO socioeconomic data. The next two sections compare the expansion to the ACS 2011-2015 data across various socio-demographic characteristics and to AAMPO's 2015 socioeconomic data distribution by geographic sector.

2.2.2 Household Travel Survey Compared to ACS 2011-2015 5-Year Estimates

The unweighted household travel survey and the expanded household travel survey were compared to the American Community Survey 2011-2015 5-year estimates for year 2015 across a number of sociodemographic characteristics. For all datasets, total household numbers were scaled to match the 2015 AAMPO socioeconomic data.

Table 2.1 shows the distribution of each set of data by household size. Compared to the ACS, the unweighted survey underrepresents one person households. Table 2.2 shows the number of households by household size for the ACS data compared to the expanded survey. The expansion results in underrepresenting one person households by 8%. Note that while the expansion used household size as a control variable, it also caps the weights. Given the significant underrepresentation of one person households in the unweighted survey, matching the household size distribution exactly would have required some survey records to take on very large weights.

Table 2.1 Household Size Distribution

Household Size	ACS	Unweighted HTS	Expanded Survey
One person	26%	18%	24%
Two people	31%	36%	32%
Three people	17%	20%	17%
Four or more people	26%	27%	27%

[1] Texas Department of Transportation, "*2006 Austin/San Antonio GPS-Enhanced Household Travel Survey Technical Summary*". Prepared by the Texas Transportation Institute, August 2008.

Table 2.2 Household Size - ACS compared to Expanded Survey

Household Size	ACS	Expanded Survey	Difference	Percent Difference
One person	210,300	193,510	-16,790	-8%
Two people	255,404	259,301	3,897	2%
Three people	138,166	143,131	4,965	4%
Four or more people	217,631	225,556	7,925	4%
Total	821,501	821,499	-2	0%

Table 2.3 shows the distribution of each set of data by number of household workers. Compared to the ACS, the unweighted survey oversamples zero worker households. The expansion matches the ACS better than the unweighted survey. Table 2.4 shows the number of households by number of household workers for the ACS data compared to the expanded survey. The expansion totals match up well against the ACS data.

Table 2.3 Distribution of Number of Workers in Household

Household Workers	ACS	Unweighted HTS	Expanded Survey
Zero workers	23%	33%	24%
One worker	42%	34%	40%
Two or more workers	35%	32%	36%

Table 2.4 Number of Household Workers - ACS compared to Expanded Survey

Household Workers	ACS	Expanded Survey	Difference	Percent Difference
Zero workers	187,916	194,019	6,103	3%
One worker	345,887	330,967	-14,920	-4%
Two or more workers	287,695	296,513	8,818	3%
Total	821,498	821,499	1	0%

Table 2.5 shows the distribution of each set of data by number of household vehicles. Unlike the unweighted survey, which underrepresents zero vehicle households, the expansion matches the ACS well.

Table 2.6 shows the number of households by number of household vehicles for the ACS data compared to the expansion. The expanded survey results in underrepresenting zero vehicle households by 12%. Note that while the expansion used household vehicles as a control variable, it also caps the weights. Given the significant underrepresentation of zero vehicle households in the unweighted survey, matching the household vehicle distribution exactly would have required some survey records to take on very large weights.

Table 2.5 Distribution of Number of Vehicles in Household

Household Vehicles	ACS	Unweighted HTS	Expanded Survey
Zero vehicles	7%	3%	6%
One vehicle	35%	28%	33%
Two vehicles	39%	47%	40%
Three or more vehicles	20%	22%	20%

Table 2.6 Household Vehicles - ACS compared to Expanded Survey

Household Vehicles	ACS	Expanded Survey	Difference	Percent Difference
Zero vehicles	57,585	50,646	-6,939	-12%
One vehicle	283,885	274,694	-9,191	-3%
Two vehicles	319,727	329,580	9,853	3%
Three vehicles	160,302	166,579	6,277	4%
Total	821,499	821,499	0	0%

Table 2.7 shows the distribution of each set of data by household income. Compared to the ACS, the unweighted survey underrepresents households with income greater than $75,000. The expansion matches the ACS better than the unweighted survey. Table 2.8 shows the number of households by household income for the ACS data compared to the expanded survey. The expansion totals match up well against the ACS data.

Table 2.7 Distribution of Household Income

Household Income	ACS	Unweighted HTS	Expanded Survey
$0 - $25,000	23%	23%	23%
$25,000 - $35,000	10%	13%	11%
$35,000 - $50,000	14%	19%	14%
$50,000 - $75,000	19%	21%	19%
$75,000 or more	34%	24%	33%

Table 2.8 Household Income - ACS compared to Expanded Survey

Household Income	ACS	Expanded Survey	Difference	Percent Difference
$0 - $25,000	186,092	185,518	-574	0%
$25,000 - $35,000	85,833	86,626	793	1%
$35,000 - $50,000	114,481	117,356	2,875	3%
$50,000 - $75,000	154,094	157,257	3,163	2%
$75,000 or more	280,999	274,741	-6,258	-2%
Total	821,499	821,499	0	0%

2.2.3 Household Travel Survey Compared to 2015 AAMPO Socioeconomic Data

The AAMPO region was divided into eight sectors and three aggregate sectors for the purpose of expanding the household travel survey data and comparing the survey data to the 2015 AAMPO socioeconomic data. Figure 2.2 and Figure 2.3 show the geographic distribution of the sectors and aggregate sectors. Sector 1 represents the downtown central business district while Sector 7 is composed of all of Comal, Guadalupe, Kendall, and Wilson counties that are within the AAMPO region, with the exception of a portion of the I-35 corridor up to New Braunfels which is grouped into Sector 8. Aggregate sectors group Sector 1, 2, 3, 4, 5 into Group A, Sector 6 and 8 into Group B, and Group 7 into Group C.

Figure 2.2 Map of Sectors

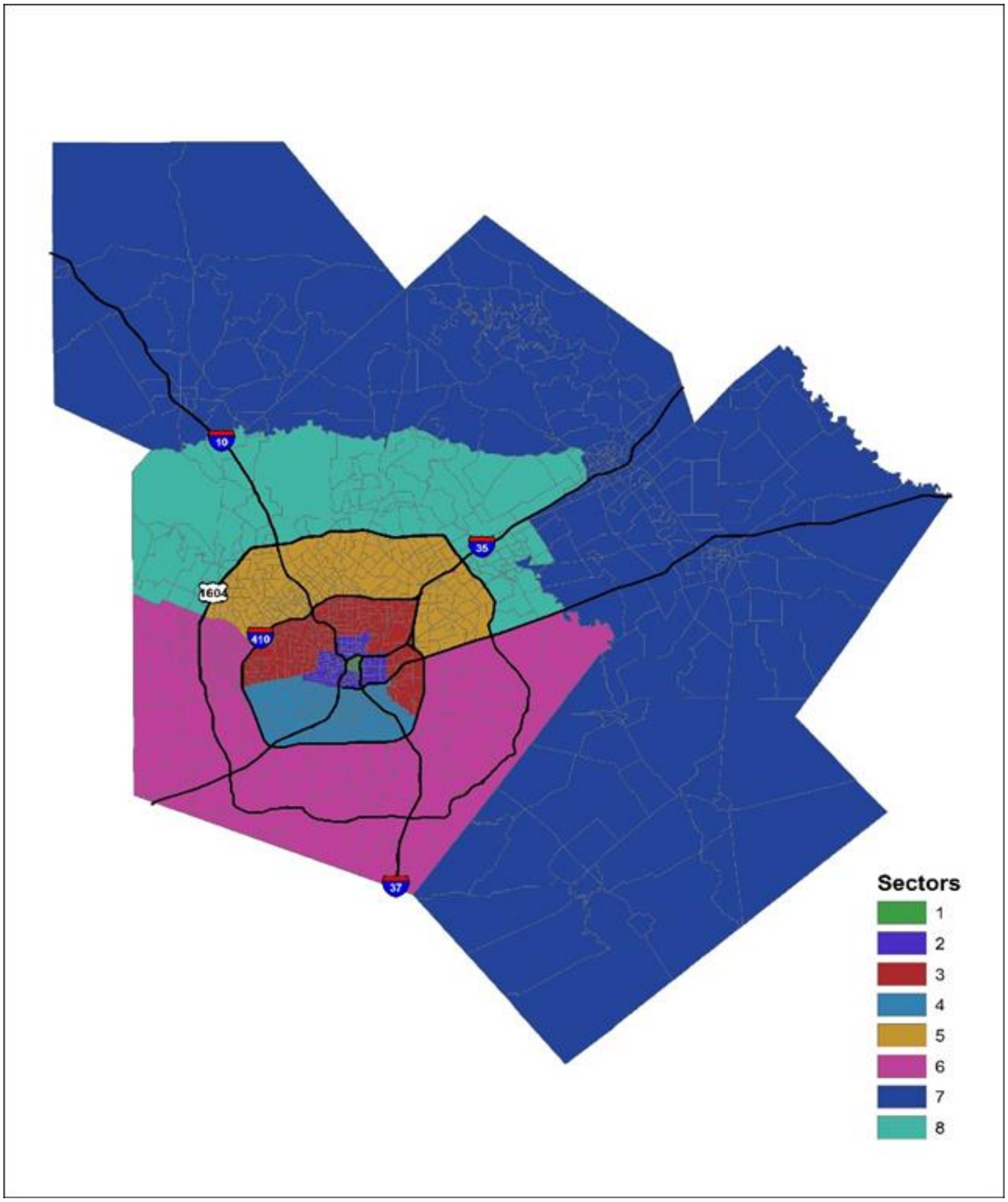


Figure 2.3 Map of Aggregate Sectors

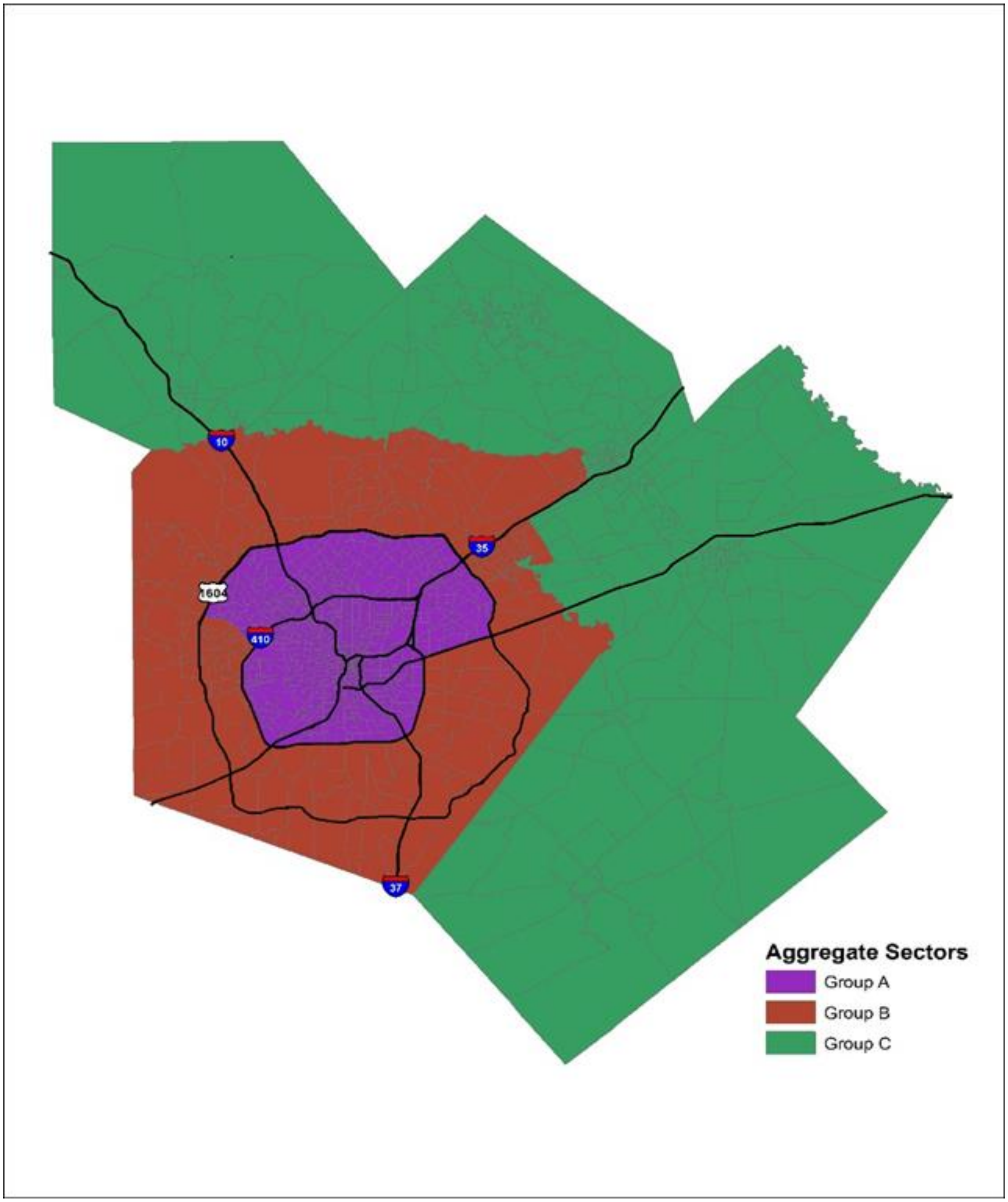


Table 2.9 and Table 2.10 show the distribution of each set of data by sector and aggregate sector. At the Sector level, the expansion does better than the unweighted survey compared to the 2015 socioeconomic data for some sectors (2, 3, 6, and 8) and worse for one sector (5). At the aggregate sector level (which is used as a control total in the expansion weighting), the expansion matches closely with the 2015 socioeconomic data.

Table 2.9 Distribution of Households by Sector

Household Income	2015 SED	Unweighted HTS	Expanded Survey
Sector 1	0%	0%	0%
Sector 2	5%	7%	6%
Sector 3	14%	25%	22%
Sector 4	9%	10%	9%
Sector 5	31%	28%	24%
Sector 6	12%	7%	11%
Sector 7	14%	14%	14%
Sector 8	14%	9%	14%

Table 2.10 Distribution of Households by Aggregate Sector

Household Income	2015 SED	Unweighted HTS	Expanded Survey
Group A	60%	70%	62%
Group B	26%	16%	24%
Group C	14%	14%	14%

Table 2.11 and Table 2.12 show the number of households by sector and aggregate sector for the 2015 socioeconomic data compared to the expanded survey. The expansion underrepresents Sector 1 by 74% while over representing Sector 3 by 57%. The unweighted survey only contained two survey records in Sector 1, thus it was not possible to weight the data to better represent Sector 1, even when high weights were not capped. The expansion totals match up well against the 2015 socioeconomic data at the aggregate sector level.

Table 2.11 Household by Sector - 2015 Socioeconomic Data Compared to Expanded Survey

Household Income	2015 SED	Expanded Survey	Difference	Percent Difference
Sector 1	3,325	868	-2,457	-74%
Sector 2	44,271	49,234	4,963	11%
Sector 3	116,401	182,179	65,778	57%
Sector 4	77,246	74,518	-2,728	-4%
Sector 5	254,075	198,655	-55,420	-22%
Sector 6	99,624	86,698	-12,926	-13%
Sector 7	114,947	115,838	891	1%
Sector 8	111,611	113,509	1,898	2%
Total	821,500	821,499	-1	0%

Table 2.12 Household by Aggregate Sector - 2015 Socioeconomic Data Compared to Expanded Survey

Household Income	2015 SED	Expanded Survey	Difference	Percent Difference
Group A	495,318	505,454	10,136	2%
Group B	211,235	200,207	-11,028	-5%
Group C	114,947	115,838	891	1%
Total	821,500	821,499	-1	0%

2.2.4 Auto and Non-motorized Mode Share Targets

The expanded 2005 household travel survey was used to obtain non-transit mode share targets as input into mode choice calibration. The calibration process is set-up to take in as input separate mode share targets for each combination of trip purpose, time period (peak or off-peak), and income group. However, given the size of the household travel survey, there were not enough survey records to sufficiently develop mode share targets by that detailed level of segmentation. Therefore, for the bike and walk modes one set of mode share targets was developed for each trip purpose (i.e. all income groups and time periods were combined). For the auto modes, mode share targets were developed by trip purpose and time period, while income groups were combined in different ways depending on trip purpose. For home-based work, income groups 3, 4, and 5 were combined. For home-based shopping and home-based other income groups 1 and 2 were combined and income groups 3, 4, and 5 were combined. For home-based education 1, home-based education 2, non home-based, and airport trips the mode share targets were not segmented by income. Table 2.13, shows the mode share targets for the auto and non-motorized modes by trip purpose, time period, and income.

The regional model does not model school bus trips. It was determined that 30% of the home-based education 1 trips are made by school bus within the expanded survey. The mode shares shown in Table 2.13 reflect the share of trips made by all other auto and non-motorized modes. As discussed further in Section 4.3, within the model system, home-based education 1 trips were factored down by 30% before the mode choice model is implemented to account for the number of trips made by school bus and to ensure that other modes are not overrepresented for this trip purpose.

The mode shares for airport trips were calculated by assuming that all trips will be made by an auto mode (i.e. no walk, bike, or transit trips), and SOV, SR2, and SR3 mode shares are identical to home-based other income level 3, 4, and 5 share of auto trips.

Table 2.13 Auto and Non-Motorized Mode Shares

Purpose	Time Period	Income Group	Auto and Non-Motorized Mode Share				
			SOV	SR2	SR3	BIKE	WALK
Home-Based Work	Peak	1	68%	27%	4%	0%	1%
Home-Based Work	Peak	2	86%	11%	2%	0%	1%
Home-Based Work	Peak	3, 4, 5	91%	7%	2%	0%	1%
Home-Based Work	Off-Peak	1	84%	14%	1%	0%	1%
Home-Based Work	Off-Peak	2	84%	12%	3%	0%	1%
Home-Based Work	Off-Peak	3, 4, 5	91%	7%	2%	0%	1%
Home-Based Shopping	Peak	1, 2	41%	24%	33%	0%	1%
Home-Based Shopping	Peak	3, 4, 5	54%	26%	19%	0%	1%
Home-Based Shopping	Off-Peak	1, 2	46%	33%	20%	0%	1%
Home-Based Shopping	Off-Peak	3, 4, 5	51%	31%	17%	0%	1%
Home-Based Other	Peak	1, 2	34%	29%	33%	0%	4%
Home-Based Other	Peak	3, 4, 5	34%	27%	35%	0%	4%
Home-Based Other	Off-Peak	1, 2	41%	33%	22%	0%	4%
Home-Based Other	Off-Peak	3, 4, 5	36%	32%	29%	0%	4%
Home-Based Education 1	Peak	1, 2, 3, 4, 5	5%	33%	46%	1%	14%
Home-Based Education 1	Off-Peak	1, 2, 3, 4, 5	11%	30%	44%	1%	14%
Home-Based Education 2	Peak	1, 2, 3, 4, 5	82%	9%	1%	3%	5%
Home-Based Education 2	Off-Peak	1, 2, 3, 4, 5	86%	5%	1%	3%	5%
Nonhome-Based	Peak	1, 2, 3, 4, 5	41%	28%	28%	0%	2%
Nonhome-Based	Off-Peak	1, 2, 3, 4, 5	47%	29%	21%	0%	2%
Airport	Peak	1, 2, 3, 4, 5	35%	29%	36%	0%	0%
Airport	Off-Peak	1, 2, 3, 4, 5	37%	33%	30%	0%	0%

Source: 2005 Household Travel Survey

2.3 Transit On-board Survey

In 2014, the transit agency in San Antonio (VIA) conducted a transit on-board survey on all of its fixed-route bus routes[2]. The purpose of the survey was to collect data on travel patterns and demographic characteristics of its passengers. The survey was used to formulate mode choice targets and validate the model. This survey gathered data from transit users based on trip details and demographics of those using transit. Based on the survey, trip records were weighted in order to estimate average weekday ridership by route. Trip details included route on which the trip was taking place, routes transferred to and from, trip

[2] VIA Metropolitan Transit, "Origin and Destination Study Summary of Findings". Prepared by Creative Consumer Research, February 2015.

purpose, trip origin and destination, trip time of day traveled, and mode of access and egress. Demographic data included details about the rider such as vehicle availability and household income level.

As part of the base year transit validation, the survey records from the VIA On-board survey were processed into trip tables for assignment to the model transit network. The first step involved reviewing the records and removing invalid responses. Using the latitude and longitude data provided for a passenger's origin location, destination location, boarding location, and alighting location, each record was geocoded to the nearest transportation analysis zone (TAZ) in the model network.

2.3.1 Trip Purpose and Income

Survey records were classified by trip purpose based on each respondent's reported origin and destination purpose. One of six trip purposes were assigned to each record: HBW, HBED1, HBED2, HBSH, HBO, and NHB. All trip purposes except for NHB records were also segmented by the five household income groups. Trip purposes of medical, recreational, and Other were grouped into the Other category. Home-based school trips were divided into HBED1 (K-12) trips and HBED2 (college/university) trips based on the age of the respondent with those ages 17 and under grouped in HBED1 and those with ages 18+ grouped in HBED2. Records were flipped from origin-destination format to production-attraction by flagging records that report their home on the destination end as the model generates all home based trips with the home on the production side. Trip purposes of home-based work, school, shopping, and other were determined based on if one trip end had home and the category of the other trip end while all other records were categorized as non-home based. For flipped records the origin zone is treated as the attraction zone, the destination zone is treated as the production zone, the access mode is treated as the egress mode, and the egress mode is treated as the access mode.

2.3.2 Mode of Access

Access mode was determined by the response to the question on the means of arrival to the bus stop. In order to determine the access mode of each record, all buses reported in the trip path were analyzed. Records reporting a Primo trip in their path were initially grouped in the BRT path; all records with an Express (EXP) route and no PRIMO were grouped in the EXP path, and all records without Primo or Express routes reported were grouped in the local (LOC) path. During validation, however, Primo records were re-assigned to the LOC path in order to address unassigned trips which could not find a path.

Using the access modes reported by the respondent, each record was classified as either a "walk to transit" or "drive to transit" trip. Passengers who reported transferring from another bus, walking, riding a bike, other, using a wheelchair, or taking a taxi were classified as "walk to transit." Records where the respondent reported driving to a bus stop were classified as "drive to transit."

2.3.3 Time of Day

In the on-board survey, trip records were assigned one of two time of day periods: Peak (open to 9 AM, 3 to 6 PM), and off-peak (rest of the service day).

2.3.4 Transit Mode Share Targets

With the survey processed into time of day, mode of access, and transit mode, ineligible records were filtered out of the survey. First, records that had the same reported TAZ for origin and destination were removed.

These records account for short or erroneously reported transit trips that can not be properly modeled. In addition, for the mode choice targets, trips that did not have sufficient income details available were removed. Based on the route reported for the removed records, route trips for records that were not removed were re-weighted by route number and time of day to keep the average weekday ridership on each route consistent. Route ridership was then converted to linked transit trips by dividing the record ridership weight by the number of total routes reported in the path (1 reported transfer means the route weight is divided by 2 to account for 1 boarding on each route).

Accordingly, there were 139,015 boardings (or unlinked transit trips) during an average weekday in 2014. Accounting for the number of transfers reported by passengers, there were 102,026 linked transit trips. On average, passengers made 1.36 boardings per linked transit trip.

Table 2.14 and Table 2.15 show transit link trips before and after re-weighting records without detailed income information, respectively.

Table 2.14 2014 On-board Survey Transit Linked Trips by Purpose and Income Level

Income Level	HBW	HBED1	HBED2	HBSH	HBO	NHB	Total
1	17,533	756	2,588	6,038	13,740	7,667	48,322
2	8,509	259	1,128	1,595	3,331	2,487	17,309
3	1,946	39	339	302	794	670	4,090
4	1,382	50	234	229	600	429	2,924
5	593	45	99	127	220	240	1,324
Subtotal	**29,963**	**1,149**	**4,388**	**8,291**	**18,685**	**11,493**	**73,969**
Refused	10,377	926	2,385	3,483	6,896	4,434	28,501
Total	**40,340**	**2,075**	**6,772**	**11,774**	**25,581**	**15,927**	**102,470**

Source: VIA 2014 On-board Survey

Table 2.15 Re-weighted 2014 On-board Survey Transit Linked Trips by Purpose and Income Level

Income Level	HBW	HBED1	HBED2	HBSH	HBO	NHB	Total
1	24,118	1021	3,589	8,126	18,505	10,721	**66,080**
2	11,942	352	1,618	2,280	4,538	3,485	**24,215**
3	2,765	51	480	417	1062	931	**5,706**
4	1,970	64	339	309	818	617	**4,117**
5	848	57	158	184	324	337	**1,908**
Total	**41,643**	**1,545**	**6,184**	**11,316**	**25,247**	**16,091**	**102,026**

Source: VIA 2014 On-board Survey

The transit calibration targets developed based on the re-weighted survey can be found in Table A.1 in Appendix. Primo was grouped in with local bus, and the corresponding survey records were appended to those of local bus. Linked trips were segmented by time of day, mode of access, transit mode, trip purpose, and income group. In addition trips were classified into URB and OTH based on the area designation of the production TAZ (TAZs are urban if they fall inside of I-410). Transit calibration, as shown in Section 6.2, confirmed that Primo calibrates well to observed boardings when it was treated as a local bus. These transit mode share targets were combined with those in Table 2.13 to create a comprehensive set of mode share targets used in the mode choice model calibration.

2.4 Highway Network Development

The AAMPO with TxDOT and other stakeholders performed the initial step in roadway network development. Together, they inventoried and identified which facilities should comprise the 2015 base year roadway network. Generally, all facilities functionally classified as a collector, or higher functional classification, were included in the roadway description provided by both agencies.

For the roadway network, both physical and operational characteristics are coded for each link. These include functional class, facility type, area type, number of lanes, direction (1-way/2-way), access (divided/undivided), and counts. As part of the network requirements for Air Quality Non-Attainment areas, additional network attributes were added, including Annotations, Description and Project ID. The Annotations field usually contains the Letting date (year); Description Field contains a very brief description of any changes that affect that link and the Project ID is an MPO project number tying link changes to current or planned roadway projects. The Edits field usually shows the network year that was first affected by projects or other network changes caused by associated network coding activities, such as split links, realignments, added centroid connectors, etc. Table 2.16 defines the functional classes and facility types found in SAMM.

Table 2.16 Functional Class and Facility Type Definition

Functional Class	Functional Class Description	Facility Type	Facility Type Description
0	Centroid Connectors	0	Centroid Connectors
1	Interstate Freeways	1	Radial IH Freeways (Mainlanes)
1	Interstate Freeways	2	Radial IH Freeways (HOV/Toll Lanes)
1	Interstate Freeways	3	Loop IH Freeways (Mainlanes)
1	Interstate Freeways	4	Loop IH Freeways (HOV/Toll Lanes)
2	Other Freeways	5	Radial Other Freeways (Mainlanes)
2	Other Freeways	6	Radial Other Freeways (HOV/Toll Lanes)
2	Other Freeways	7	Loop Other Freeways (Mainlanes)
2	Other Freeways	8	Loop Other Freeways (HOV/Toll Lanes)
3	Expressways	9	Radial Expressways
3	Expressways	10	Loop Expressways
4	Principal Arterials	11	Principal Arterials (Divided)
4	Principal Arterials	12	Principal Arterials (Cont. Left Turn)
4	Principal Arterials	13	Principal Arterials (Undivided)
5	Minor Arterials	14	Minor Arterials (Divided)

Functional Class	Functional Class Description	Facility Type	Facility Type Description
5	Minor Arterials	15	Minor Arterials (Cont. Left Turn)
5	Minor Arterials	16	Minor Arterials (Undivided)
6	Collectors	17	Collectors (Divided)
6	Collectors	18	Collectors (Cont. Left Turn)
6	Collectors	19	Collectors (Undivided)
7	Frontage Roads	20	Frontage Roads
8	Ramps	21	Ramps (Frontage to Mainlanes)
8	Ramps	22	Ramps (Freeway to Freeway)
8	Ramps	23	HOV/Toll Ramps
9	Transit-Only Links	24	Transit-Only Links

Other link data fields pertain to the four time periods as used in the modeling process. After all of the traffic volumes are filled in for these four time periods, the total daily volumes are calculated by summing all of the time period volumes.

2.5 Transit Network Development

The 2015 transit network was based on the 2015 General Transit Feed Specifications (GTFS) provided by VIA[3]. Along with route alignments, the transit networks include information on stop locations, peak and off-peak headways, as well as mode, base fare, and transfer fare.

Table 2.17 shows the different transit modes considered in SAMM along with their peak and off-peak stop dwell times.

Table 2.17 Transit Modes

Mode	Mode Description	Peak Stop Dwell	Off-peak Stop Dwell
1	Metro Local	0.26	0.32
2	Metro Frequent	0.36	0.42
3	Metro Express	0.34	0.53
4	Metro Skip	0.37	0.58
5	Flex	0.26	0.32
6	Rubber Tire Streetcar	0.37	0.58
7	Modern Streetcar	0.26	0.32
8	Bus Rapid Transit	0.33	0.33
9	Light Rail Transit	0.33	0.33
41	Skip Primo	0.31	0.50

[3] https://www.viainfo.net/developers-resources/

3.0 Trip Generation

Trip generation is the first phase of the traditional four-step travel demand modeling process. It identifies trip ends (productions and attractions) that correspond to places where activities occur, represented by socioeconomic data (households and employment). Trip generation estimates productions and attractions by trip purpose for each TAZ, then balances trips at the regional level so total productions and attractions are equal. The resulting productions and attractions by trip purpose and TAZ are subsequently used by the Trip Distribution model to estimate zone-to-zone travel patterns.

This section describes the trip generation model in SAMM. The trip generation model is a cross-classification model that is run using TxDOT's TripCal5 trip generation modeling software package.

The trip generation model is run for the geographic areas, trip purposes, income groups, household sizes, and number of workers defined in Overview of Model Data. This section discusses TripCal5 implementation and the integration of the TripCal5 procedures into the model stream, and provides the production and attraction trip rates.

3.1 TripCal5

The SAMM4 Trip Generation model (Tripcal5) estimates trip productions and trip attractions (trip ends) by trip purpose for each of the internal TAZs in the region. The various trip purposes as used in the AAMPO models are defined in the Overview of Model Data section.

Note that the trip purposes specified as person trips are processed through the Destination Choice Distribution Model and the Mode Choice Model. Those trip purposes specified as vehicle trips are not processed through the Mode Choice Model.

The Tripcal5 Trip Generation Model is the first step in the modeling process which introduces market segmentation of travel, which is continued into subsequent model steps. This process is used to better describe characteristics of the traveler, based upon data from the traveler's home TAZ. Tripcal5 both estimates and produces zonal trip ends that are disaggregated and reported by income range, persons per household, workers per household and auto sufficiency for all Home-Based trip purposes. This type of household "market segmentation" of travel improves the estimation of trip destinations as well as mode of travel as applied in subsequent model steps.

For the current 2015 base year model and forecasts, there are three separate Tripcal5 runs for each analysis year, including a Tripcal5 for each of Home-Based Work, Non Home-based Visitor/Commuter and then all other trip purposes (except External Through and Non-work Airport). Each of these separate Tripcal5 runs is described as follows:

- Tripcal5 Run for Home-Based Work Person Trips – This model is set up to estimate and report HBW person trip productions by three dimensions (market segments) including income range, household size & workers per household as described in Section 2.1. All of these trip generation strata, including 5 income ranges X 5 household sizes X 3 household worker sizes = 75 specific HBW person trip production rates applied to each of the 1317 internal TAZs within the five-county model. In addition to these TAZ-level demographics (DA1 Records), the HBW Tripcal5 model also relies on an independently estimated Regional Household Distribution (PCR Records) describing the region's households by these same three dimensions. The Regional Household Distribution operates as a regional control total to force the zonal disaggregations to conform to those of the entire five-county region.

The model also estimates HBW person trip attractions, based upon characteristics of each TAZ, including the type of zonal employment and area type (zonal population & employment density). Various HBW person trip attraction rates are applied by these two dimensional strata.

Also, because the HBW trip productions and trip attractions are estimated independently, the Tripcal5 model scales (factors) one total to another (attractions are scaled to productions) so that there will be two and only two HBW trip ends to be exported to the distribution model. The program produces Table 10 which is a summary of the A to P scaling process. Significant differences in trip productions vs. attractions can be a sign of faulty demographic inventories or forecasts, assuming that the trip production & trip attraction rates have been properly calibrated.

- Tripcal5 Run for Non-Home Based (Special) Person Trips – This model is set up to estimate and report zonal NHB Visitor/Commuter person trip productions and attractions based upon zonal area types and activities known to attract this segment of urban travel. This trip purpose is indicated as NHB-Special (NHBS) for travel by regional visitors, commuting workers from outside the region and those attending work conventions. Many of these trips originate and terminate around regional activity centers and special traffic generators. For the San Antonio Region, there is a significant amount of this type of travel occurring on a daily basis, as indicated by Census journey-to-work flows, hotel occupancy rates & the number and size of conventions. For example, in 2015 there were about 600,000 of these NHBS trips occurring on a typical weekday within the region. After the next trip distribution step, the NHBS person trips are combined with regular NHB person trips before being processed by the Mode Choice Model.

- Tripcal5 Run for All Other Person & Vehicle Trip Purposes (Except External Through) – This Tripcal5 Model is set up to individually estimate and report either person or vehicle trip ends for each of the other trip purposes, although for the External-Local vehicle and External-Local Commercial truck, only the internal attraction trip ends are estimated at the TAZ level. External-Local productions are determined by the traffic volume at the External Stations. These are estimated and projected independently of Tripcal5.

  This particular Tripcal5 model also operates in three dimensions and stratifies Home-based productions by household income, household size and urban/rural. The urban/rural stratum was added to provide a way to apply slightly different (lower) trip production rates to rural areas, which are found throughout the five-county region. These TAZs receiving the rural trip rates are identified using the regular area type model formula, which is basically less than one person or one employee per acre. This approach causes a reduction of VMT on the rural roadways, which is consistent with observed traffic volumes. The trip attraction rates are also different for rural and are applied the usual way for various employment types & area types.

  HBSH, HBO, HBED1 and HBED2 (Person Trip Ends) are all generated by Tripcal5 using three dimensions (household income, household size & urban/rural) for trip productions and two dimensions (employment type and area type) for applying person trip attraction rates. Total ED2 trip ends are however estimated independently of Tripcal5 & entered on the TP Control records.

  Internal Non home-based (NHB) Person Trip productions and attractions at the TAZ level are estimated through the application of the NHB trip rates, which are the same for each employment type and area type. Thus for any TAZ the number of NHB trip productions will equal the trip attractions. The overall total NHB trip ends, however, is still controlled by the household distribution of households by the three dimensions within the Tripcal5 model.

Internal Truck and Taxi (TRTX) vehicle trip ends are estimated in Tripcal5 in similar fashion, although the trip end production and attraction rates differ significantly from other trip purposes and are thus much higher for basic employment or industrial/warehouse style facilities. Commercial trucks for this trip purpose are assumed to be larger style trucks with 8,500+ lb gross vehicle weight and having 6+ tires.

Also, for the External-local Commercial truck (EXLO-C) trip purpose, the resulting internal commercial truck attractions are used for the zonal attraction end of the EXLO-C trip productions at the external stations. For regular External-local vehicle trips, Tripcal5 uses NHB trip ends as the attraction end for each TAZ.

Non-work Airport trips are modeled (in reverse) from the Airport TAZ (910) to all other zones. Total non-work airport trips are estimated independently at the production TAZ and zonal airport attractions are estimated using a regression model equation[4] shown in Equation 1. This airport sub-model estimates airport travel at the TAZ level based upon households, income and population/employment densities. Later in the modeling process, the Non-work Airport trip matrix is transposed to convert the travel to the P to A direction.

$$AirTrips_i = 0.69154 * (0.0000942 * Pop_i * \sqrt{HHInc_i} + 0.00925 * Emp_i) \quad (1)$$

Where:

$AirTrips_i$ = Trips destined to the airport produced by TAZ_i

Pop_j = Total population in TAZ_j.

$HHInc_j$ = Household income in TAZ_j.

Emp_j = Total employment in TAZ_j.

And 0.69154 is the scaling factor to match observed 2015 air trips.

The Inputs folder includes a TripGen folder containing TransCAD fixed format binary (*.bin) files containing all data necessary to run TripCal5. The model reads TripCal5 data from the bin files, creates TripCal5 control files (*.fil) files, runs the TripCal5l program, and converts TripCal5 output to TransCAD format for use in destination choice.

The TripCal5 function also requires a modified zonal socioeconomic data input file that has been formatted for use by TripCal5. This file must contain socioeconomic and special generator data as described in Table 3.1.

[4] This model was borrowed from the Austin airport model.

Table 3.1 Required Zone Data Fields

Field Name	Description	Notes
TAZ	TAZ Number	
Internal	Designates internal TAZs	1 for internal zones, null (blank) for external stations.
Acres	TAZ area in Acres	
ATYPE	TAZ Area Type	
COUNTY	County ID	
PARK	Parking cost in dollars	
Pop	Population	
Tot_HH	Total households	
Avg_HH	Average household size	
Med_Income	Median household income	
Special		
0_WORKER, 1_WORKER, 2+WORKER	Number of households by workers	
Tot_Emp	Total employment	Additional copies of each of these fields must be included with the following suffixes: • _HNBW • _NHBS This allows the user to use different employment and enrollment assumptions in trip generation for the named trip purposes.
Basic_Emp	Basic employment	
Retail_Emp	Retail employment	
Service_Emp	Service employment	
ED1	K-12 enrollment	
ED2	University enrollment	
Urban_dist, Rural_dist	Designates urban and rural districts	
SGP_HBW, SGP_NHB SGP_HBNW_RET, SGP_HBNW_OTH, SGP_HBNW_ED1, SGP_HBNW_ED2, SGP_TRTX, SGP_NHBS	Special generator production values	Special generator production values by trip purpose, separated by employment/enrollment category for HBNW
SGA_HBW, SGA_NHB SGA_HBNW_RET, SGA_HBNW_OTH, SGA_HBNW_ED1, SGA_HBNW_ED2, SGA_TRTX, SGA_NHBS	Special generator attraction values	Special generator attraction values by trip purpose, separated by employment/enrollment category for HBNW

Field Name	Description	Notes
SGZ_*	Special generator zone data records	Records must be present with the following suffixes: HH, EMP, BASIC, RETAIL, SERVICE, NHBS, NHBS_ACRE, NHBS_POP, NHBS_HH, NHBS_INC, NHBS_EMP, NHBS_BASIC, NHBS_RETAIO, and NHBS_SERV.
AOP_NHB	NHB add-on productions	
COMMENT, HBNW_CMT, CMT_HBNW, NHBS_CMT, CMT_NHBS	Comment fields	

3.2 Trip Rates

3.2.1 Production Trip Rates

During assignment validation, production rates were factored by income segment (by 20% for low and medium-low income households; 17% for medium income households; and 12% for medium-high and high income households) so that the assigned VMT matched the observed VMT for base year 2015. Table 3.2 shows the factored HBW production trip rates.

Table 3.2 HBW Production Trip Rates

Purpose	Worker	Income Range	HHSize1	HHSize2	HHSize3	HHSize4	HHSize5
HBW	0	1	0	0	0	0	0
HBW	0	2	0	0	0	0	0
HBW	0	3	0	0	0	0	0
HBW	0	4	0	0	0	0	0
HBW	0	5	0	0	0	0	0
HBW	1	1	1.85	1.50	1.59	1.58	1.55
HBW	1	2	1.77	1.53	1.66	1.71	1.69
HBW	1	3	1.51	1.47	1.74	1.84	1.82
HBW	1	4	1.32	1.48	1.74	1.85	1.87
HBW	1	5	1.18	1.51	1.80	1.93	1.95
HBW	2+	1	0	3.85	3.91	4.03	4.49
HBW	2+	2	0	3.60	3.61	3.77	4.24
HBW	2+	3	0	3.22	3.34	3.51	3.85
HBW	2+	4	0	3.04	3.16	3.32	3.65
HBW	2+	5	0	2.93	2.97	3.18	3.54

The NHB purpose is appended to the HBNW production trip rate table in SAMM. Unlike the HBW trip purpose, HBNW trip purposes are not segmented by the number of workers in the household, but rather the area type where the trip is taking place (Table 3.3). The NHBS trip table is prepared externally and fed into the model.

Table 3.3 HBNW Production Trip Rates

Purpose	Urban/Rural	Income Range	HHSize1	HHSize2	HHSize3	HHSize4	HHSize5
NHB	Urban	1	1.32	1.52	1.84	2.88	3.45
NHB	Urban	2	1.66	1.86	2.32	3.28	4.82
NHB	Urban	3	1.85	2.00	2.55	3.59	6.00
NHB	Urban	4	1.98	2.04	2.68	3.93	6.73
NHB	Urban	5	2.10	2.11	2.87	4.18	7.55
NHB	Rural	1	1.32	1.52	1.84	2.88	3.45
NHB	Rural	2	1.66	1.86	2.32	3.28	4.82
NHB	Rural	3	1.85	2.00	2.55	3.59	6.00
NHB	Rural	4	1.98	2.04	2.68	3.93	6.73
NHB	Rural	5	2.10	2.11	2.87	4.18	7.55
HBSH	Urban	1	1.29	1.86	2.14	2.47	3.27
HBSH	Urban	2	1.33	1.93	2.25	2.73	3.51
HBSH	Urban	3	1.32	1.85	2.37	2.81	3.61
HBSH	Urban	4	1.33	1.81	2.38	2.81	3.67
HBSH	Urban	5	1.36	1.83	2.42	2.87	3.78
HBSH	Rural	1	0.77	1.29	1.48	1.67	2.40
HBSH	Rural	2	0.89	1.47	1.75	2.19	2.91
HBSH	Rural	3	0.97	1.49	1.97	2.35	3.10
HBSH	Rural	4	1.01	1.49	2.05	2.49	3.24
HBSH	Rural	5	1.04	1.51	2.10	2.55	3.43
HBO	Urban	1	1.12	1.28	1.60	1.79	2.46
HBO	Urban	2	1.13	1.40	1.68	1.91	2.68
HBO	Urban	3	1.09	1.40	1.75	1.94	2.89
HBO	Urban	4	1.07	1.43	1.73	7.99	3.12
HBO	Urban	5	1.11	1.49	1.80	2.08	3.23
HBO	Rural	1	0.72	0.76	1.09	1.24	1.75
HBO	Rural	2	0.78	1.02	1.28	1.50	2.21
HBO	Rural	3	0.79	1.07	1.40	1.58	2.50
HBO	Rural	4	0.81	1.18	1.48	1.73	2.87
HBO	Rural	5	0.85	1.23	1.54	1.82	2.97
HBED1	Urban	1	0.03	0.46	3.31	4.11	8.37

Purpose	Urban/Rural	Income Range	HHSize1	HHSize2	HHSize3	HHSize4	HHSize5
HBED1	Urban	2	0.03	0.37	2.50	4.00	7.98
HBED1	Urban	3	0.03	0.29	2.00	3.73	7.19
HBED1	Urban	4	0.03	0.19	1.49	3.53	6.78
HBED1	Urban	5	0.03	0.18	1.40	3.43	6.68
HBED1	Rural	1	0.02	0.25	3.11	3.9	8.17
HBED1	Rural	2	0.02	0.16	2.29	3.80	7.77
HBED1	Rural	3	0.02	0.09	1.80	3.53	7.00
HBED1	Rural	4	0.02	0.05	1.29	3.34	6.59
HBED1	Rural	5	0.02	0.03	1.21	3.24	6.48

3.2.2 Attraction Trip Rates

The attraction model in SAMM is a cross-classification regression designed for estimating trip rates stratified by area type and employment type. Table 3.4 shows the trip attraction rates by employment and area types in SAMM.

Table 3.4 Trip Attraction Rates by Employment and Area Type

Trip Purpose	Area Type	Basic Employment	Retail Employment	Service Employment	Education Employment 1	Education Employment 2
Home-Based Work (HBW)	CBD	1.360	1.060	1.320	1.310	1.310
	CBD Fringe	1.270	1.040	1.430	1.090	1.090
	Urban	1.220	1.080	1.360	1.140	1.140
	Suburban	1.220	1.070	1.390	1.170	1.170
	Rural	1.000	1.070	1.220	1.220	1.220
Home-Based Non Work Retail (HBSH)	CBD	-	3.000	-	-	-
	CBD Fringe	-	6.390	-	-	-
	Urban	-	6.980	-	-	-
	Suburban	-	7.580	-	-	-
	Rural	-	8.380	-	-	-
Home-Based Non Work Other (HBO)	CBD	0.637	-	1.000	-	-
	CBD Fringe	0.533	-	1.660	-	-
	Urban	0.416	-	1.590	-	-
	Suburban	0.351	-	1.710	-	-
	Rural	0.286	-	2.520	-	-

Trip Purpose	Area Type	Basic Employment	Retail Employment	Service Employment	Education Employment 1	Education Employment 2
Home-Based Non Work Education 1 (HBED1)	CBD	-	-	-	25.960	-
	CBD Fringe	-	-	-	26.550	-
	Urban	-	-	-	27.680	-
	Suburban	-	-	-	29.320	-
	Rural	-	-	-	30.680	-
Home-Based Non Work Education 2 (HBED2)	CBD	-	-	-	-	-
	CBD Fringe	-	-	-	-	-
	Urban	-	-	-	-	-
	Suburban	-	-	-	-	-
	Rural	-	-	-	-	-
Non Home-Based (NHB)	CBD	0.842	5.500	0.940	6.160	6.156
	CBD Fringe	0.778	5.486	1.000	4.920	4.925
	Urban	0.691	4.900	1.180	3.830	3.834
	Suburban	0.616	4.690	1.270	2.440	2.441
	Rural	0.518	3.845	1.140	1.190	1.188

4.0 Trip Distribution

Trip distribution is the second phase of the traditional four step travel model. Trip distribution is the process through which trip productions and attractions from the trip generation model are apportioned between all zone pairs in the modeling area. The resulting trip table matrix contains both intrazonal trips (i.e., trips that do not leave the zone) on the diagonal and interzonal trips in all other zone interchange cells for each trip purpose.

SAMMV4 uses a destination choice model to distribute trips among zones. Although more input-intensive than gravity models, destination choice models are found to be better suited to capture the change in choices resulting from congestion because they reflect the impacts of the time and distance impedances between zones.

4.1 Estimation

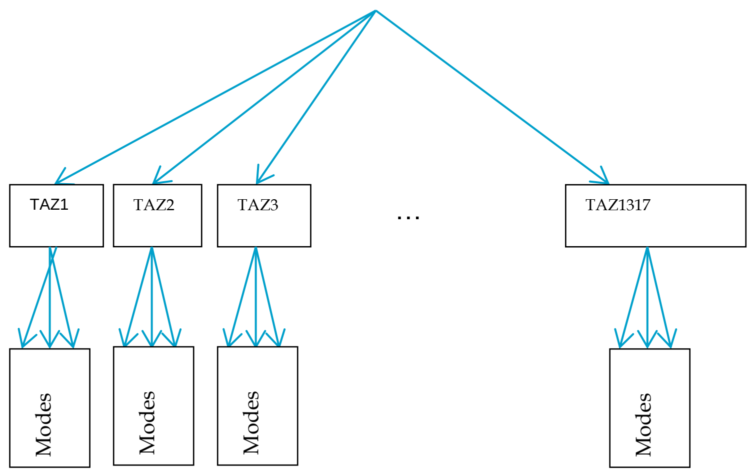
Three destination choice models were estimated by trip purpose, including HBW, HBNW, and NHB. The HBW model uses income groups to segment certain variables while the HBNW model includes additional purpose segmentation across specific variables, based on the HBNW sub-purposes (ED1, ED2, shopping, and other).

4.1.1 Relationship to Mode Choice

A key variable in the destination choice model is the mode choice logsum. The logsum is computed from the mode choice model estimated coefficients. More precisely, the logsum is equal to the natural logarithm of the generating function of the nested logit models used for mode choice. The mode choice logsum is computed once for each destination zone. The logsum represents the maximum expected utility associated with the mode alternatives for each destination alternative. In this sense, it is a measure of accessibility for a zone.

In another sense, it can be viewed as a nested logit model with the mode choice model (as shown in Figure 4.1), where below each zonal destination alternative, the mode alternatives are nested. The model is equivalent to a nested logit model when the mode choice logsums are used as explanatory variables in the destination choice model. The coefficient associated with the logsum variable is equivalent to the nesting coefficient of the model, and therefore, is bounded between 0 and 1 (as is the case with any nested logit model).

Figure 4.1 Nested Structure of Destination-Mode Model



4.1.2 Choice Set

All zones in the region are considered alternatives in the model. However, there is one exception to this in that for HBNW and NHB trips, the airport zone is considered an invalid destination option. This is because non-work airport trips are generated as a specific trip purpose at the zonal level (AIR). Therefore, other non-work trips (i.e., HBNW and NHB trips) must be non-airport trips and airport non-work trips have a predetermined destination. Airport work trips, on the other hand, are not generated as a specific purpose, and thus, the airport zone is treated as a valid destination option in the HBW model.

4.1.3 Size Function Specification

Destination choice models include several zonal variables like employment which are best represented by size functions. These size functions measure attractiveness of a zone for a given trip. The attractiveness depends on the zone's size, that is, its capacity for accommodating the stop's activity purpose. The size function consists of several utility-like terms that are combined in the utility function in a form that corresponds with utility theory for aggregate alternatives. A size function is used instead of a single size variable because the defined activity purposes and size attributes do not have a simple one-to-one correspondence. Rather, several attributes can indicate capacity for accommodating a given purpose. For example, personal business could be conducted at many types of places, such as restaurants, stores, or office buildings. The estimated coefficients give different weights to different size variables for a given purpose, and a scale parameter captures correlation among elemental activity opportunities within zones.

In a typical multinomial logit (MNL) choice model, there is only a utility function, which measures the quality of each choice alternative. In a destination choice model, in addition to a utility function, a size function is also included, which measures the quantity of the alternative. This is important because zones are not created equal in terms of the opportunity in each zone. The opportunity contained within each zone is measured by the number of jobs and/or population in the zone (and sometimes zonal area). So even if a zone is very attractive in terms of utility, if the zone contains no jobs, the size function ensures the zone will not be chosen. The model specification can be written as follows:

$$W_j = V_j + S_j \tag{2}$$

$$V_j = \beta X_j \tag{3}$$

$$S_j = \ln\left(\exp(\gamma) Z_j\right) \tag{4}$$

$$P_j = \frac{\exp(W_j)}{\sum \exp(W_k)} \tag{5}$$

Here, P_j is the probability of choosing zone *j*; V_j is the typical utility function with utility coefficients, β, and variables, X_j; and S_j is the size function with parameters, γ, and size variables, Z_j. The fact that the parameter vector associated with the size variables is exponentiated, each size variable has a positive contribution to the size function, which makes sense given that its purpose is to measure the quantity of or opportunity in a zone. Lastly, for statistical identification, one of the size coefficients must be constrained. As is typical, this coefficient is constrained to zero (equal to one after taking the exponent) in each of the models, and the associated variable is referred to as the base or reference size variable.

4.1.4 Input Variable Formulations

Utility Variables

- Mode Choice Logsum – as described earlier.
- Travel distance
  - Some segmentation by trip purpose and income used.
  - Piecewise linear distance representation - The effect of distance is always linear, but the slope of the distance curve changes based on distance. We have found that a piecewise linear specification is useful in model calibration.
- Intrazonal indicator
  - This variable takes value of 1 if the destination zone is the same as the origin zone.
- Airport zone indicator
  - This variable is used only in the HBW model, where the airport zone is a valid zonal alternative.
  - This is important to ensure we generate a reasonable number of airport trips for the HBW purpose.

Size Variables

- Employment by type
  - Basic, Retail, Service, ED1, and ED2
- Population
- Zonal Area

- Some size variables are only used for specific trip purposes. For instance, ED1 and ED2 trips use only ED1 and ED2 employment, plus population in the size function. Retail trips use only basic, retail, and service employment, and HBW trips do not use zonal area.

4.1.5 HBW Model

Mode choice logsum: The mode choice logsum coefficient was estimated to be 0.82, well within the range of 0 and 1 that the behavioral theory requires. Moreover, the value should provide a great deal of sensitivity to level of service changes.

Travel distance: The distance variable is negative. For low income households and households of size 2 or less, the distance effect is slightly more negative, suggesting these households typically travel shorter distances. The piecewise linear variables mean that the slope of the distance curve changes at 5, 15, and 35 miles. Specifically, the slope lessens at each of these benchmark distances. The base distance curve for HBW trips is shown in Figure 4.2.

Intrazonal indicator: All else being equal, the positive coefficient on the intrazonal indicator suggests that the production zone is more likely to be chosen as the attraction zone than other zones in the region. For high income households, the intrazonal indicator is slightly negative (since the high income coefficient is additive to the base coefficient).

Airport zone indicator: The airport indicator is used to ensure the airport attracts the correct number of HBW trips, and is positive as we would expect.

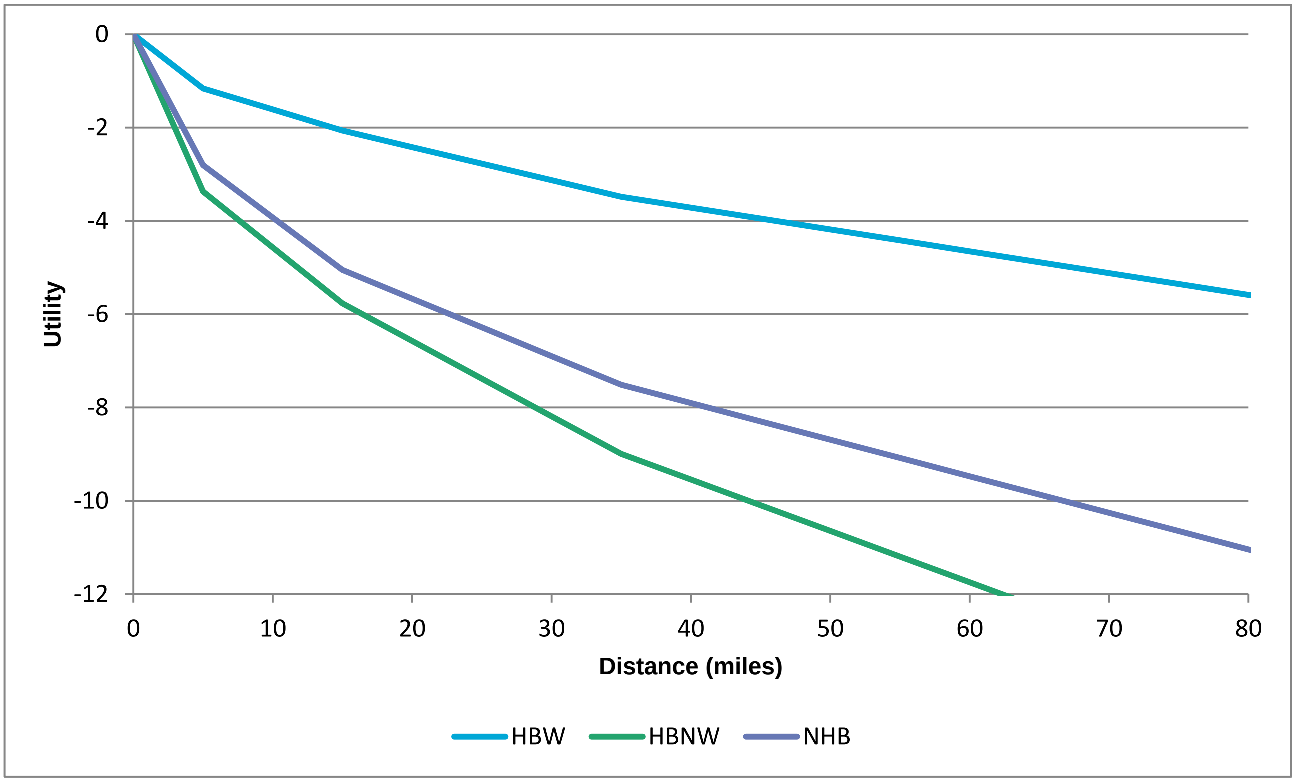
Size variables: The size variables are segmented by two aggregate household income segments – low/medium combined and high income. Both these segments use an identical base/reference variable: basic employment. In order to understand the relative impacts of specific size variables on HBW destination choice, the coefficients cannot simply be compared to one another, but must also be compared against regional totals for each zonal size variable. In doing so, we can compare low/medium income effects relative to high income effects. Relative to low/medium income households, high income households are much more likely to hold ED2 or service jobs, slightly less likely to hold ED1 jobs, and much less likely to hold basic or retail employment jobs.

The estimation results for the HBW Model are in Table 4.1.

Table 4.1 HBW Model Estimation Results

Variable	Coeff.	t-stat
Mode Choice Logsum	0.822	5.6
Distance - All	-0.2319	-9.5
Distance - Low Income	-0.0167	-2.7
Max (Distance-5, 0)	0.1414	5.5
Max (Distance-15, 0)	0.0196	1.7
Max (Distance-35, 0)	0.0241	1.1
Distance - Hhsize <= 2	-0.0120	-2.0
Airport Zone - All	-0.014	0.0
Airport Zone - High Income	0.787	2.2
Airport Zone – Veh>=HH Size	0.481	1.4
Intrazonal – All	1.324	9.1
Intrazonal - High Income	-2.016	-4.8
Intrazonal – Veh>=HH Size	0.524	2.5
Log Size Multiplier	1.000	Constrained
Basic Employment	0.000	Constrained
Population - Low/Med Income	-2.356	-17.0
Retail - Low/Med Income	0.229	1.8
Service - Low/Med Income	-0.431	-3.6
ED1 - Low/Med Income	0.944	6.0
ED2 - Low/Med Income	-1.269	-2.5
Population - High Income	-1.511	-4.0
Retail - High Income	0.523	1.2
Service - High Income	1.362	4.2
ED1 - High Income	1.470	3.1
ED2 - High Income	1.001	2.1
Observations	8,145	
LL at Zero	-21409.6	
LL at Convergence	-18161.9	
Rho Squared	0.152	

Figure 4.2 Base Distance Curves for Each Destination Choice Model



4.1.6 HBNW Model

Mode choice logsum: The mode choice logsum coefficient, like the home-based work model, was estimated to be between 0 and 1 at 0.35.

Travel distance: The distance variable is highly negative and varies by trip purpose. Moreover, the slope of the distance curve (like HBW model) changes at 5 miles, 15 miles, and 35 miles. The base distance curve for HBNW trips is shown in Figure 4.2. (Note that the distance curve for ED2 trips is constrained to always be non-positive, despite what the individual piecewise linear coefficients suggest. See Figure 4.3 for more detail.)

Intrazonal Indicator: All else being equal, the positive coefficient on the intrazonal indicator suggests that the production zone is more likely to be chosen as the attraction zone than other zones in the region.

Size Variables: Each trip purpose uses a different set of size variables.

- ED1 trips use ED1 employment as the base/reference size variable. The only other size variable is population, with very small effect relative to the ED1 employment effect.
- ED2 trips use ED2 employment as the base/reference size variable. Population and retail employment are also used in the size function for this trip purpose, each with relatively small effect, relative to ED2 employment.
- Retail trips use basic employment as the base/reference size variable. The positive coefficient associated with retail employment suggests that each retail job in a zone has a greater impact on that

zone's choice than does basic employment. Service employment has slightly lesser effect here than basic employment.

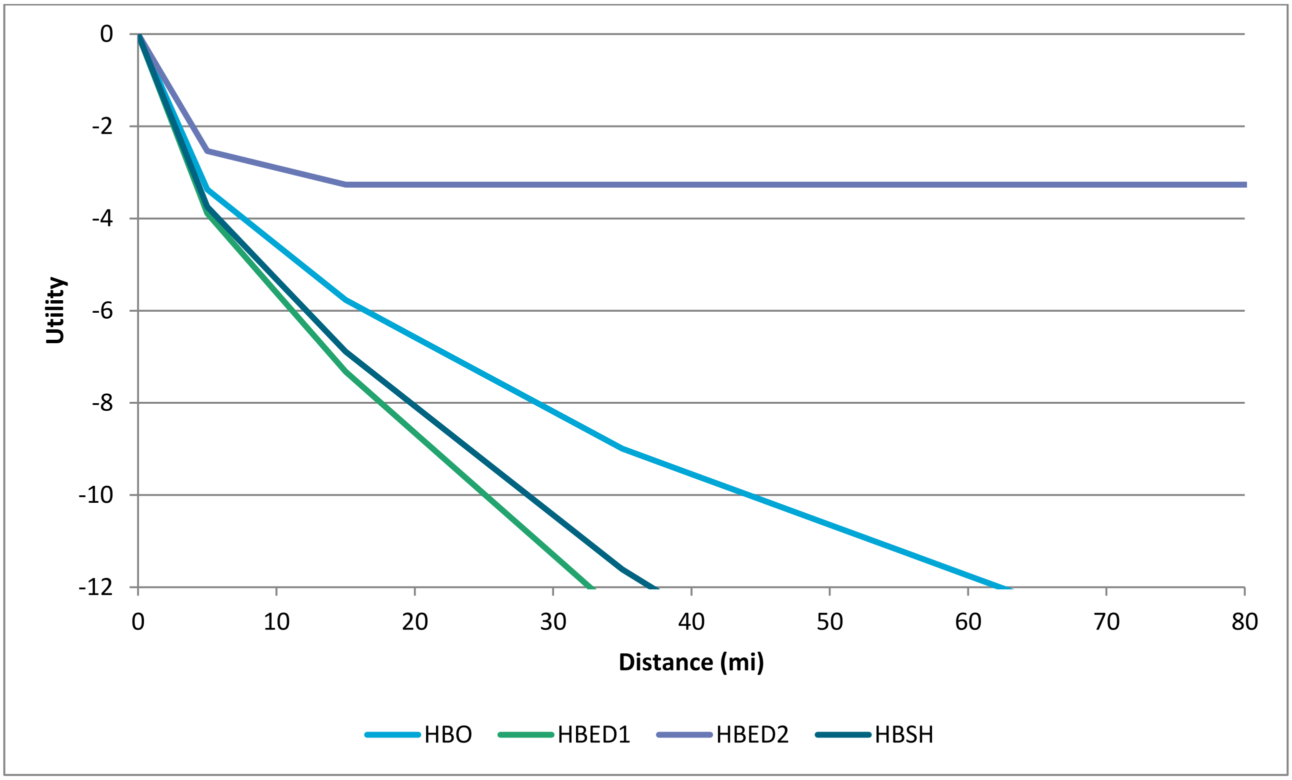
- Other trips use basic employment as the base/reference size variable. The positive coefficients associated with retail, service, and ED1 employment mean that each job of these types has larger impact on other purpose destination choice than does basic employment. Zonal area and population are also size variables for this trip purpose.

The estimation results for the HBNW Model are in Table 4.2.

Table 4.2 HBNW Model Estimation Results

Variable	Coeff	t-stat
Mode Choice Logsum	0.346	4.8
Distance - All	-0.674	-62.1
Max (Distance-5, 0)	0.434	34.1
Max (Distance-15, 0)	0.078	8.3
Max (Distance-35, 0)	0.051	2.3
Distance - ED1	-0.104	-12.4
Distance - ED2	0.167	9.9
Distance - Retail	-0.075	-12.3
Intrazonal - All	0.732	12.2
Intrazonal - Low Income	0.474	6.8
Intrazonal - ED1	-0.148	-1.6
Intrazonal - Retail	-0.368	-3.5
Intrazonal – Veh>=HH Size	-0.150	-1.8
Log Size Multiplier	1.000	Constrained
ED1 Emp - ED1	0.000	Constrained
Population - ED1	-4.408	-60.5
ED2 Emp - ED2	0.000	Constrained
Population - ED2	-4.971	-20.7
Retail Emp - ED2	-2.122	-11.1
Basic Emp - Ret	0.000	Constrained
Retail Emp - Ret	2.859	10.9
Service Emp - Ret	-0.453	-1.4
Basic Emp - Oth	0.000	Constrained
Population - Oth	-0.200	-0.9
Retail Emp - Oth	1.995	8.5
Service Emp - Oth	0.789	3.3
ED1 Emp - Oth	3.346	14.7
Zonal Area - Oth	-1.381	-5.1
Observations	18,636	
LL at Zero	-71191.6	
LL at Convergence	-47765.8	
Rho Squared	0.329	

Figure 4.3 Base Distance Curves by HBNW Purpose



4.1.7 NHB Model

Mode choice logsum: Unlike the HBW and HBNW models, the estimated logsum coefficient for NHB trips was negative, and thus, had to be constrained. In this case, since the estimated value was negative, we decided to constrain to a low value, and chose the HBNW estimated value as an approximate benchmark. The value was constrained to 0.3 in the final model, only slightly lower than the HBNW estimated logsum coefficient.

Travel distance: The distance variable is highly negative and the slope of the distance curve changes (increases) at 5, 15, and 35 miles, as shown in Figure 4.2.

Intrazonal Indicator: All else being equal, the positive coefficient on the intrazonal indicator suggests that the production zone is more likely to be chosen as the attraction zone than other zones in the region.

Size Variables: The NHB model uses a full complement of zonal variables in the size function. The large coefficient on retail employment and on ED1 employment seems reasonable, due to the nature of NHB trips (e.g., drop off or pick up children at school between work and/or meal and shopping trips).

The estimation results for the NHB Model are in Table 4.3.

Table 4.3 NHB Model Estimation Results

Variable	Coef	t-stat
Mode Choice Logsum	0.300	Constrained
Distance - All	-0.561	-42.1
Max (Distance-5, 0)	0.336	18.8
Max (Distance-15, 0)	0.101	8.1
Max (Distance-35, 0)	0.045	1.6
Intrazonal - All	0.929	17.0
Log Size Multiplier	1.000	Constrained
Basic Employment	0.000	Constrained
Population	-0.358	-1.4
Retail Employment	2.266	8.6
Service Employment	0.181	0.6
ED1 Employment	2.947	11.1
ED2 Employment	0.329	0.8
Zonal Area	-0.389	-1.3
Observations	7,189	
LL at Zero	-32756.6	
LL at Convergence	-23892.2	
Rho Squared	0.271	

4.2 Calibration

The expanded 2005 HTS was used to calibrate the estimated destination choice constants by trip purpose. Table 4.4 - Table 4.6 show the new destination choice constants, calibrated to match trip length frequency distributions by trip purpose versus the estimated constants.

Table 4.4 HBW Model Calibration Results

Variable	Estimated Coeff.	Calibrated Coeff.
Mode Choice Logsum	0.822	0.822
Distance - All	-0.2319	-0.2319
Distance - Low Income	-0.0167	-0.0167
Max (Distance-5, 0)	0.1414	0.0727
Max (Distance-15, 0)	0.0196	0.1106
Max (Distance-35, 0)	0.0241	-0.0856
Distance - Hhsize <= 2	-0.0120	-0.0120
Airport Zone - All	-0.014	-0.014
Airport Zone - High Income	0.787	0.787
Airport Zone – Veh>=HH Size	0.481	0.481
Intrazonal – All	1.324	1.324
Intrazonal - High Income	-2.016	-2.016
Intrazonal – Veh>=HH Size	0.524	0.524
Log Size Multiplier	1.000	1.000
Basic Employment	0.000	0.000
Population - Low/Med Income	-2.356	-2.356
Retail - Low/Med Income	0.229	0.229
Service - Low/Med Income	-0.431	-0.431
ED1 - Low/Med Income	0.944	0.944
ED2 - Low/Med Income	-1.269	-1.269
Population - High Income	-1.511	-1.511
Retail - High Income	0.523	0.523
Service - High Income	1.362	1.362
ED1 - High Income	1.470	1.470
ED2 - High Income	1.001	1.001

Table 4.5 HBNW Model Calibration Results

Variable	Estimated Coeff.	Calibrated Coeff.
Mode Choice Logsum	0.346	0.346
Distance - All	-0.674	-0.674
Max (Distance-5, 0)	0.434	0.4852
Max (Distance-15, 0)	0.078	-0.0229
Max (Distance-35, 0)	0.051	0.1693
Distance - ED1	-0.104	-0.104
Distance - ED2	0.167	0.167
Distance - Retail	-0.075	-0.075
Intrazonal - All	0.732	0.732
Intrazonal - Low Income	0.474	0.474
Intrazonal - ED1	-0.148	-0.148
Intrazonal - Retail	-0.368	-0.368
Intrazonal – Veh>=HH Size	-0.150	-0.150
Log Size Multiplier	1.000	1.000
ED1 Emp - ED1	0.000	0.000
Population - ED1	-4.408	-4.408
ED2 Emp - ED2	0.000	0.000
Population - ED2	-4.971	-4.971
Retail Emp - ED2	-2.122	-2.122
Basic Emp - Ret	0.000	0.000
Retail Emp - Ret	2.859	2.859
Service Emp - Ret	-0.453	-0.453
Basic Emp - Oth	0.000	0.000
Population - Oth	-0.200	-0.200
Retail Emp - Oth	1.995	1.995

Table 4.6 NHB Model Calibration Results

Variable	Estimated Coeff.	Calibrated Coeff.
Mode Choice Logsum	0.300	0.300
Distance - All	-0.561	-0.561
Max (Distance-5, 0)	0.336	0.289
Max (Distance-15, 0)	0.101	0.237
Max (Distance-35, 0)	0.045	-0.314
Intrazonal - All	0.929	0.929
Log Size Multiplier	1.000	1.000
Basic Employment	0.000	0.000
Population	-0.358	-0.358
Retail Employment	2.266	2.266
Service Employment	0.181	0.181
ED1 Employment	2.947	2.947
ED2 Employment	0.329	0.329
Zonal Area	-0.389	-0.389

Calibration was an iterative process that updated the constants for distance by bin (0-5 miles, 5-15 miles, 15-35 miles) with 35+ miles serving as the base. AIR and HBNW constants are the same. This assumption is consistent throughout the model because it is expected that AIR trips best resemble HBNW trips and there was not sufficient data to calibrate separate constants for the AIR trips.
As shown in Figure 4.5- Figure 4.10, the model compares very well to the expanded survey data across all trip purposes with regard to both trip length frequency distribution and attractions by area type.

Figure 4.4 shows the geographic distribution of the different area types defined in the model.

Figure 4.4 Destination Choice Area Type Classifications

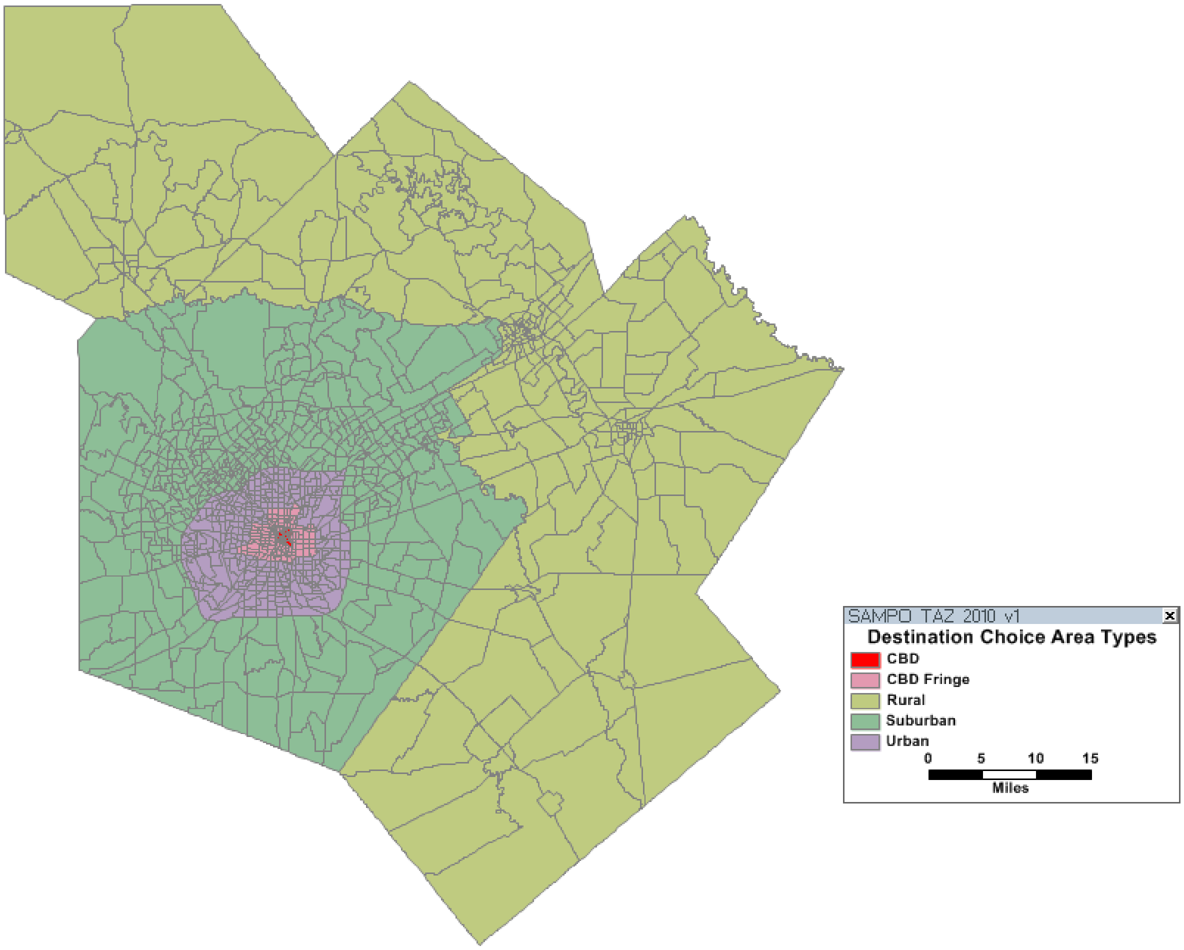


Figure 4.5 HBW Trip Length Frequency Distribution

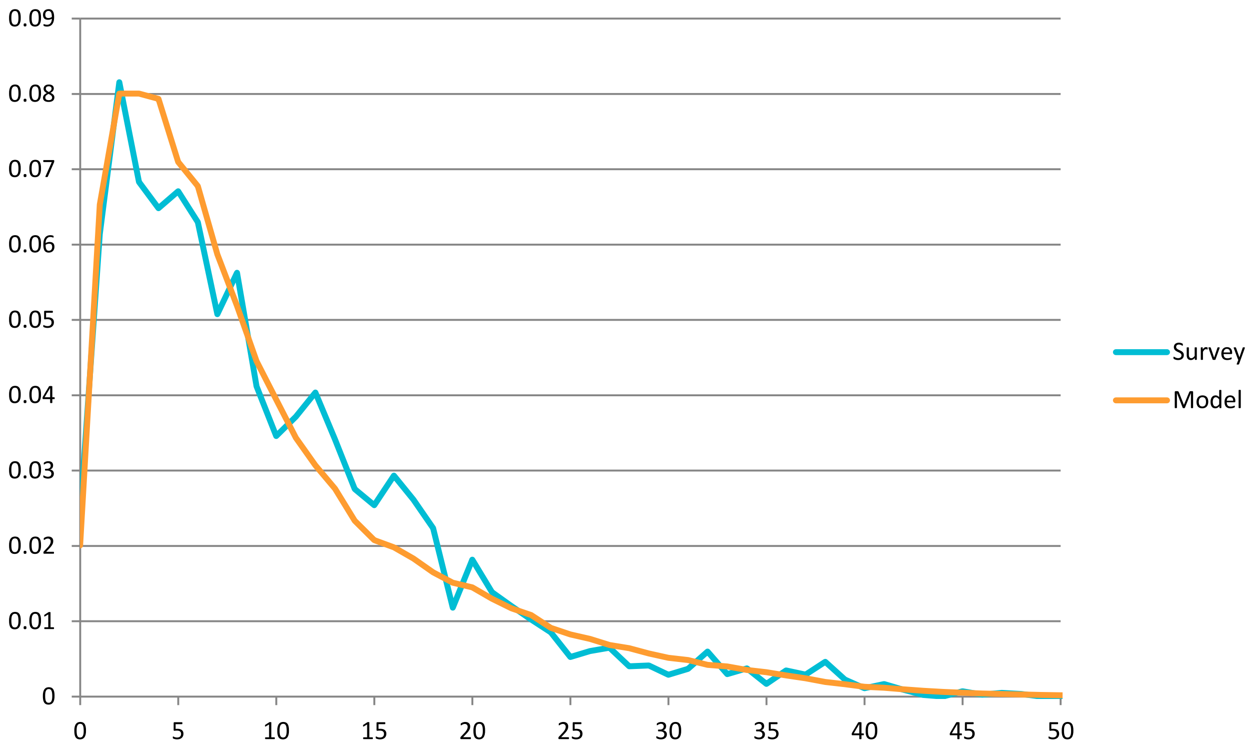


Figure 4.6 HBW Attractions by Area Type

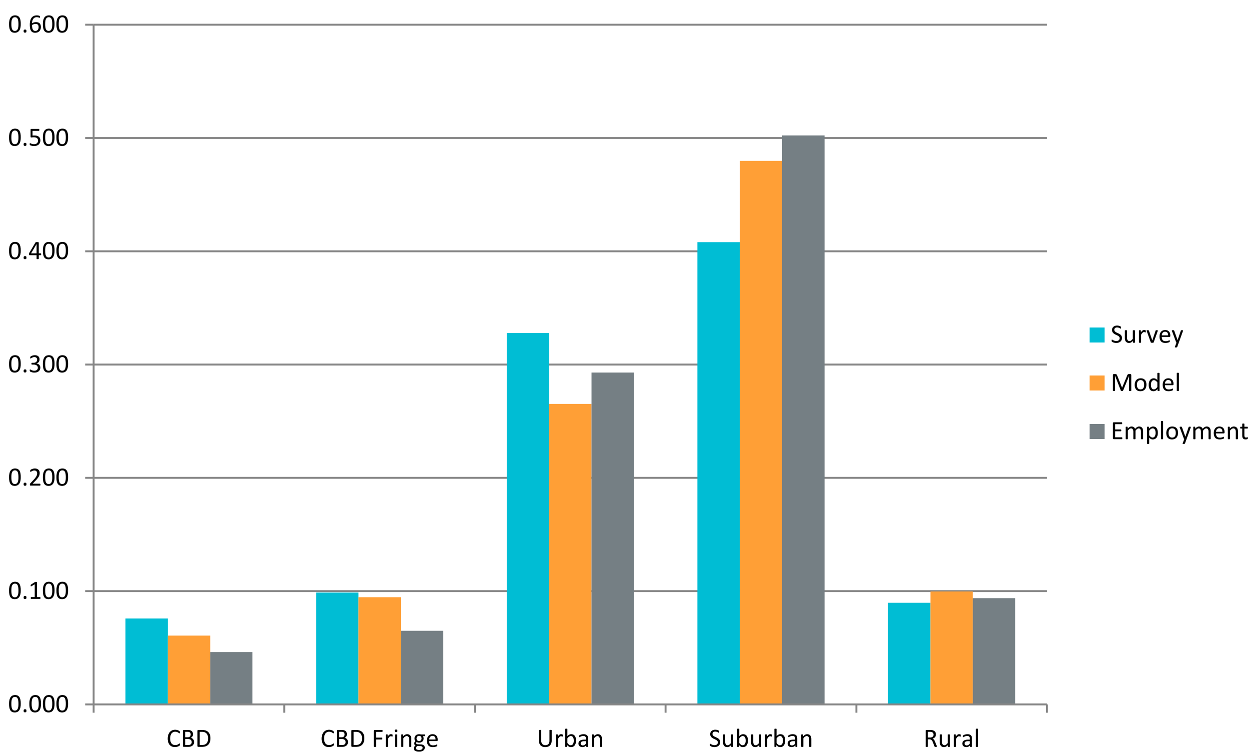


Figure 4.7 HBNW Trip Length Frequency Distribution

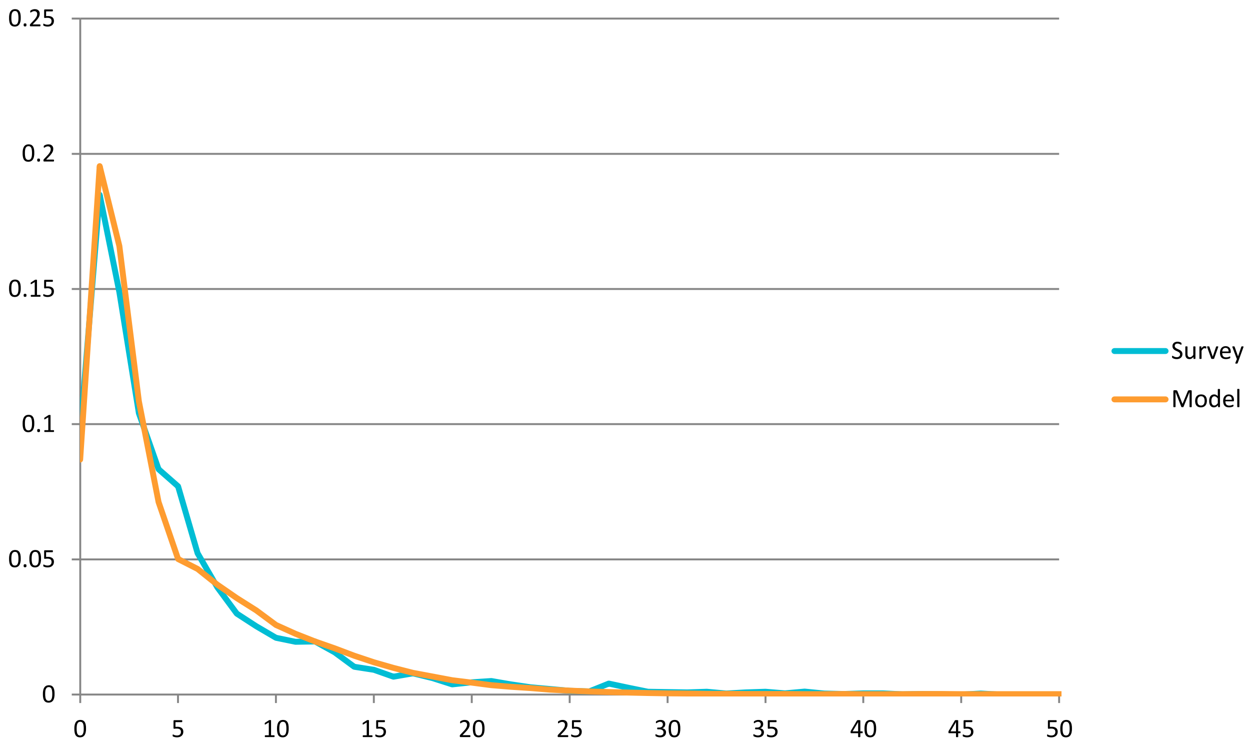


Figure 4.8 HBNW Attractions by Area Type

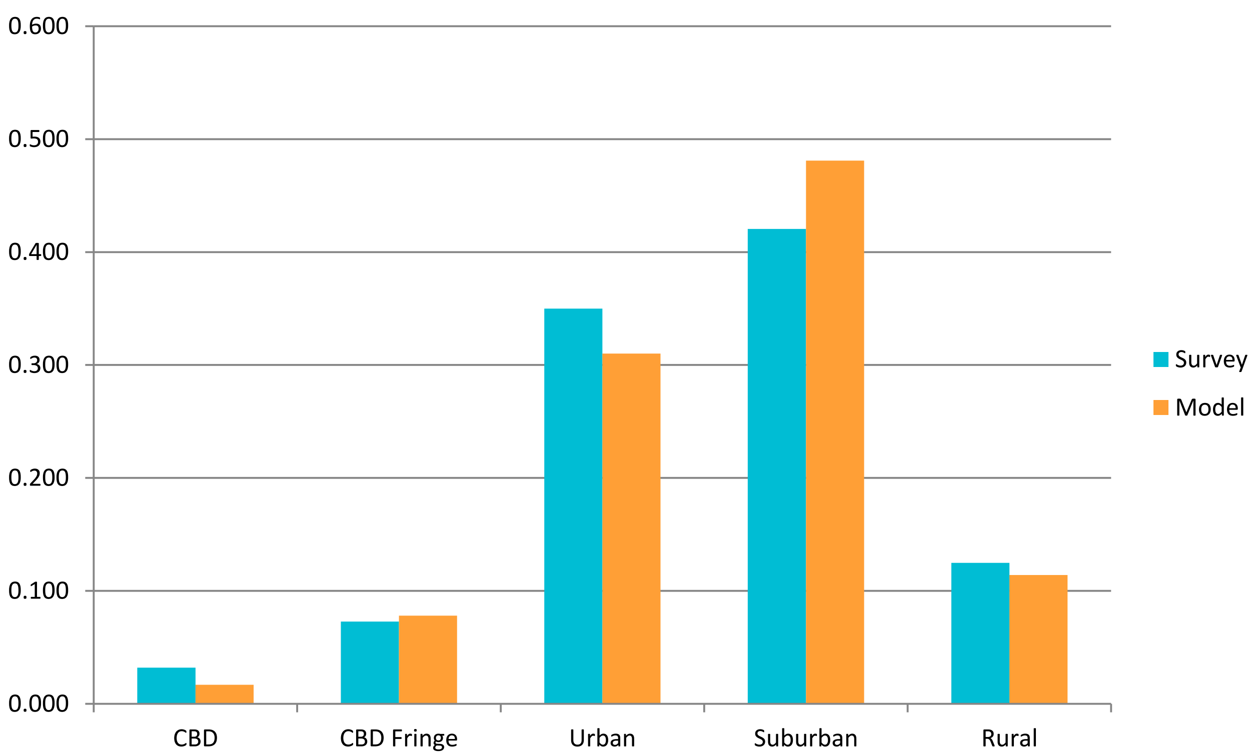


Figure 4.9 NHB Trip Length Frequency Distribution

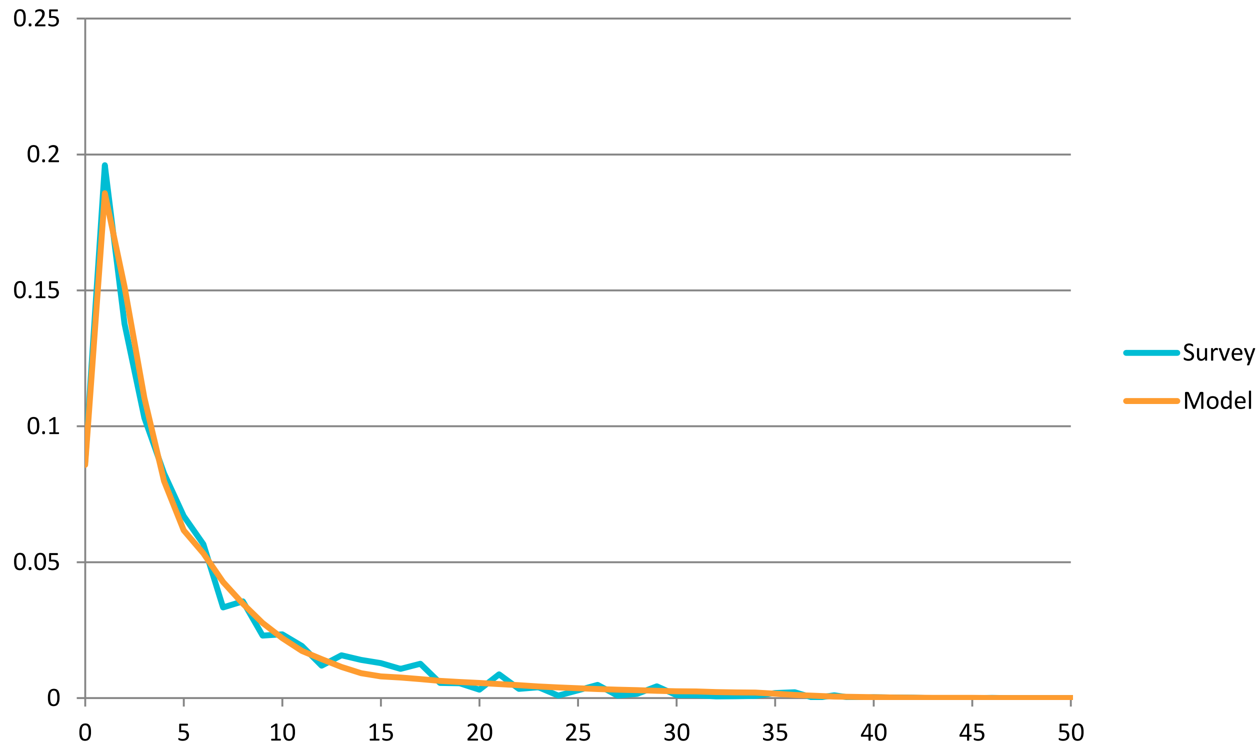
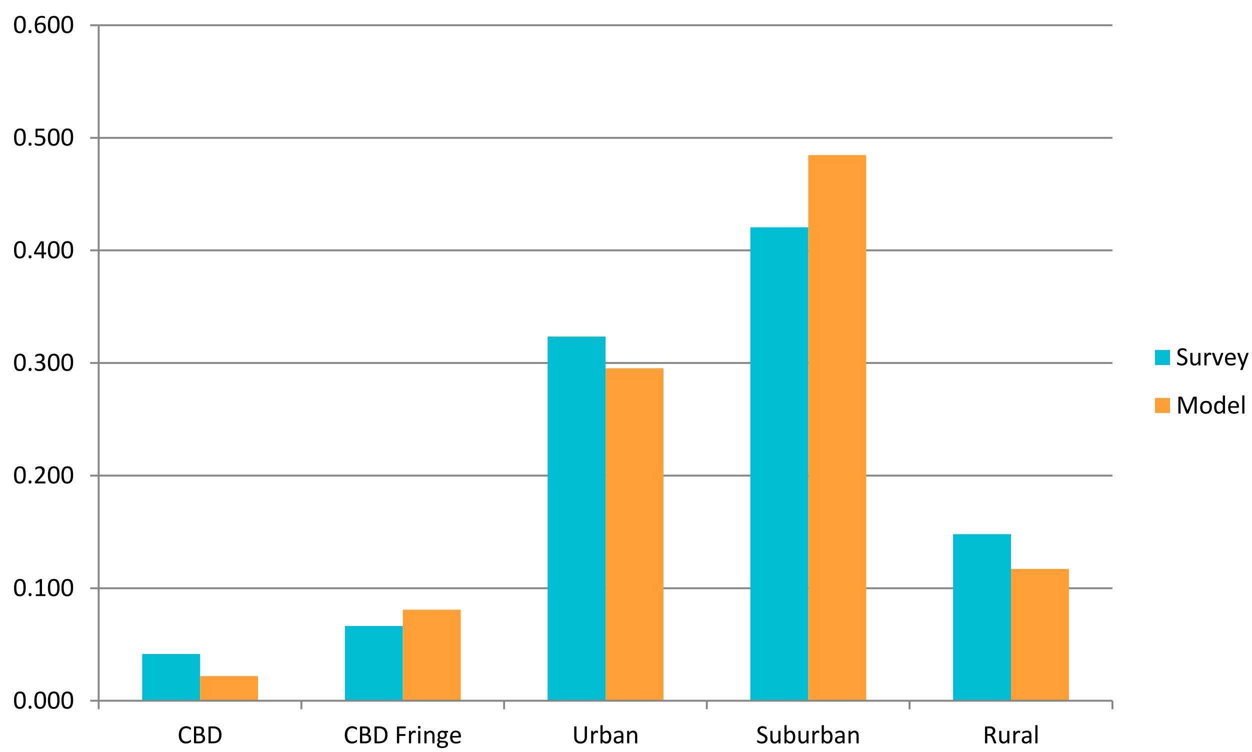


Figure 4.10 NHB Attractions by Area Type



For HBW trips, modeled worker flows were compared to the CTPP data, based on the 2006-2010 5-year ACS data. Figure 4.11-Figure 4.13 show how modeled worker flows between aggregate sectors (see Figure

2.3 for map of aggregate sectors) compare to the CTPP and expanded survey. Group A includes all TAZs within I-410 and the northern group of TAZs bounded between I-410, Route 1604, Route 151, and I-10. Group B includes all other TAZs within Bexar County plus a portion of southern Comal County up to New Braunfels. Group C includes the rest of Comal County, Guadalupe County, Kendall County, and Wilson County. Overall the model flows between aggregate sectors match pretty closely to the observed data. As Figure 4.11 shows, the model matches CTPP and survey data flows well for trips produced within or near downtown (i.e. Group A). Figure 4.12 indicates that flows produced in Group B may be under predicting flows toward downtown but over predicting flows farther out when compared to CTPP, however they match up more closely to survey data. Figure 4.13 shows that the model over predicts the number of people who travel from the outer portions of the AAMPO region (i.e. Group C) into locations closer to downtown (i.e. Group A).

Figure 4.11 HBW Flows Between Aggregate Sectors - Group A Productions

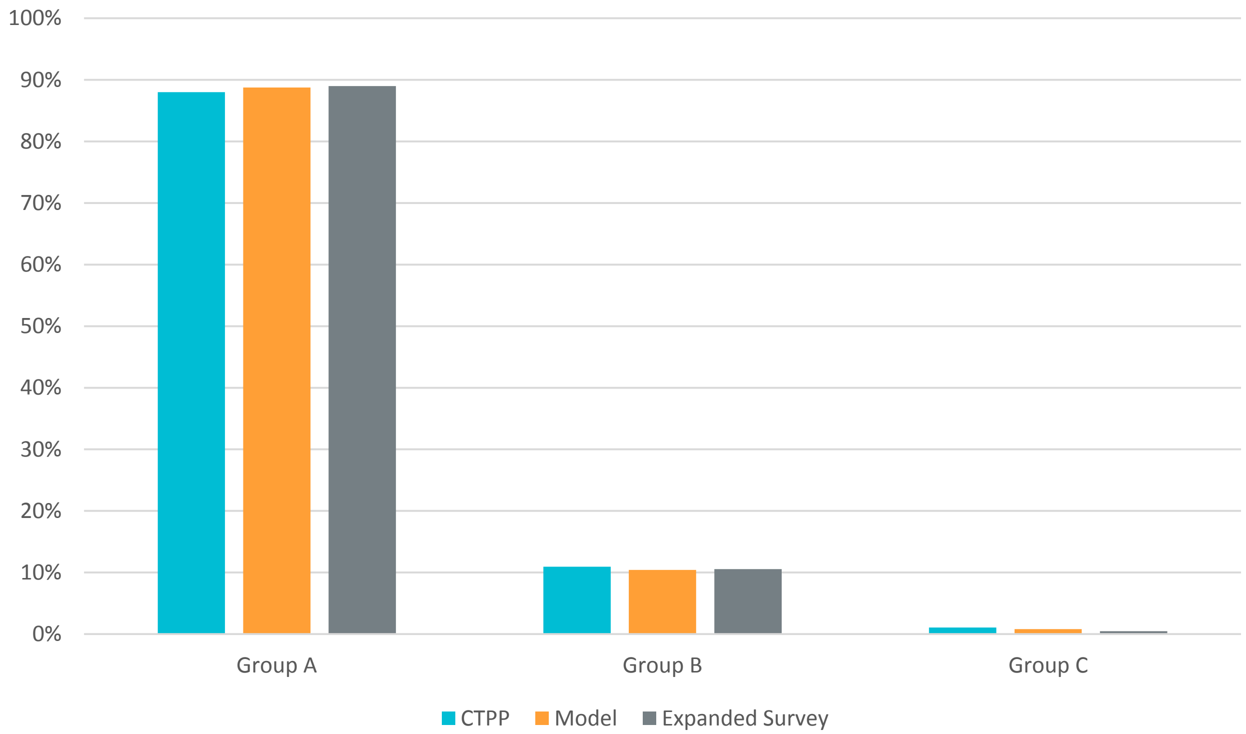


Figure 4.12 HBW Flows Between Aggregate Sectors - Group B Productions

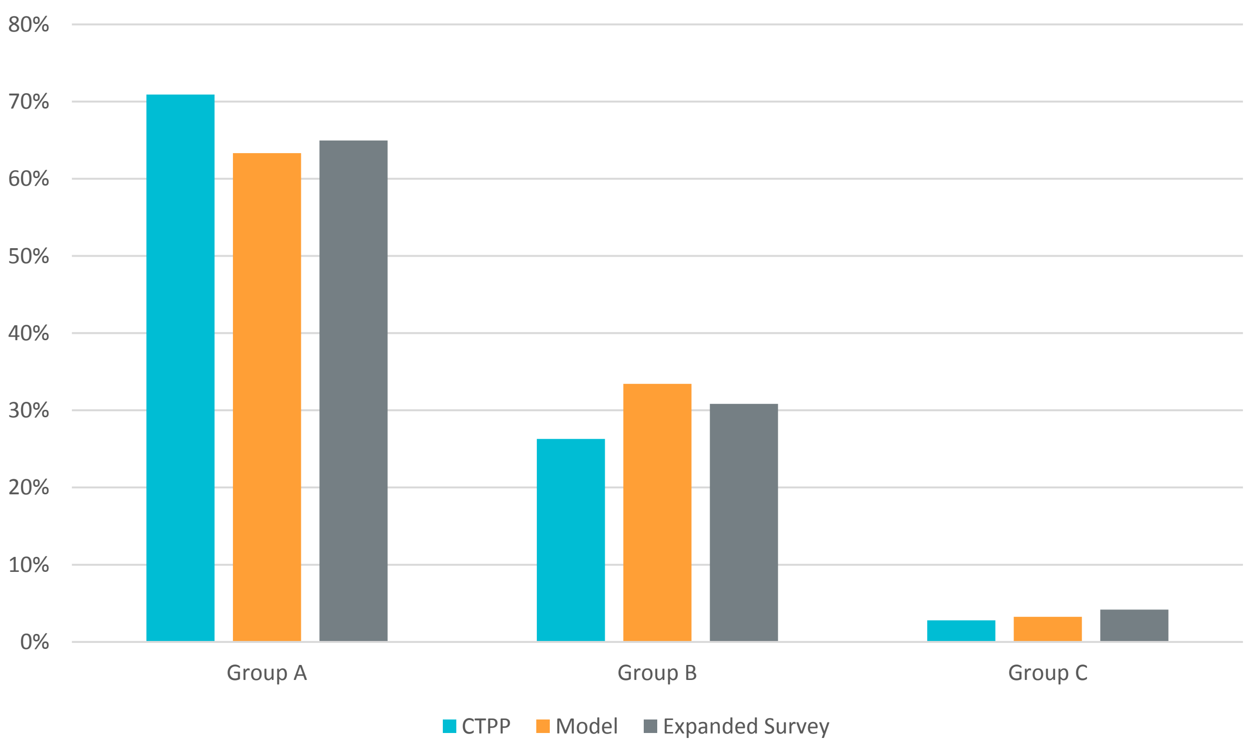
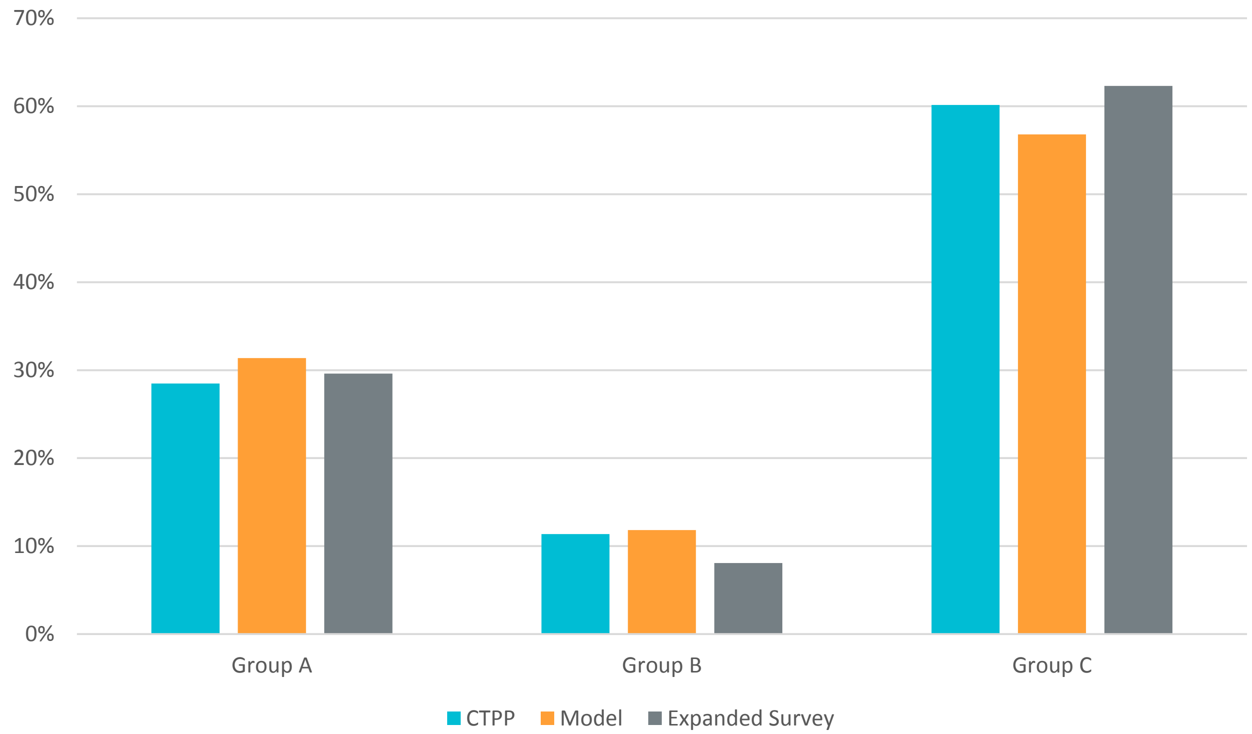


Figure 4.13 HBW Flows Between Aggregate Sectors - Group C Productions



5.0 Vehicle Availability Model

This section describes the vehicle availability model used to estimate vehicle sufficiency at the household level. The model was developed using the 2005 household travel survey as the estimation data set.

5.1 Model Structure

The vehicle availability model was developed as a discrete choice model with five alternatives:

- 0-vehicles available;
- 1-vehicle available;
- 2-vehicles available;
- 3-vehicles available; and
- 4-vehicles or more available.

Three discrete choice model formulations or structures were considered for the vehicle availability model: 1) the multinomial logit (MNL) model, 2) the ordered response logit (ORL) model, and 3) the nested logit (NL) model.

The ORL model is specifically suited for choice contexts where the alternatives follow some natural ordering, as is the case for vehicle availability. Whereas MNL treats each alternative distinctly and estimates the coefficients of linear (latent) utility functions specific for each alternative, ORL assumes a single latent function (modeled as a linear function of explanatory variables, similar to MNL) measuring the propensity for a household to own vehicles. The higher the latent variable for a specific household, the more likely it is for that household to own a higher number of vehicles.

Experience in vehicle availability modeling shows that the ORL model usually provides a slightly better statistical fit than the MNL model. The NL structure generally shows no advantage. The model results presented here are from the ORL model specification.

The vehicle availability model runs along three segments: household size, household income group, and number of workers in a household.

5.2 Estimation

The estimation dataset is based on the 2005 household travel survey. The onboard transit survey was not used in estimation because it does not include household worker information. The number of workers in the household is a significant explanatory variable for vehicle availability because work trips are typically made regularly and tie up a car for the day. Distinct household records were extracted from the household travel survey so that each surveyed household is represented once in the data set. The validated highway and transit skims were then attached to the merged survey dataset and used to calculate accessibilities and transit availability, as discussed below. The observations were expanded according to the expansion factor from the household survey.

5.2.1 Variables

The following variables were used in the vehicle availability model.

Theta Values

Theta values are specified for (5-1) = 4 alternatives, where the 0-vehicle alternative is held as the base. These theta values are intercepts but work in the opposite direction; that is, they measure the difficulty of moving from one alternative to another. Having access to 4+ vehicles has the highest difficulty (2.92) compared to any other alternatives as shown in Table 5.1. These theta values represent the breakpoints, at which moving across transitions the household from one level of vehicle availability to the next. For instance, if a household's simulated propensity to own vehicles was -6.0, that household would be assigned 0 vehicles since the breakpoint between owning 0 and 1 vehicle is greater than -6.0. If the simulated propensity to own vehicles was 0.0, the household would be assigned 2 vehicles since 0.0 is between theta2 and theta3.

Table 5.1 Theta Values

Alternatives	Variable	Coefficients	Relative Difference
1-veh	theta1	-5.53	n/a
2-veh	theta2	-1.87	3.66
3-veh	theta3	1.05	2.91
4+-veh	theta4	2.92	1.87

Household Characteristics

The household characteristic variables available for estimation are limited to those variables that are generated by TripCal5, which includes income, household size, and number of workers. Therefore the following household characteristic variables were tested:

- Household size, segmented by income; and
- Household workers, segmented by income.

Location Attributes of the Household Zone

These variables include highway and transit accessibility variables and zonal density variables:

- Presence of transit stops within walking distance of the home zone segmented by household income;
- Mixed use density at the home zone which is captured in the form of *LN[1 + (Population + 2.21 * Employment) / Acres]* segmented by household income;
- Ratio of highway and transit accessibility to various employment types segmented by household income. This is computed as follows:

$$A_i = \ln\left(1 + \sum_j TotEmp_j \times \exp^{-20 \times T_{ij}/\hat{T}_i}\right) \quad (6)$$

$$\hat{T}_i = (\sum_j T_{ij}) / J \quad (7)$$

Where:

A_i = Auto accessibility during the peak hours for TAZ_i

$TotEmp_j$ = Total employment in TAZ_j.

T_{ij} = Peak auto travel time from TAZ_i to TAZ_j.

J = Total number of TAZ_i to TAZ_j pairs.

$$TR_i = \ln\left(1 + \sum_j TotEmp_j \times R_{ij} \exp^{-20 \times S_{ij}/\hat{S}_i}\right) \quad (8)$$

$$\hat{S}_i = (\sum_j R_{ij} \times S_{ij}) / K \quad (9)$$

Where:

TR_i = Transit accessibility during the peak hours for TAZ_j.

R_{ij} = 1 if TAZ_i to TAZ_j has transit access, 0 otherwise.

S_{ij} = Peak non-park-and-ride transit total travel time from TAZ_i to TAZ_j.

K = Total number of TAZ_i to TAZ_j pairs having transit access.

$$Acc_i = TR_i/(1 + A_i) \quad (10)$$

Where:

Acc_i = Ratio of transit accessibility during the peak hours to auto accessibility during the peak hours

5.2.2 Estimation Findings

The estimation results are presented in Table 5.2. Some of the key findings of the vehicle availability model estimation are as follows:

- All else being equal, higher income households have higher propensity to own vehicles.
- Household size and number of workers both have positive impacts on the vehicle availability propensity.

- Mixed use density in the home zone has a negative relationship to the propensity to own vehicles, which makes sense since mixed use density measures the overall density of the home zone and the mix of population and employment in the zone.

- The ratio of transit accessibility to auto (highway) accessibility has an opposite effect on the propensity to own vehicles, which means that as the transit accessibility goes up, vehicle availability decreases. This is logical and consistent with findings in other areas.

The vehicle availability alternatives can be combined in application or interacted with the household size to create a vehicle sufficiency variable. Unfortunately, the vehicle availability model results cannot be interacted with household workers, although it is generated by TripCal5, because the number of workers is not available in the Transit Onboard survey data. The transit survey data is critical in the mode choice model estimation; therefore worker information cannot be used in estimation.

Table 5.2 Vehicle Availability Model Estimation Results

	Segment	Coeff	St. Err.	t-stat
Thetas	1	-5.529	0.017	-330.9
	2	-1.867	0.015	-123.7
	3	1.046	0.015	70.3
	4	2.917	0.016	187.4
Income group constants	inc2	0.357	0.013	28.2
	inc3	0.938	0.013	69.5
	inc4	1.490	0.013	111.2
	inc5	1.673	0.014	121.6
Household size	1 person	-2.596	0.01	-265.4
	2 people	-0.534	0.007	-76.3
	3 people	-0.016	0.008	-2.1
Household workers	0 workers	-0.994	0.008	-118.6
	1 worker	-0.915	0.007	-135.8
Mixed Use density	All	-0.215	0.003	-74.6
Ratio of transit to highway access to total employment	Income < $20K	-2.326	0.044	-52.4
N		2000		
Expanded		641,485		
Final LL		-647,591		
LL(0)		-1,032,430		
Rho square		0.373		

5.3 Calibration

Table 5.3 shows the calibrated theta values in the vehicle availability model.

Table 5.3 Vehicle Availability Model Calibration Results

	Segment	Estimated Coeff.	Calibrated Coeff.
Thetas	1	-5.529	-5.397
	2	-1.867	-1.735
	3	1.046	1.177
	4	2.917	3.049
Income group constants	inc2	0.357	0.357
	inc3	0.938	0.938
	inc4	1.490	1.490
	inc5	1.673	1.673
Household size	1 person	-2.596	-2.596
	2 people	-0.534	-0.534
	3 people	-0.016	-0.016
Household workers	0 workers	-0.994	-0.994
	1 worker	-0.915	-0.915
Mixed Use density	All	-0.215	-0.215
Ratio of transit to highway access to total employment	Income < $20K	-2.326	-2.326

6.0 Mode Choice Model

SAMMV4 produces and distributes all person trips. The mode choice models separate the resulting person trip tables into the drive alone, shared ride (i.e., carpool), transit (walk access and drive access), and non-motorized (bicycle and walk) modes. Roadway and transit networks provide important input to the mode choice model.

6.1 Estimation

The estimation dataset was created by merging the auto and non-motorized observations from the 2005 household travel survey with the transit observations from the onboard transit survey. There were very few transit observations from the 2005 household survey (99 out of 18,000 records) which did not distinguish transit access mode nor the type of bus (express or local). These were not included in the dataset. The validated highway and transit skims were then attached to the merged survey dataset.

The observations were weighted according to the shares from the household survey and the total weights equals the total number of household survey records.

6.1.1 Weighting Survey Observations

When estimating most discrete choice models using choice based data or enriched sample data (as we are using the combined household survey data and the transit onboard surveys), it is necessary to use weighted exogenous sampling maximum likelihood (WESML) estimation techniques. The weighted estimation techniques correct for the biases in alternative specific constants (ASC) that are introduced by the nonrandom combined data source[5]. For WESML, the weight for each observation is the fraction of the population choosing the alternative selected by the decision maker divided by the corresponding fraction in the entire sample[6].

As the mode choice models are estimated using the nested logit model structure, it is necessary to employ the WESML estimation, and to develop observation-specific weights. The fraction of the sample choosing each modal alternative is derived from the enriched dataset we prepared from combining the household survey trip data and the transit onboard survey data.

6.1.2 Market Segmentation

- Trip purpose and income segmentation is done according to the model design plan
- Constants for HBNW sub-purposes (Retail, Other, ED1, ED2) were tested and significant estimators were retained.
- Education trip purposes are expected to favor non-motorized modes with ED1 also favoring shared ride modes.

[5] An exception to the weighting requirement is the case where multinomial logit models are being employed. For these models, standard ESML estimation techniques may be employed without biasing the alternative-specific constants.

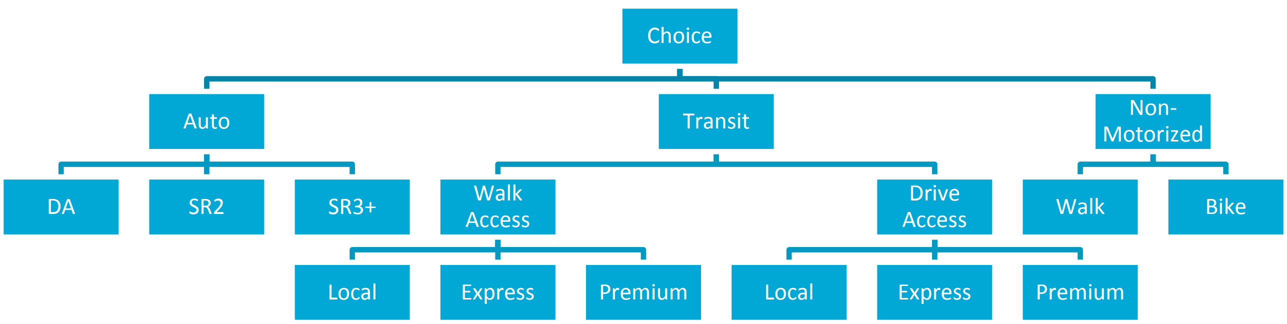
[6] See Moshe Ben-Akiva and Steven Lerman, *Discrete Choice Analysis* (MIT Press, 1985), Chapter 8 for a complete discussion of the sampling issues.

- Shopping is expected to not favor non-motorized or transit modes due to the need to carry things home.
- Constants for NHB Other and airport-bound trips were tested and significant estimators retained.

6.1.3 Model Formulation

Figure 6.1 describes the structure of the nested logit mode choice model. The three main choices are whether to complete a trip using auto, transit or non-motorized modes. Each of these three main options have sub-modes that a person trip is then assigned to.

Figure 6.1 Nested Logit Mode Choice Model Structure



6.1.4 Mode Availability

Vehicle availability

SOV is only available if there is at least one vehicle in the household. There are 8 survey records with SOV mode and zero vehicles in the household, these records are not used in estimation.

Non-motorized mode distances

The walk and bike modes are not necessarily true alternatives as trip distance increases. Making non-motorized modes available for all trips will likely bias the distance coefficient and/or the ASC.

The distribution of walk trips in Figure 6.2 shows that more than 90 percent of the observations are less than 3 miles and 95 percent are less than 4 miles. A reasonable walking speed assumption is 3 mph so a maximum walk time of 80 minutes is asserted (4 miles).

The distribution of bike trips in Figure 6.3 shows that more than 95 percent of the observations are less than 3 miles and 95 percent are less than 5 miles. The longest observed bike trip has a skim distance of 13.3 miles. A maximum bike distance of 16 miles is asserted based on the assumption of a similar maximum travel time as walking (80 minutes) and a 12 mph bike speed.

Figure 6.2 Walk Distance Distribution in Survey

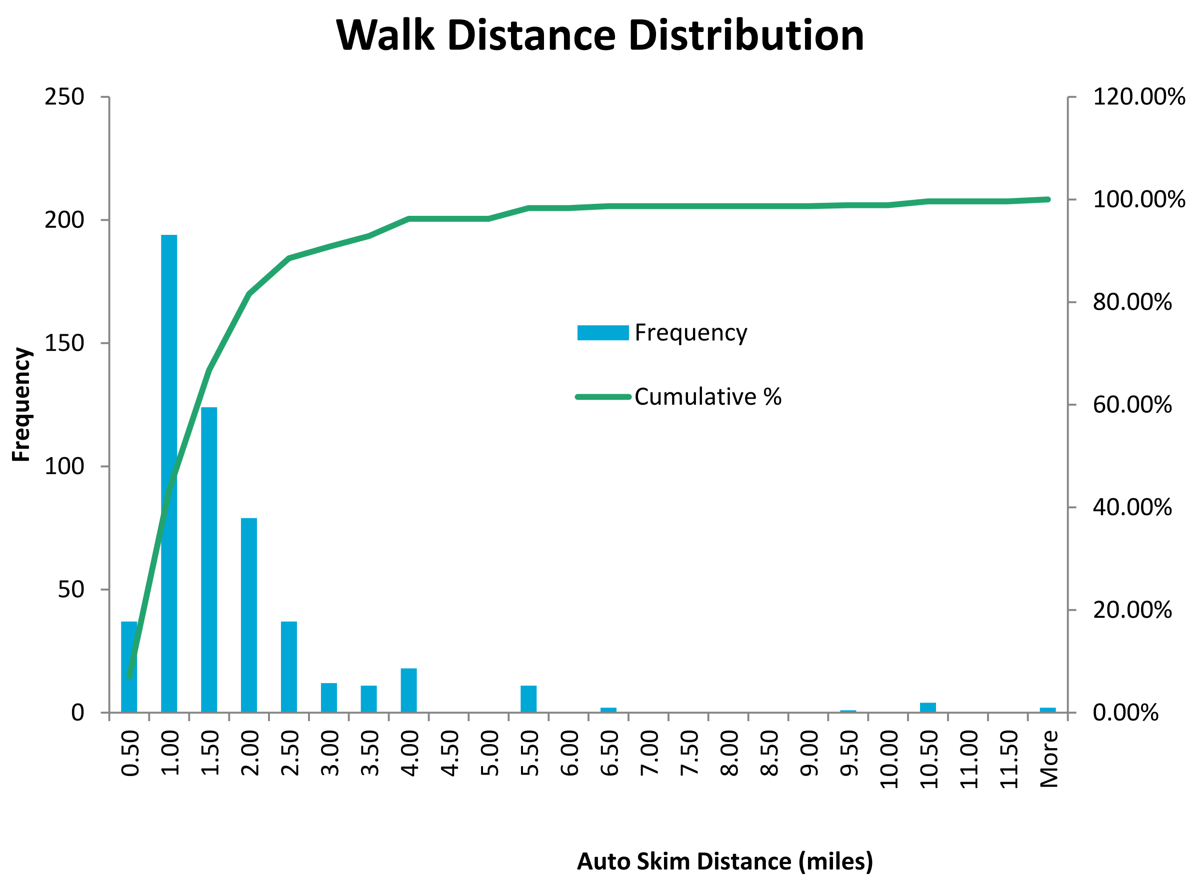
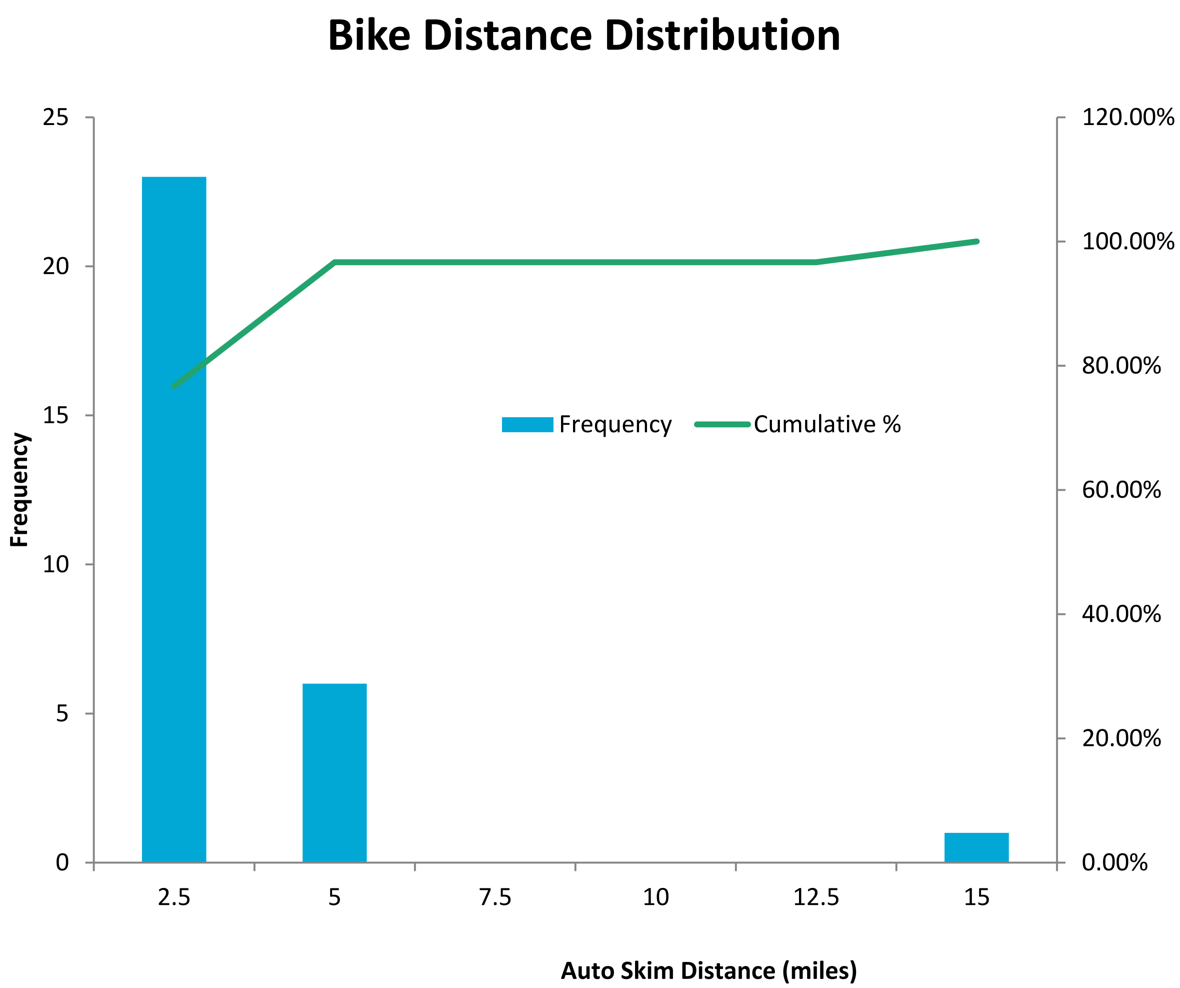


Figure 6.3 Bike Distance Distribution in Survey



Transit

Transit alternatives are only available if there is a path in the transit skim.

6.1.5 Input Variable Formulations

Level of Service

- Initial estimation did not find a reasonable OVT to IVT coefficient ratio, therefore the ratio is constrained to 2.5 to be consistent with FTA guidelines.
- Drive-access time is weighted equally with IVT.
- A separate coefficient for OVT of 9 minutes was implemented to represent users timing the transit schedule for longer headway services.

- A coefficient for the number of transfers was estimated to represent the additional inconvenience of changing services above and beyond the walking and waiting time.

Cost

The cost variable is in 2015 cents and consists of the following components:

- $0.15 / mile of auto operating (SOV, SR2, SR3, EXD, LCD)
- Parking costs from 2015 model divided by 2
- Transit fares (2015$)

Initial estimation for HBW and HBNW yielded reasonable cost coefficients only for a couple of income groups. That is, the cost coefficient was either positive or the sensitive to cost did not vary inversely with income. Therefore, some of the cost coefficients had to be constrained to values of time ranges derived from available wage rates for the San Antonio region. Based on available literature, the mode choice values of time are about 50 to 75 percent of the average wage rates in a region for home-based work trips. The home-based non work values of time are about half that of the work trips. These assumptions were used in deriving ranges of values of times to be used or constrained in the mode choice model estimation process.

NHB and airport trips are not segmented by income group, so the cost coefficient represents the average value of time across all income groups. The estimated NHB cost coefficients for non-airport and airport trips yielded a value of time that was higher than expected given the wage rates for the San Antonio-New Braunfels area. The NHB non-airport cost coefficient is constrained so that the value of time is half that for HBW trips. The NHB airport cost coefficient is constrained so that the value of time is equal to HBW trips.

Other Variables Tested

Travel during peak. Our assumption is that peak travel would be more likely to use non-SOV modes, in particular shared ride and transit. Shared ride is expected more in the peak travel times because more trips are being made in the peak so the potential for coordinated travel should be higher. Transit systems are often designed for peak service in ways that the skims may not completely represent.

Household Size: Smaller households (<=2 members) are assumed to be less likely to use multi-occupant modes and more likely to use transit. Multi-occupant modes may be harder to organize from smaller households. Transit may be more attractive to smaller households because they are less likely to include children in the household and hence are less sensitive to being constrained by transit schedules.

Attraction zone density factor: Higher density attraction zones are expected to promote non-SOV modes because of the higher congestion, walkability, and transit service. The density factor is calculated as:

*(Population + 2.21 * Employment) / Acres*

Income Specific Constants: HBW and HBNW are segmented by income. We expect that lower income travelers may have less availability of vehicles and thus be more likely to use public transit or to carpool. Conversely, higher income travelers would have higher vehicle availability and be more likely to drive alone.

Household vehicle ownership: The number of vehicles in the household are expected to be directly correlated to the propensity to use auto modes over transit or non-motorized modes. Households with zero vehicles should be significantly more likely to take transit or non-motorized models. Similarly, households with fewer vehicles than household members are also expected to be more likely to use transit and/or non-motorized although not to the same degree as zero-vehicle households. Model formulations with both the number of vehicles and the relationship between vehicles and household members as input variables were tested. Unfortunately, the 2010 transit onboard did not record the number of household workers therefore the relationship between household vehicles and number of workers could not be estimated.

6.1.6 Model Specifications

For a previous version of SAMM, several rounds of model estimation were carried out that involved different mode structures, nesting structures, various explanatory variables, and combination of LOS and SED variables for the three trip purposes. The best models were chosen based on the sign and magnitude of the variables, t-statistics of each variable, and the overall model fit. The models are specified at the bottom level in contrast to other models that are typically specified at the top level. The effective value of the parameters is derived by scaling by the nesting coefficients. The estimated models have since been calibrated and refined to demonstrate reasonable sensitivities to input variables. The resulting mode choice coefficients are specified in Table 6.1, Table 6.2, and Table 6.3.

Home-Based Work

- **Income Specific Constants**: As expected, shared ride and transit modes are more attractive to low-income (income < $35,000) travelers as indicated by the positive coefficients. Similarly, shared ride and transit modes are less attractive to higher income (income > $50,000) travelers. Walk is also less attractive to higher income travelers.

- **Household Vehicles:** The model estimates imply that shared ride and walk to transit modes are much more attractive to households with zero vehicles, as expected. Conversely, drive alone and drive to transit are more attractive to households with 'sufficient' vehicles (at least as many vehicles as household members - up to 4 vehicles).

- **Household Size:** Significant coefficients were estimated for small households (<=2 members) and shared ride modes. The shared ride mode coefficients are negative, as expected.

- **Density Factor:** A significant positive coefficient was estimated on the attraction zone density factor for transit drive access and bike modes.

- **In-Vehicle Travel Time:** The estimated value for in-vehicle time had a smaller magnitude than the FTA recommended range of -0.020 to -0.030 so the coefficient is constrained to an effective value of -0.020.

- **Non-Motorized Distance:** Travelers are more sensitive to walk distance than bike distance, which reflects the faster bike travel speed.

Table 6.1 HBW Mode Choice Estimation Results

	Variable	Coeff.	St. Err.	t-stat
Level Of Service				
	generalized time and cost	-0.0495	0.000	const
	travel distance (bike)	-1.0201	0.133	-5.1
	travel distance (walk)	-3.3619	0.604	-3.7
Nest Coefficients				
	theta12	0.8		const
	theta23	0.5		Const.
Effective Level Of Service				
	generalized time (2.5 OVT/IVT)	-0.0198		
	OVTT	-0.0495		
	travel distance (bike)	-0.4080		
	travel distance (walk)	-1.3447		
VOT				
	All	VOT		Cost Coeff.
	Income 1	$ 5.05		-0.5885
	Income 2	$ 7.20		-0.4125
	Income 3	$ 10.10		-0.2942
	Income 4	$ 16.59		-0.1790
	Income 5	$ 21.51		-0.1381
Model Fit				
	Observations		8106	
	Log Likelihood at Zero		-4684.0	
	Log Likelihood at Convergence		-1268.1	
	Rho-Squared		0.73	

Home-Based Non-Work

- **HBED1 Purpose Specific Constants:** HBED1 travelers are more likely to use shared ride, non-motorized, and transit modes than HBO travelers. This is reasonable considering that school trips are made by young people who may not be able to drive and that the trips are short distances.

- **HBED2 Purpose Specific Constants:** HBED2 travelers are more likely to use transit and non-motorized modes and less likely to use shared ride modes than HBO travelers. College students are not dropped off at school in the same manner as elementary or secondary school students. College students also may not have vehicles available and rely more on transit or non-motorized modes.

- **HBSH Purpose Specific Constants:** HBSH travelers are more likely to drive alone than HBO travelers. HBSH trips may involve carrying parcels, which make it harder to use transit or non-motorized modes.

- **Income Specific Constants**: As expected, the walk mode is more attractive to low-income (income < $35,000) travelers as indicated by the positive coefficient. Conversely, walk and walk-transit modes are less attractive to higher income (income > $50,000) travelers.

- **Household Vehicles:** Unlike HBW trips, only walk to transit modes are more attractive to households with zero vehicles. Shared ride modes are less attractive to households with zero vehicles. A potential explanation for this is that HBW trips are more regular than HBNW and are therefore easier to coordinate carpooling with non-household members. If there are sufficient vehicles in the household the drive alone mode is more attractive than otherwise, as expected.

- **Household Size:** A significant coefficient was estimated for small households (<=2 members) and the shared ride 3 mode. The shared ride mode coefficients are negative, as expected.

- **Density Factor:** A significant positive coefficient was estimated on the attraction zone density factor for shared ride, transit, and bike modes.

- **In-Vehicle Travel Time:** The estimated value for in-vehicle time of -0.0125 is within the FTA recommended range of -0.010 to -0.020 for HBNW trip purposes.

- **Non-Motorized Distance:** Travelers are more sensitive to walk distance than bike distance, which reflects the faster bike travel speed.

Table 6.2 HBNW Mode Choice Estimation Results

	Variable	Coeff	St. Err.	t-stat
Level Of Service				
	generalized time and cost	-0.0313	0.003	-7.0
	travel distance (bike)	-1.4280	0.135	-7.1
	travel distance (walk)	-2.2397	0.130	-11.5
Nest Coefficients				
	theta12	0.8		const
	theta23	0.5		const
Effective Level Of Service				
	generalized time (2.5 OVT/IVT)	-0.0125		
	OVTT	-0.0313		
	travel distance (bike)	-0.5712		
	travel distance (walk)	-0.8959		
VOT				
	All	VOT		Cost Coeff
	Income 1	$ 2.52		-0.7449
	Income 2	$ 3.60		-0.5222
	Income 3	$ 5.05		-0.3724
	Income 4	$ 8.29		-0.2266
	Income 5	$ 10.76		-0.1747
Model Fit				
		Observations	18594	
		Log Likelihood at Zero	-16430.8	
		Log Likelihood at Convergence	-10489.7	
		Rho-Squared	0.36	

Non Home-Based / Non-work airport

- **Airport:** Non-work trips to the airport zone were found to be more likely to use SR2 and SR3 modes.
- **Peak Travel:** The positive coefficient for SR3 implies that this mode is more attractive in the peak, perhaps because it is easier to coordinate peak period trips.
- **Density Factor:** A significant positive coefficient was estimated on the attraction zone density factor for local bus and walk modes.

- **In-Vehicle Travel Time:** The in-vehicle time is constrained to be -0.015, which is in the middle of the FTA recommended range of -0.010 to -0.020 for NHB trip purposes. The estimated value for in-vehicle time was outside the recommended range.

- **Non-Motorized Distance:** Travelers are more sensitive to walk distance than bike distance, which reflects the faster bike travel speed.

Table 6.3 NHB and AIR Mode Choice Estimation Results

	Variable	Coeff	St. Err.	t-stat
Level Of Service				
	generalized time and cost	-0.0375	0.000	Const.
	travel distance (bike)	-3.0301	0.920	-2.2
	travel distance (walk)	-5.3030	0.409	-8.6
Nest Coefficients				
	theta12	0.8		Const.
	theta23	0.5		Const.
Effective Level Of Service				
	generalized time (2.5 OVT/IVT)	-0.0150		
	OVTT	-0.0375		
	travel distance (bike)	-1.2120		
	travel distance (walk)	-2.1212		
VOT				Cost Coeff.
	All (non-airport)	$ 5.20		-0.4327
	Airport Trips	$ 10.40		-0.2163
Model Fit				
		Observations	6,933	
		Log Likelihood at Zero	-7649.8	
		Log Likelihood at Convergence	-5320.0	
		Rho-Squared	0.30	

6.2 Calibration

The alternative-specific constants in the mode choice models were examined and calibrated using auto and non-motorized mode shares obtained from the expanded 2005 household travel survey and using observed ridership by transit mode obtained from the 2014 on-board transit survey (Table 2.13 and Table A.1). The calibrated mode choice constants can be found in Table A.2-Table A.5.

SAMMV4 already includes an automated calibration procedure that is consistent with the most current Federal Transit Administration (FTA) guidance regarding calibration of alternative-specific constants (ASC). This procedure calibrates each node incrementally, with ASCs computed additively.

Mode choice calibration can be run for each trip purpose separately, or for all purposes together. The model calibration utility automatically updates the constants in the mode choice parameters file and outputs summary text files that compare observed to modeled trips for peak and off-peak, and by income level where applicable. The comparisons help the user determine how close the calibration is to convergence.

Table 6.4 shows the daily mode choice results of the calibrated model. Table 6.5 shows the daily mode choice targets by applying the target transit shares from Table A.1 and the auto and non-motorized shares from Table 2.13. Note that the trip totals don't match up exactly because of rounding issues. Table 6.6 and Table 6.7 show the modeled and target mode shares, respectively. The modeled results match closely with the target mode shares.

Table 6.4 Modeled Daily Mode Choice Results

	HBW	HBED1	HBED2	HBSH	HBO	NHB	AIR	Total
Automobile	1,435,487	947,599	124,079	1,792,288	1,485,606	2,952,957	37,036	**8,775,053**
Drive Alone	1,281,296	69,042	113,507	895,752	547,066	1,339,132	13,607	**4,259,403**
2 Person SR	126,496	366,187	9,082	532,662	463,880	879,188	11,286	**2,388,781**
3+ Person SR	27,695	512,370	1,490	363,874	474,660	734,637	12,142	**2,126,868**
Transit	41,691	1,543	6,130	11,165	24,796	16,148	156	**101,630**
Drive Access	931	0	266	164	204	228	1	**1,794**
LRT Transit	0	0	0	0	0	0	0	**0**
BRT Transit	0	0	0	0	0	0	0	**0**
Express Bus	172	0	62	7	20	21	0	**282**
Local Bus	759	0	203	158	184	207	1	**1,512**
Walk Access	40,760	1,543	5,864	11,001	24,593	15,920	155	**99,836**
LRT Transit	0	0	0	0	0	0	0	**0**
BRT Transit	0	0	0	0	0	0	0	**0**
Express Bus	1,551	61	887	135	533	756	10	**3,933**
Local Bus	39,209	1,482	4,978	10,865	24,060	15,164	145	**95,903**
Non-Motorized	14,741	164,960	10,690	18,714	58,028	75,727	8	**342,868**
Bike	3,429	9,109	3,432	1,129	4,441	751	1	**22,292**
Walk	11,312	155,851	7,258	17,585	53,586	74,976	7	**320,576**
Total Person Trips	**1,491,919**	**1,114,102**	**140,900**	**1,822,167**	**1,568,430**	**3,044,833**	**37,200**	**9,219,551**

Table 6.5 Daily Mode Choice Targets

	HBW	HBED1	HBED2	HBSH	HBO	NHB	AIR	Total
Automobile	1,435,487	947,599	124,079	1,792,288	1,485,606	2,952,957	37,036	**8,775,053**
Drive Alone	1,281,296	69,042	113,507	895,752	547,066	1,339,132	13,607	**4,259,403**
2 Person SR	126,496	366,187	9,082	532,662	463,880	879,188	11,286	**2,388,781**
3+ Person SR	27,695	512,370	1,490	363,874	474,660	734,637	12,142	**2,126,868**
Transit	41,691	1,543	6,130	11,165	24,796	16,148	156	**101,630**
Drive Access	931	0	266	164	204	228	1	**1,794**
LRT Transit	0	0	0	0	0	0	0	**0**
BRT Transit	0	0	0	0	0	0	0	**0**
Express Bus	172	0	62	7	20	21	0	**282**
Local Bus	759	0	203	158	184	207	1	**1,512**
Walk Access	40,760	1,543	5,864	11,001	24,593	15,920	155	**99,836**
LRT Transit	0	0	0	0	0	0	0	**0**
BRT Transit	0	0	0	0	0	0	0	**0**
Express Bus	1,551	61	887	135	533	756	10	**3,933**
Local Bus	39,209	1,482	4,978	10,865	24,060	15,164	145	**95,903**
Non-Motorized	14,741	164,960	10,690	18,714	58,028	75,727	8	**342,868**
Bike	3,429	9,109	3,432	1,129	4,441	751	1	**22,292**
Walk	11,312	155,851	7,258	17,585	53,586	74,976	7	**320,576**
Total Person Trips	**1,491,919**	**1,114,102**	**140,900**	**1,822,167**	**1,568,430**	**3,044,833**	**37,200**	**9,219,551**

Table 6.6 Modeled Daily Mode Shares

	HBW	HBED1	HBED2	HBSH	HBO	NHB	AIR	Total
Automobile	96.22%	85.05%	88.06%	98.36%	94.72%	96.98%	99.56%	**95.18%**
Drive Alone	85.88%	6.20%	80.56%	49.16%	34.88%	43.98%	36.58%	**46.20%**
2 Person SR	8.48%	32.87%	6.45%	29.23%	29.58%	28.87%	30.34%	**25.91%**
3+ Person SR	1.86%	45.99%	1.06%	19.97%	30.26%	24.13%	32.64%	**23.07%**
Transit	2.79%	0.14%	4.35%	0.61%	1.58%	0.53%	0.42%	**1.10%**
Drive Access	0.06%	0.00%	0.19%	0.01%	0.01%	0.01%	0.00%	**0.02%**
LRT Transit	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	**0.00%**
BRT Transit	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	**0.00%**
Express Bus	0.01%	0.00%	0.04%	0.00%	0.00%	0.00%	0.00%	**0.00%**
Local Bus	0.05%	0.00%	0.14%	0.01%	0.01%	0.01%	0.00%	**0.02%**
Walk Access	2.73%	0.14%	4.16%	0.60%	1.57%	0.52%	0.42%	**1.08%**
LRT Transit	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	**0.00%**
BRT Transit	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	**0.00%**
Express Bus	0.10%	0.01%	0.63%	0.01%	0.03%	0.02%	0.03%	**0.04%**
Local Bus	2.63%	0.13%	3.53%	0.60%	1.53%	0.50%	0.39%	**1.04%**
Non-Motorized	0.99%	14.81%	7.59%	1.03%	3.70%	2.49%	0.02%	**3.72%**
Bike	0.23%	0.82%	2.44%	0.06%	0.28%	0.02%	0.00%	**0.24%**
Walk	0.76%	13.99%	5.15%	0.97%	3.42%	2.46%	0.02%	**3.48%**

Table 6.7 Daily Mode Share Targets

	HBW	HBED1	HBED2	HBSH	HBO	NHB	AIR	Total
Automobile	96.22%	85.05%	88.06%	98.36%	94.72%	96.98%	99.56%	**95.18%**
Drive Alone	85.88%	6.20%	80.56%	49.16%	34.88%	43.98%	36.58%	**46.20%**
2 Person SR	8.48%	32.87%	6.45%	29.23%	29.58%	28.87%	30.34%	**25.91%**
3+ Person SR	1.86%	45.99%	1.06%	19.97%	30.26%	24.13%	32.64%	**23.07%**
Transit	2.79%	0.14%	4.35%	0.61%	1.58%	0.53%	0.42%	**1.10%**
Drive Access	0.06%	0.00%	0.19%	0.01%	0.01%	0.01%	0.00%	**0.02%**
LRT Transit	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	**0.00%**
BRT Transit	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	**0.00%**
Express Bus	0.01%	0.00%	0.04%	0.00%	0.00%	0.00%	0.00%	**0.00%**
Local Bus	0.05%	0.00%	0.14%	0.01%	0.01%	0.01%	0.00%	**0.02%**
Walk Access	2.73%	0.14%	4.16%	0.60%	1.57%	0.52%	0.42%	**1.08%**
LRT Transit	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	**0.00%**
BRT Transit	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	**0.00%**
Express Bus	0.10%	0.01%	0.63%	0.01%	0.03%	0.02%	0.03%	**0.04%**
Local Bus	2.63%	0.13%	3.53%	0.60%	1.53%	0.50%	0.39%	**1.04%**
Non-Motorized	0.99%	14.81%	7.59%	1.03%	3.70%	2.49%	0.02%	**3.72%**
Bike	0.23%	0.82%	2.44%	0.06%	0.28%	0.02%	0.00%	**0.24%**
Walk	0.76%	13.99%	5.15%	0.97%	3.42%	2.46%	0.02%	**3.48%**

7.0 Time of Day Factors

There are two occurrences where time of day factors are used in the model: after trip generation, to split the daily balanced productions and attractions to peak and off-peak; and after mode choice, to split the vehicle matrices into four time periods for assignment: AM Peak (6 AM. to 9 AM), PM Peak (3 PM – 7 PM), Mid-Day (MD) (9 AM – 3 PM) and Night-Time (NT) (7 PM – 6 AM).

To define time of day for each trip in the household survey, reported trips were multiplied by zone to zone distance to produce an observed distribution of VMT for each one-hour period, with the resulting VMT distribution shown in Figure 7.1. Separating out the daily travel into four time periods is important for air quality analysis, as varying temperatures throughout the day impact ozone pollutant generation.

7.1 Peak versus Off-peak

Table 7.1 shows the time of day factors derived from the expanded household survey for the destination choice model. For each purpose, the time of day factors should sum up to 1.

Table 7.1 Trip Distribution Time of Day Factors

Purpose	Period	Factor
HBW	PK	0.6637
HBW	OP	0.3363
HBED1	PK	0.8687
HBED1	OP	0.1313
HBED2	PK	0.4287
HBED2	OP	0.5713
HBSH	PK	0.3495
HBSH	OP	0.6505
HBO	PK	0.5140
HBO	OP	0.4860
NHB	PK	0.4431
NHB	OP	0.5569
AIR	PK	0.4130
AIR	OP	0.5870

7.2 Four Time Periods

Using the expanded household survey, time of day factors by trip purpose and directionality were calculated. The mode choice component outputs matrices for the peak and off-peak time periods, after which the conversion from production-attraction (PA) to origin-destination (OD) format takes place. Vehicle trips are then output in OD format for the four time periods, whereas transit trips are output for the peak and off-peak periods in PA format. Time of day factors for the AIR trip purpose are assumed to be the same as those for HBO. Truck and External time of day factors are assumed equivalent to NHB factors.

The peak hours were determined by plotting the temporal distribution of the expanded trips from the household survey against collected traffic counts (Figure 7.1). The AM peak hour is from 7 to 8 AM, and the PM peak hour is from 5 to 6 PM. Dividing the number of expanded trips from the household survey occurring during the peak hour by the number of trips occurring during the peak period yields the peak hour factor (Table 7.2). MD and NT trips are assumed to be uniformly distributed across the time period.

Figure 7.1 Hourly Trip Distribution and Peak Hour Determination

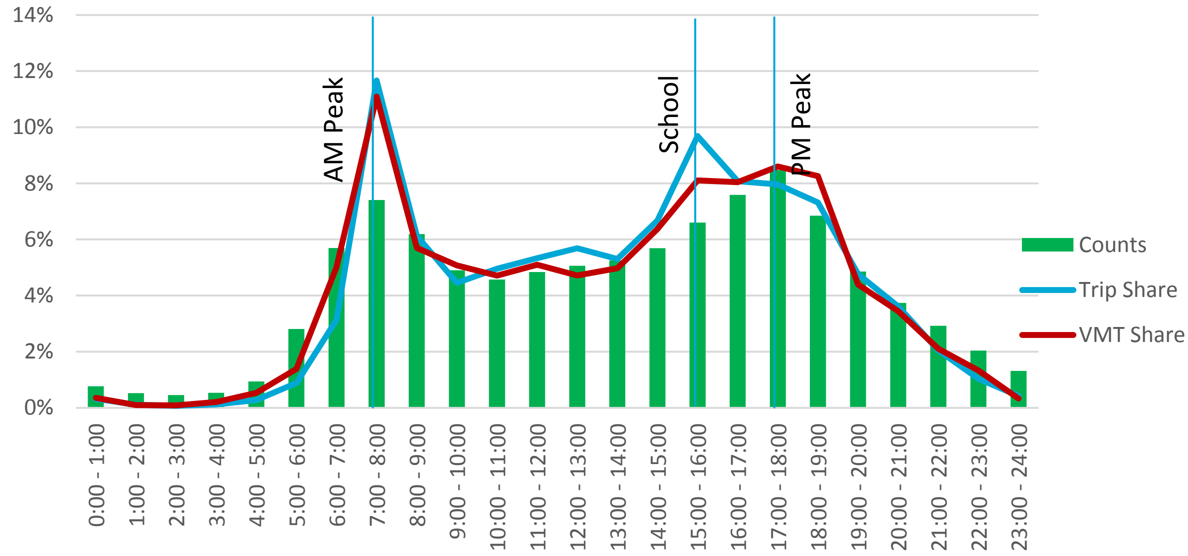


Table 7.2 Time Period Definitions and Peak Hour Factor

Period	Hours	Peak Hour Factor
AM Peak	6 AM – 9 AM	0.384
PM Peak	3 PM – 7 PM	0.287
Mid-Day	9 AM – 3 PM	0.167
Night-Time	7 PM – 6 AM	0.091

Next, the network initialization step reads a speed/capacity lookup table, transforms daily capacities to hourly capacities (typically 9% of daily capacities), applies peak hour factors to transform hourly to period capacities, and assign speeds and period capacities to the network based on time of day, facility type, and area type. Table A.6 in the Appendix furnishes the speed/capacity lookup values by facility type and area type.

Just before the trip assignment module, the time of day macro converts the peak and off-peak vehicle trip matrices produced by the mode choice model into vehicle trip matrices for the four time periods. In the travel model, time of day factors are applied directly to purpose-specific vehicle trip tables created by the mode choice model. As described in this section, daily trip tables are separated into peak period (combined AM and PM peak periods) and off-peak period trips after trip generation. The traffic assignment time of day module further separates peak period trips into AM and PM peak period trips and off-peak trips into mid-day trips and night-time off-peak trips. During this conversion, trip tables are also converted from PA format to OD format.

Table A.7 in the Appendix shows the time of day factors derived from the expanded household survey to convert the PA matrices to OD matrices. For each purpose, the sum of departure and return factors for the peak period (AM and PM) should sum up to 1. Similarly, the sum of the departure and return factors for the off-peak period (MD and NT) should sum up to 1. This table is set up this way in order to facilitate the conversion of peak and off-peak matrices separately. During validation, the MD and NT factors were updated so that highway assignment by time of day better matched the available counts by time of day.

8.0 Assignment Model

Trip assignment is the final phase of the traditional four-step travel model. Trip assignment includes a process where person trips from mode choice are converted into directional vehicle trips by time of day, as well as the assignment of route choice for both vehicle and transit trips. The resulting traffic volumes are available for the four time periods defined in Table 7.2 and transit boarding data are available for the peak and off-peak periods.

When the model is run with speed feedback enabled, travel times resulting from traffic assignment are fed back to trip distribution. The model is then run iteratively until speeds input to trip distribution are reasonably consistent with speeds resulting from traffic assignment.

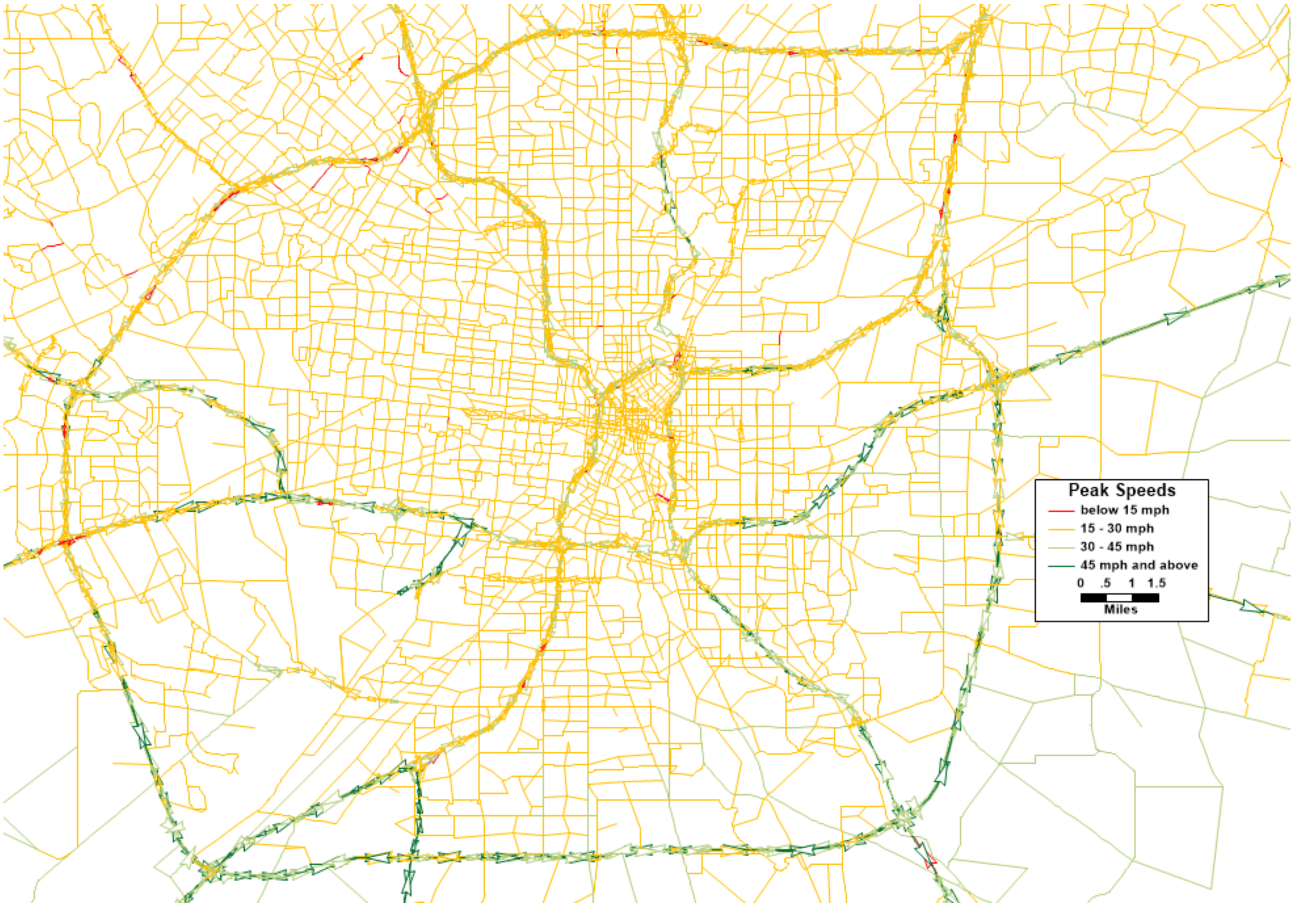
8.1 Traffic Assignment

The traffic assignment module loads the vehicle trip tables, by time of day, onto the roadway network. The model utilizes user equilibrium assignment, which minimizes travel time for all vehicle trips assigned to the network. This is an iterative assignment algorithm that calculates congested travel time as a function of link volume and shifts travelers to the shortest path. As a result, user equilibrium traffic assignment represents traffic diversion from congested links.

After each iteration, the user equilibrium traffic assignment algorithm computes a relative gap corresponding to the difference between the previous and current iteration volumes. The algorithm stops when a pre-selected relative gap is achieved, indicating the network has reached equilibrium and users have found their optimal paths. The relative gap parameter is set to 0.0001 for SAMMV4, which ensures a sufficiently high level of convergence. When a larger relative gap is used, oscillations between equilibrium iterations can sometimes result in unstable assignment results. If closure criteria are not sufficient, two very similar model runs (e.g., with only one small adjustment to the roadway network) can produce non-intuitive results. There are, however, cases when the network is extremely congested and the relative gap of 0.0001 cannot be reached within a reasonable amount of time and hence an upper limit is imposed on the number of iterations. This limit is set to 100 for SAMMV4.

Figure 8.1 shows the peak speeds in the City of San Antonio resulting from traffic assignment.

Figure 8.1 2015 Peak Speeds in the City of San Antonio



8.1.1 Volume-Delay Functions

A volume-delay function represents the effect of increasing traffic volume on link travel time in the assignment process. While several volume delay functions are available for consideration, the most commonly used function is the modified Bureau of Public Roads (BPR) function. The modified BPR function is based on the original BPR equation shown in Equation (11), and is the function utilized in the model.

$$T_C = T_F \left(1 + \alpha \left(\frac{V}{C}\right)^{\beta}\right) \tag{11}$$

Where:

- T_C = Congested travel time
- T_F = Freeflow travel time
- V = Traffic volume
- C = Highway design (practical) capacity
- α = Coefficient alpha (0.15)
- β = Exponent beta (4.0)

The modified BPR equation uses the same form, but replaces design capacity (i.e., upper limit LOS C capacity) with ultimate roadway capacity (i.e., upper limit LOS E capacity). The modified BPR function also replaces the coefficient alpha and the exponent beta with calibrated values which vary by facility type and area type (Table A.6).

8.2 Multi-Class Assignment

SAMMV4 traffic assignment segments single-occupancy vehicles for work trips by income group. The ten vehicle classes assigned to the highway network are: SOV_I1, SOV_I2, SOV_I3, SOV_I4, SOV_I5, SOV_NonWork, SR2, SR3, Truck, External. The vehicle classes are assigned using the equilibrium assignment process described earlier.

In the constrained traffic assignment, the ten vehicle classes are assigned simultaneously, but with slightly different settings as different values of time and toll value are permitted. A description of settings applied for each class is included below, with value of time values shown in Table 8.1. The truck value of time is transferred from the statewide model. The drive alone work values of time are the weighted average of dividing the mode choice in-vehicle time coefficient by the mode choice cost coefficient by income group. The drive alone non-work value of time are the weighted average of the non-work values of time calculated as the ratio of the in-vehicle time coefficient to the cost coefficient. The SR2, SR3, and External values of time reflect an average value of time of all trip purposes. Values of time for SR2 and SR3 are multiplied by vehicle occupancy within the model.

Table 8.1 Value of Time by Vehicle Class

Vehicle Class	Value of Time (per person)
SOV_I1	$2.904 / hour ($0.0484 / min)
SOV_I2	$4.362 / hour ($0.0727 / min)
SOV_I3	$6.246 / hour ($0.1041 / min)
SOV_I4	$10.404 / hour ($0.1734 / min)
SOV_I5	$13.626 / hour ($0.2271 / min)
SOV_NonWork	$6.000 / hour ($0.1000 / min)
SR2	$7.260 / hour ($0.1210 / min)
SR3	$7.260 / hour ($0.1210 / min)
Truck	$29.250 / hour ($0.4875 / min)
External	$7.260 / hour ($0.1210 / min)

Note: Values are input to the model in units of $/minute.

8.3 Speed Feedback

The destination choice model used in the trip distribution process relies on congested zone to zone travel time information to distribute trips. Later in the model process, the traffic assignment procedure calculates congested travel speeds based on traffic flows and application of a volume-delay equation. The speeds input to trip distribution and the speeds output by traffic assignment are generally not consistent after the initial model run. To rectify this inconsistency, results from traffic assignment are used to re-compute zone to zone travel times for input to trip distribution. The model is rerun, and a comparison is then made between the initial and updated zone to zone travel times. If the travel times are not reasonably similar, the updated travel times are then used to re-run trip distribution and the subsequent model steps. This process is repeated iteratively until a convergence criterion is met (described in the Traffic Assignment section).

Inclusion of a speed feedback process in the travel model process can have interesting and desirable effects on the way the travel model represents the effects of network improvements in congested situations. Without speed feedback, overall regional travel demand remains constant regardless of the roadway network assumptions because trip distribution patterns are not affected by changing congestion levels. Vehicle travel routes are always affected by congestion in the traffic assignment model by virtue of the volume-delay functions.

When speed feedback is added to the process, heavy congestion results in slower speeds, leading to shorter trip patterns throughout the region. As roadway improvements are added to the model, addition of capacity to the network will initially result in faster travel speeds because of less localized congestion. The speed feedback process recognizes the additional capacity and higher speeds and allows for longer trip lengths across the region, which has the effect of incrementally increasing overall travel demand due to roadway network characteristics. However, the speed feedback process only results in *longer* trips, not more trips.

8.3.1 Methodology

There are various approaches to solving the speed feedback problem. Three well-documented methods are the naïve method, constant-weight method, and method of successive averages (MSA). The naïve method is not recommended for use as lack of information sharing between subsequent iterations leads to an inefficient process that will often fail to converge. Furthermore, the naïve method feeds speed data directly from traffic assignment to trip distribution; while the constant weight and MSA methods feed volumes to trip distribution which are then used to compute updated speeds (speed feedback is sometimes referred to as volume balancing). SAMMV4 implements speed feedback using the constant weight method.

The Constant Weight Method uses a simple average of all flows resulting from previous assignment runs. Flows can be computed as in Equation (12).

$$MSAFlow_n = MSAFlow_{n-1} + wt * (Flow_n - MSAFlow_{n-1}) \qquad (12)$$

Where:

MSAFlow	= Flow calculated using the MSA
n	= current iteration
wt	= constant weight factor – 0.5 in SAMMV4
Flow	= Flow resulting from traffic assignment

The method of successive averages is commonly used in regional travel models and is the approach recommended by the TransCAD documentation. Where constant weight method differs is by assigning a constant weight factor instead of a different weight factor for every iteration. The method of successive averages also is supported by built-in functions in the TransCAD software.

This method effectively assigns a weight to traffic volumes from each traffic assignment iteration equal to 0.5. After the new MSA-weighted flows are calculated, speeds on each link in the roadway network are re-estimated, and the remainder of the model is run to complete the iteration.

8.3.2 Initial Speeds and Borrowed Feedback Results

Use of the MSA feedback procedure produces results sensitive to the initial speeds/travel times input to the first iteration of the trip distribution model. For this reason, a consistent set of initial speeds should be used when running multiple different scenarios. This is particularly important when model results and summary statistics from different scenarios will be directly compared.

In some cases, it is desirable to run the model to test multiple alternatives without running speed feedback for each scenario. For these cases, it is possible to run the model once with speed feedback enabled to establish a baseline forecast scenario (e.g., future growth on existing and committed network) and then save the final model results with speed feedback for use in alternatives testing runs. When this approach is taken, it is important that feedback is disabled when using the copied feedback results. In addition, the baseline scenario should be run a second time using copied speeds as input data and with speed feedback disabled to ensure consistency between all scenarios.

8.3.3 Application of Speed Feedback for Alternatives Analysis

Generally, speed feedback is most sensitive to network changes that provide a significant travel time improvement, such as a new freeway into a relatively undeveloped area. These types of alternatives warrant running the feedback process because they can affect regional travel patterns. Less significant improvements can also affect travel times and regional travel patterns to various degrees and should be considered for feedback.

For any and all interim milestone and horizon years, speed feedback should be executed to closure. For subsequent alternatives analysis, speed feedback should be considered for any of the conditions listed below.

- A significant new roadway alternative (i.e., new or greatly improved access) over the base case would likely warrant speed feedback. This would be true for new or significantly better access to areas that are undeveloped, developing, or already developed. For undeveloped areas, it is likely the effect is more significant in later years. Examples include new freeway interchanges, new freeways and arterials, and in limited cases new collector roads.

- Less significant roadway improvements might warrant running speed feedback. These might include roadway widening or corridor improvements that imply functional class, speed, or capacity changes. Improvements limited to a short section of roadway or an intersection generally would <u>not</u> warrant running speed feedback.

- A significant change to socioeconomic assumptions as compared to the base case. Speed feedback is more likely to be necessary when changes cover a large area and involve significant demographic shifts, but could conceivably be warranted after changes to a small number of zones with very high activity. Socioeconomic changes should also include an update to area type assumptions.

- Significant changes to external trip or special generator assumptions.

- Any model run in which a significant change in congestion on any corridor is anticipated could affect regional travel times and travel patterns. This criterion is largely covered by those above.

- Changes to model parameters, factors, coefficients, etc. – *Note: These changes should only be made in conjunction with model calibration and validation, but any tests of changes to parameters should include running the feedback process.*

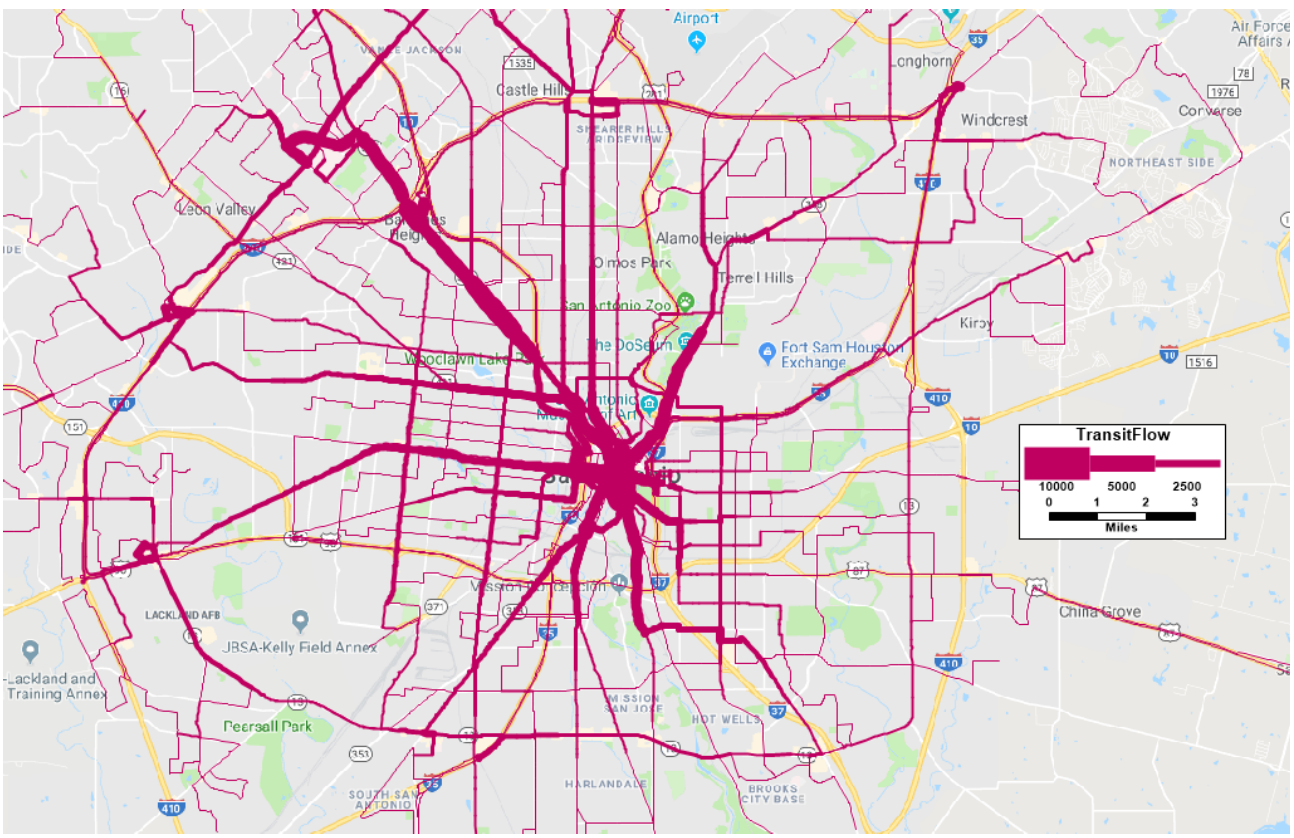
8.4 Transit Assignment

Transit person trips resulting from the mode choice model are assigned to the transit route system. Each trip is assigned from zone centroid to zone centroid using walk or drive access links, transit routes, and walk egress links. The transit path-building parameters are documented in Table A.8 in the Appendix. The transit assignment step does not include capacity constraint, so increasing transit volumes do not result in diversion of transit trips to other transit service.

Transit assignment results include the total number of boardings at each transit stop, as well as transit volumes on all stop to stop transit route segments. However, transit results are generally best evaluated at the systemwide or route group level. Individual route, stop, and segment values have not been validated to observed conditions.

Figure 8.2 shows the 2015 transit assignment results in the core area of the City of San Antonio.

Figure 8.2 Transit Flows in San Antonio



9.0 Model Validation

9.1 Traffic Assignment Validation

Roadway volumes resulting from traffic assignment were compared to traffic count data to ensure the model is reasonably representing observed traffic patterns. Daily traffic count data collected by AAMPO and TxDOT were linked to the TransCAD roadway network. Travel model results were compared to traffic count data using a variety of techniques, including regional comparisons, facility type comparisons, and inspection of individual link values.

In order to match regional-level volumes, trip rates by income groups were iteratively factored. The final production trip rates are shown in Table 3.2 and Table 3.3.

Validation statistics, including total volumes, RMSE, and r-squared, for the validated run can be found in Table 9.1. Table 9.2 and Table 9.3 show the percent difference between assigned volumes and traffic counts by functional class and facility type, respectively. As evident, volumes on expressways and freeways match very closely with counts.

Validation results by time of day are shown in Table 9.4 and indicate that the model matches up well with traffic counts.

Table 9.1 Validation Run Statistics

Validation Run	Total Traffic Count	Total Assigned Volume	% Difference	RMSE	% RMSE	R	R^2
2015	159,187,933	159,048,922	-0.09%	3,718	31%	0.96097	0.92347

Table 9.2 Volume to Count Difference By Functional Class

Functional Class	Description	2015 Validation Run
1	Interstate Freeways	-2%
2	Other Freeways	0%
3	Expressways	+2%
4	Principal Arterials	+9%
5	Minor Arterials	+6%
6	Collectors	+9%
7	Frontage Roads	-17%
8	Ramps	-10%

Table 9.3 Volume to Count Difference By Detailed Facility Type

FTYPE	Description	2015 Validation Run
1	Radial IH Freeways (Mainlanes)	+1%
2	Radial IH Freeways (HOV/Toll Lanes)	0%
3	Loop IH Freeways (Mainlanes)	-9%
4	Loop IH Freeways (HOV/Toll Lanes)	0%
5	Radial Other Freeways (Mainlanes)	+2%
6	Radial Other Freeways (HOV/Toll Lanes)	-15%
7	Loop Other Freeways (Mainlanes)	-3%
8	Loop Other Freeways (HOV/Toll Lanes)	0%
9	Radial Expressways	0%
10	Loop Expressways	+2%
11	Principal Arterials (Divided)	+12%
12	Principal Arterials (Cont. Left Turn)	+5%
13	Principal Arterials (Undivided)	+13%
14	Minor Arterials (Divided)	+9%
15	Minor Arterials (Cont. Left Turn)	-2%
16	Minor Arterials (Undivided)	+6%
17	Collectors (Divided)	-4%
18	Collectors (Cont. Left Turn)	-10%
19	Collectors (Undivided)	+12%
20	Frontage Roads	-17%
21	Ramps (Frontage to Mainlanes)	-5%
22	Ramps (Freeway to Freeway)	-21%
23	HOV/Toll Ramps	+6%

Table 9.4 Time of Day Validation

Time	Model VMT Share	HH Survey VMT Share	Traffic Counts VMT Share
AM Peak period	19%	22%	19%
AM Peak hour	7%	11%	7%
PM Peak period	31%	33%	30%
PM Peak hour	9%	9%	8%
Mid-Day	30%	31%	30%
Night-Time	20%	14%	21%

9.2 Transit Assignment Validation

The 2014 on-board transit survey was processed to create an expanded and weighted observed transit trip table. The observed transit trip table from the on-board transit survey was then assigned to the transit networks, and the results were validated against observed boardings by type, route group and route from the on-board survey. The validation effort resulted in updating the transit path building parameters, furnished in Table A.8 in the Appendix.

9.2.1 Survey Assignment Validation

This section details the survey assignment validation results done in order to check and update the transit network and path building parameters. From the linked trips developed from the VIA On-Board Survey detailed in Table 2.15, trip tables were developed in production-attraction format segmented by access mode, transit mode, and time of day. These trip tables were then input into the model as if they were the transit trip tables generated by mode choice and the transit assignment portion of the model was run. Table 9.5 displays the linked trip and transit boarding summary developed from the on-board survey.

Table 9.5 2014 On-board Survey Linked Trips and Boardings by Transit and Access Modes

	2014 Survey Linked Trips			Survey Boardings			Survey Transfer Ratio		
Path	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total
WalkLoc	39,615	52,634	92,249	53,583	69,608	123,191	1.35	1.32	1.34
WalkExp	1,805	1,633	3,438	3,060	2,672	5,732	1.70	1.64	1.67
WalkBRT	2,025	3,149	5,174	3,300	5,075	8,375	1.63	1.61	1.62
WalkLRT	-	-	-	-	-	-	-	-	-
DriveLoc	324	571	895	358	615	973	1.11	1.08	1.09
DriveExp	425	171	596	443	198	641	1.04	1.16	1.08
DriveBRT	57	18	75	67	36	103	1.17	2.02	1.37
DriveLRT	-	-	-	-	-	-	-	-	-
Walk to Transit	43,445	57,416	100,861	59,943	77,354	137,298	1.38	1.35	1.36
Drive to Transit	806	760	1,566	868	849	1,717	1.08	1.12	1.10
Total	44,251	58,176	102,427	60,811	78,204	139,015	1.37	1.34	1.36

Table 9.11 shows model results from assigning the survey trip tables with the transit path parameters detailed in Table A.8. As part of the path checks, unassigned trips were checked and in some cases moved to other transit paths as detailed in Transit On-board Survey section.

Table 9.6 2014 On-Board Survey Transit Assignment in Model with Updated Transit Path Parameters

	2014 Survey Linked Trips			Unassigned Trips			Survey Assignment Boardings			Transfer Ratio		
Path	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total
WalkLoc	39,615	52,634	92,249	95	30	125	53,184	67,686	120,870	1.35	1.29	1.31
WalkExp	1,805	1,633	3,438	5	0	5	3,333	2,887	6,219	1.85	1.77	1.81
WalkBRT	2,025	3,149	5,174	0	0	0	3,683	5,581	9,264	1.82	1.77	1.79
WalkLRT	-	-	-	-	-	-	-	-	-	-	-	-
DriveLoc	324	571	895	3	25	28	417	649	1,066	1.30	1.19	1.23
DriveExp	425	171	596	3	2	5	499	202	701	1.18	1.20	1.19
DriveBRT	57	18	75	0	0	0	132	36	168	2.32	2.02	2.25
DriveLRT	-	-	-	-	-	-	-	-	-	-	-	-
Walk acc	43,445	57,416	100,861	100	30	130	60,200	76,154	136,354	1.39	1.33	1.35
Drive acc	806	760	1,566	6	27	33	1,047	888	1,935	1.31	1.21	1.26
Total	44,251	58,176	102,427	106	57	163	61,247	77,042	138,289	1.39	1.33	1.35

Table 9.7 and Table 9.8 show the aggregated route level boardings to mode/service and geographic region of service, respectively. At the regional level, the new path building parameters result in a survey trip table assignment that matches closely with the survey. Table 9.9 shows the route level summaries along with the Mode and Region of each route.

Table 9.7 Mode/Service Level Boardings from 2014 On-Board Survey Transit Assignment

Mode	Mode Description	Survey	Model	Diff
1	METRO	78,577	78,067	(510)
2	FREQ	36,833	36,602	(231)
3	EXP	4,551	4,812	261
4	SKIP	11,980	12,130	150
6	STCAR	758	709	(49)
41	SKIP_Primo	6,316	5,969	(347)
Total	Total	139,015	138,289	(726)

Table 9.8 Region Level Boardings from 2014 On-Board Survey Transit Assignment

	Survey	Model	
Region	Ridership	Ridership	Difference
East/West	41,439	40,556	-883
North/South	29,719	29,629	-90
Northeast	14,911	14,193	-718
Northwest	43,638	43,296	-342
Other	9,308	10,615	1,307
Total	139,015	138,289	-726

Table 9.9 Route Level Boardings from 2014 On-Board Survey Transit Assignment

			Survey	Model	
Region	**Mode**	**LineGroup**	**Ridership**	**Ridership**	**Difference**
East/West	EXP	64	1,050	1,302	252
East/West	METRO	21 + 77	2,874	2,709	-165
East/West	FREQ	24 + 66	4,296	3,173	-1,123
East/West	FREQ	25 + 75	5,192	5,194	2
East/West	METRO	26 + 68	4,710	5,246	536
East/West	METRO	28 + 76	6,132	6,129	-3
East/West	METRO	36 + 90	2,956	1,902	-1,054
East/West	METRO	51 + 82	4,451	6,763	2,312
East/West	METRO	607 + 610	688	881	193
East/West	METRO	611 + 612	847	369	-478
East/West	METRO	613 + 619	1,215	1,520	305
East/West	METRO	614 + 615	1,150	1,011	-139
East/West	METRO	616 + 617	1,250	1,218	-32
East/West	METRO	62 + 89	1,791	704	-1,087
East/West	SKIP	7 + 70	390	133	-257
East/West	METRO	8 + 67	2,447	2,304	-143
Subtotal East/West		**Subtotal**	**41,439**	**40,556**	**-883**
North/South	EXP	6	448	521	73
North/South	EXP	48	61	55	-6
North/South	METRO	505	732	346	-386
North/South	METRO	509	1,116	253	-863
North/South	METRO	515	1,136	725	-411

Region	Mode	LineGroup	Survey Ridership	Model Ridership	Difference
North/South	METRO	651	784	638	-146
North/South	METRO	2 + 34	5,943	8,066	2,123
North/South	SKIP	3 + 46	3,040	2,091	-949
North/South	FREQ	4 + 20	9,031	9,755	724
North/South	METRO	5 + 30	3,152	2,869	-283
North/South	METRO	647 + 648	1,073	1,120	47
North/South	METRO	9 + 43	3,203	3,191	-12
Subtotal North/South		**Subtotal**	**29,719**	**29,629**	**-90**
Northeast	FREQ	22	1,383	1,203	-180
Northeast	METRO	502	1,428	1,360	-68
Northeast	METRO	630	972	625	-347
Northeast	METRO	632	1,395	1,353	-42
Northeast	METRO	10 + 44	3,548	4,505	957
Northeast	FREQ	14 + 79	5,185	4,565	-620
Northeast	METRO	641 + 642	1,000	580	-420
Subtotal Northeast		**Subtotal**	**14,911**	**14,193**	**-718**
Northwest	METRO	95	1,352	570	-782
Northwest	SKIP_Primo	100	6,316	5,969	-347
Northwest	FREQ	520	7,946	8,220	274
Northwest	METRO	522	1,375	1,220	-155
Northwest	FREQ	524	3,800	4,493	693
Northwest	METRO	534	2,750	5,010	2,260
Northwest	METRO	606	966	575	-391
Northwest	EXP	17 + 93	1,079	1,539	460
Northwest	EXP	17 + 94	1,913	1,396	-517
Northwest	METRO	32 + 96	4,510	4,777	267
Northwest	METRO	42 + 88	3,853	3,914	61
Northwest	METRO	54 + 97	2,491	1,194	-1,297
Northwest	METRO	602 + 604	1,918	1,395	-523
Northwest	METRO	603 + 605	1,332	1,007	-325
Northwest	METRO	609 + 618	855	637	-218
Northwest	METRO	620 + 660	1,182	1,381	199
Subtotal Northwest		**Subtotal**	**43,638**	**43,296**	**-342**
Other	STCAR	301	511	300	-211
Other	SKIP	550	4,238	4,889	651

			Survey	Model	
Region	**Mode**	**LineGroup**	**Ridership**	**Ridership**	**Difference**
Other	SKIP	551	4,312	5,016	704
Other	STCAR	304 + 305	247	409	162
Subtotal Other		**Subtotal**	**9,308**	**10,615**	**1,307**
Total		**Total**	**139,015**	**138,289**	**-726**

9.2.2 Model Assignment Validation

This section shows how well the transit assignment model performs using a trip table that was generated while running the model. Table 9.10 shows modeled transit boardings against the expanded survey boardings by route and route group. Overall, the total modeled ridership is greater than the observed ridership by 4%. Table 9.11 shows modeled transit boardings against the expanded survey boardings by transit mode. The model and survey boardings match closely with the exception of the streetcar mode for which the model over predicts by 39%, which is not alarming given the low magnitude of ridership on that mode.

Table 9.10 Transit Validation By Corridor

			Survey	Model		
Region	Mode	Route/ Route Group	Ridership	Ridership	Difference	% Difference
East/West	EXP	64	1,050	962	-88	-8%
East/West	METRO	21 + 77	2,874	2,922	48	2%
East/West	FREQ	24 + 66	4,296	3,439	-857	-20%
East/West	FREQ	25 + 75	5,192	3,813	-1,379	-27%
East/West	METRO	26 + 68	4,710	5,671	961	20%
East/West	METRO	28 + 76	6,132	6,181	49	1%
East/West	METRO	36 + 90	2,956	2,337	-619	-21%
East/West	METRO	51 + 82	4,451	7,778	3,327	75%
East/West	METRO	607 + 610	688	1,110	422	61%
East/West	METRO	611 + 612	847	657	-190	-22%
East/West	METRO	613 + 619	1,215	1,792	577	47%
East/West	METRO	614 + 615	1,150	1,083	-67	-6%
East/West	METRO	616 + 617	1,250	1,199	-51	-4%
East/West	METRO	62 + 89	1,791	919	-872	-49%
East/West	SKIP	7 + 70	390	166	-224	-57%
East/West	METRO	8 + 67	2,447	2,730	283	12%
Subtotal East/West			**41,439**	**42,757**	**1,318**	**3%**
North/South	EXP	6	448	699	251	56%

Region	Mode	Route/ Route Group	Survey Ridership	Model Ridership	Difference	% Difference
North/South	EXP	48	61	93	32	53%
North/South	METRO	505	732	549	-183	-25%
North/South	METRO	509	1,116	663	-453	-41%
North/South	METRO	515	1,136	1,347	211	19%
North/South	METRO	651	784	1,036	252	32%
North/South	METRO	2 + 34	5,943	8,734	2,791	47%
North/South	SKIP	3 + 46	3,040	2,134	-906	-30%
North/South	FREQ	4 + 20	9,031	8,284	-747	-8%
North/South	METRO	5 + 30	3,152	3,554	402	13%
North/South	METRO	647 + 648	1,073	1,211	138	13%
North/South	METRO	9 + 43	3,203	4,792	1,589	50%
Subtotal North/South			29,719	33,096	3,377	11%
Northeast	FREQ	22	1,383	936	-447	-32%
Northeast	METRO	502	1,428	1,174	-254	-18%
Northeast	METRO	630	972	847	-125	-13%
Northeast	METRO	632	1,395	1,047	-348	-25%
Northeast	METRO	10 + 44	3,548	4,793	1,245	35%
Northeast	FREQ	14 + 79	5,185	3,485	-1,700	-33%
Northeast	METRO	641 + 642	1,000	830	-170	-17%
Subtotal Northeast			**14,911**	**13,111**	**-1,800**	**-12%**
Northwest	METRO	95	1,352	404	-948	-70%
Northwest	SKIP_Primo	100	6,316	6,790	474	7%
Northwest	FREQ	520	7,946	6,503	-1,443	-18%
Northwest	METRO	522	1,375	1,367	-8	-1%
Northwest	FREQ	524	3,800	4,848	1,048	28%
Northwest	METRO	534	2,750	6,105	3,355	122%
Northwest	METRO	606	966	582	-384	-40%
Northwest	EXP	17 + 93	1,079	1,359	280	26%
Northwest	EXP	17 + 94	1,913	1,128	-785	-41%
Northwest	METRO	32 + 96	4,510	5,049	539	12%
Northwest	METRO	42 + 88	3,853	3,911	58	2%
Northwest	METRO	54 + 97	2,491	1,483	-1,008	-40%
Northwest	METRO	602 + 604	1,918	1,819	-99	-5%
Northwest	METRO	603 + 605	1,332	1,381	49	4%
Northwest	METRO	609 + 618	855	582	-273	-32%

			Survey	Model		
Region	**Mode**	**Route/ Route Group**	**Ridership**	**Ridership**	**Difference**	**% Difference**
Northwest	METRO	620 + 660	1,182	1,767	585	49%
Subtotal Northwest			**43,638**	**45,077**	**1,439**	**3%**
Other	STCAR	301	511	351	-160	-31%
Other	SKIP	550	4,238	5,061	823	19%
Other	SKIP	551	4,312	4,225	-87	-2%
Other	STCAR	304 + 305	247	700	453	183%
Subtotal Other			**9,308**	**10,337**	**1,029**	**11%**
Total			**139,015**	**144,378**	**5,363**	**4%**

Table 9.11 Transit Validation By Transit Mode

		Survey	Model		
Mode ID	**Mode**	**Ridership**	**Ridership**	**Difference**	**% Difference**
1	Metro	78,577	89,405	10,828	14%
2	Frequent	36,833	31,306	(5,527)	-15%
3	Express	4,551	4,240	(311)	-7%
4	Skip	11,980	11,586	(394)	-3%
5	Flex	-	-	-	-
6	Street Car	758	1,051	293	39%
7	Modern Street Car	-	-	-	-
8	Bus Rapid Transit	-	-	-	-
9	Light Rapid Transit	-	-	-	-
41	Skip Primo	6,316	6,790	474	7%
10	Walk	-	-	-	-
Total	**Total**	**139,015**	**144,378**	**5,363**	**4%**

Appendix A. Appendix

Table A.1 Transit Mode Shares

Purpose	Time Period	Income Group	Transit Mode Shares					
			LOC-WALK	EXP-WALK	LOC-DRIVE	EXP-DRIVE	URB	OTH
Home-Based Work	Peak	1	10,919	290	72	32	8,405	2,907
Home-Based Work	Peak	2	5,980	285	50	40	4,377	1,978
Home-Based Work	Peak	3	1,362	81	10	60	845	668
Home-Based Work	Peak	4	978	59	29	79	656	489
Home-Based Work	Peak	5	454	38	33	63	226	363
Home-Based Work	Off-Peak	1	12,471	266	39	30	9,131	3,675
Home-Based Work	Off-Peak	2	5,287	147	145	9	4,064	1,523
Home-Based Work	Off-Peak	3	1,132	47	64	9	782	469
Home-Based Work	Off-Peak	4	723	29	53	20	484	341
Home-Based Work	Off-Peak	5	245	4	2	8	129	130
Home-Based Shopping	Peak	1	2,764	28	6	0	2,276	522
Home-Based Shopping	Peak	2	672	17	0	0	477	212
Home-Based Shopping	Peak	3	121	3	0	0	84	40
Home-Based Shopping	Peak	4	113	4	0	0	75	41
Home-Based Shopping	Peak	5	56	0	0	0	42	14
Home-Based Shopping	Off-Peak	1	5,213	68	47	0	3,983	1,345
Home-Based Shopping	Off-Peak	2	1,568	13	10	0	1,065	526
Home-Based Shopping	Off-Peak	3	271	6	16	0	190	103
Home-Based Shopping	Off-Peak	4	184	2	7	0	134	58
Home-Based Shopping	Off-Peak	5	116	0	12	0	114	14
Home-Based Other	Peak	1	6,267	124	41	7	5,066	1,373
Home-Based Other	Peak	2	1,714	81	10	25	1,244	585
Home-Based Other	Peak	3	359	14	4	9	287	98
Home-Based Other	Peak	4	240	13	5	3	185	75
Home-Based Other	Peak	5	103	6	10	4	70	54
Home-Based Other	Off-Peak	1	11,919	119	28	2	9,836	2,231
Home-Based Other	Off-Peak	2	2,620	72	11	6	1,914	795
Home-Based Other	Off-Peak	3	634	29	14	0	469	208
Home-Based Other	Off-Peak	4	536	6	9	5	416	141
Home-Based Other	Off-Peak	5	194	3	1	3	136	65
Home-Based Education 1	Peak	1	684	14	0	0	513	185

Purpose	Time Period	Income Group	Transit Mode Shares					
			LOC-WALK	EXP-WALK	LOC-DRIVE	EXP-DRIVE	URB	OTH
Home-Based Education 1	Peak	2	269	0	0	0	220	49
Home-Based Education 1	Peak	3	37	0	0	0	25	11
Home-Based Education 1	Peak	4	35	0	0	0	19	16
Home-Based Education 1	Peak	5	44	0	0	0	36	8
Home-Based Education 1	Off-Peak	1	322	0	0	0	246	77
Home-Based Education 1	Off-Peak	2	84	0	0	0	40	44
Home-Based Education 1	Off-Peak	3	15	0	0	0	0	15
Home-Based Education 1	Off-Peak	4	29	0	0	0	6	23
Home-Based Education 1	Off-Peak	5	14	0	0	0	3	10
Home-Based Education 2	Peak	1	1,598	199	28	19	1,206	638
Home-Based Education 2	Peak	2	513	127	12	38	412	278
Home-Based Education 2	Peak	3	190	47	17	12	154	112
Home-Based Education 2	Peak	4	102	27	7	5	69	73
Home-Based Education 2	Peak	5	39	9	0	9	18	38
Home-Based Education 2	Off-Peak	1	1,521	193	18	12	1,042	702
Home-Based Education 2	Off-Peak	2	764	115	2	48	492	437
Home-Based Education 2	Off-Peak	3	186	20	5	3	120	93
Home-Based Education 2	Off-Peak	4	157	32	4	5	122	76
Home-Based Education 2	Off-Peak	5	83	11	0	8	35	67
Nonhome-Based	Peak	All	5,943	336	61	7	4,815	1,531
Nonhome-Based	Off-Peak	All	9,174	413	156	0	7,744	1,999
Airport	Peak	All	0	0	0	0	0	0
Airport	Off-Peak	All	0	0	0	0	0	0

Source: 2014 VIA On-board Survey Data

Table A.2 Income Mode Choice Alternative Specific Constants

PER	PURP	Inc Grp	K_OTH	K_URB	K_NM	K_DA	K_SR3	K_DACC	K_EXP	K_BIKE
PK	HBW	1	-2.0908	0.1623	3.7956	0.7329	-2.5654	-2.7842	-1.4951	-8.1500
PK	HBW	2	-3.4437	0.5066	3.7956	2.8738	-2.5654	-2.1076	-0.8264	-8.1500
PK	HBW	3	-5.6711	-4.6304	3.7956	3.3905	-2.5654	1.2842	-0.1085	-8.1500
PK	HBW	4	-5.6711	-4.6304	3.7956	3.3905	-2.5654	1.2842	-0.1085	-8.1500
PK	HBW	5	-5.6711	-4.6304	3.7956	3.3905	-2.5654	1.2842	-0.1085	-8.1500
PK	HBED1	1	-9.3978	-10.507	2.5965	-3.3659	5.4839	-3.4514	-0.7693	-7.9094
PK	HBED1	2	-13.156	-11.2282	2.5965	-3.5055	5.4839	-3.0948	-1.0754	-7.9094

PER	PURP	Inc Grp	K_OTH	K_URB	K_NM	K_DA	K_SR3	K_DACC	K_EXP	K_BIKE
PK	HBED1	3	-17.4637	-15.7026	2.5965	-3.8158	5.4839	-2.3230	3.0279	-7.9094
PK	HBED1	4	-17.4637	-15.7026	2.5965	-3.8158	5.4839	-2.3230	3.0279	-7.9094
PK	HBED1	5	-17.4637	-15.7026	2.5965	-3.8158	5.4839	-2.3230	3.0279	-7.9094
PK	HBED2	1	-2.5841	-1.5032	1.6248	4.9876	-1.9111	1.2695	-1.0605	-3.4440
PK	HBED2	2	-0.3867	0.0734	1.6248	4.2137	-1.9111	1.2744	0.1727	-3.4440
PK	HBED2	3	-3.2771	-4.0492	1.6248	3.5985	-1.9111	1.9112	-0.1241	-3.4440
PK	HBED2	4	-3.2771	-4.0492	1.6248	3.5985	-1.9111	1.9112	-0.1241	-3.4440
PK	HBED2	5	-3.2771	-4.0492	1.6248	3.5985	-1.9111	1.9112	-0.1241	-3.4440
PK	HBSH	1	-9.7154	-8.2409	-3.3386	0.7879	2.4832	-2.4008	-2.6958	-7.9071
PK	HBSH	2	-11.2743	-10.3312	-3.3386	0.5033	2.4832	4.0005	-1.7292	-7.9071
PK	HBSH	3	-14.5534	-13.0411	-3.3386	1.1135	2.4832	1.3079	-2.0126	-7.9071
PK	HBSH	4	-14.5534	-13.0411	-3.3386	1.1135	2.4832	1.3079	-2.0126	-7.9071
PK	HBSH	5	-14.5534	-13.0411	-3.3386	1.1135	2.4832	1.3079	-2.0126	-7.9071
PK	HBO	1	-6.0467	-4.3361	0.1713	0.7177	3.5159	-0.9492	-1.6665	-7.3133
PK	HBO	2	-7.6593	-6.4166	0.1713	0.4586	3.5159	0.0493	-0.3674	-7.3133
PK	HBO	3	-12.6862	-10.8343	0.1713	-0.1390	3.5159	0.6201	-0.3634	-7.3133
PK	HBO	4	-12.6862	-10.8343	0.1713	-0.1390	3.5159	0.6201	-0.3634	-7.3133
PK	HBO	5	-12.6862	-10.8343	0.1713	-0.1390	3.5159	0.6201	-0.3634	-7.3133
PK	NHB	1	-7.6562	-6.2731	1.1513	0.7094	-0.0016	-3.2567	-0.8151	-11.1453
PK	AIR	1	-7.2901	-6.5401	0.5466	0.4732	0.5560	-4.4794	-0.2198	-8.3607
OP	HBW	1	6.0646	5.8385	4.4613	2.7072	-2.3249	-5.9960	-1.1040	-8.1530
OP	HBW	2	-0.3243	3.0947	4.4613	2.6217	-2.3249	-1.9928	-0.9437	-8.1530
OP	HBW	3	-4.1329	-2.3573	4.4613	3.3673	-2.3249	-0.3165	-0.7328	-8.1530
OP	HBW	4	-4.1329	-2.3573	4.4613	3.3673	-2.3249	-0.3165	-0.7328	-8.1530
OP	HBW	5	-4.1329	-2.3573	4.4613	3.3673	-2.3249	-0.3165	-0.7328	-8.1530
OP	HBED1	1	-5.9847	-6.9414	2.8184	-1.8178	5.5279	0.0000	1.096	-7.8972
OP	HBED1	2	-7.8793	-10.3839	2.8184	-1.9546	5.5279	-2.8348	-3.0516	-7.8972
OP	HBED1	3	-10.8462	-15.6547	2.8184	-2.2631	5.5279	-0.9795	-2.8383	-7.8972
OP	HBED1	4	-10.8462	-15.6547	2.8184	-2.2631	5.5279	-0.9795	-2.8383	-7.8972
OP	HBED1	5	-10.8462	-15.6547	2.8184	-2.2631	5.5279	-0.9795	-2.8383	-7.8972
OP	HBED2	1	-2.1477	-3.8432	3.0512	7.1697	-0.6390	1.8562	-0.4577	-3.4363
OP	HBED2	2	2.1857	1.1473	3.0512	5.7619	-0.6390	0.2659	0.0816	-3.4363
OP	HBED2	3	-2.4115	-3.0971	3.0512	4.9367	-0.6390	0.0914	-0.4176	-3.4363
OP	HBED2	4	-2.4115	-3.0971	3.0512	4.9367	-0.6390	0.0914	-0.4176	-3.4363
OP	HBED2	5	-2.4115	-3.0971	3.0512	4.9367	-0.6390	0.0914	-0.4176	-3.4363
OP	HBSH	1	-9.0272	-8.8796	-3.6956	0.6718	1.3170	0.4633	-1.7956	-7.8904
OP	HBSH	2	-10.5525	-9.8142	-3.6956	0.4107	1.3170	-1.4878	-2.3882	-7.8904

PER	PURP	Inc Grp	K_OTH	K_URB	K_NM	K_DA	K_SR3	K_DACC	K_EXP	K_BIKE
OP	HBSH	3	-14.7943	-12.9368	-3.6956	0.5002	1.3170	1.7137	-2.0797	-7.8904
OP	HBSH	4	-14.7943	-12.9368	-3.6956	0.5002	1.3170	1.7137	-2.0797	-7.8904
OP	HBSH	5	-14.7943	-12.9368	-3.6956	0.5002	1.3170	1.7137	-2.0797	-7.8904
OP	HBO	1	-3.9349	-0.9600	0.0178	0.7202	2.5318	-4.6088	-1.9299	-7.2999
OP	HBO	2	-6.5466	-4.7459	0.0178	0.5531	2.5318	-2.8493	-0.7268	-7.2999
OP	HBO	3	-10.8840	-8.9865	0.0178	-0.3196	2.5318	-1.2122	-0.7691	-7.2999
OP	HBO	4	-10.8840	-8.9865	0.0178	-0.3196	2.5318	-1.2122	-0.7691	-7.2999
OP	HBO	5	-10.8840	-8.9865	0.0178	-0.3196	2.5318	-1.2122	-0.7691	-7.2999
OP	NHB	1	-7.2497	-5.4551	1.1232	0.9376	-0.6858	-2.7682	-0.4696	-11.1349
OP	AIR	1	-7.5649	-6.8149	0.2145	0.3115	-0.1504	-5.8094	0.3559	-8.3545

Note: K_Urb is the constant for urban; K_Oth for non-urban; K_NM is the constant for non-motorized; K_DA is the constant for drive alone; K_SR3 is the constant for shared ride 3+; K_DACC is the constant for drive to transit; K_EXP is the constant for express bus; K_BIKE is the constant for bike (in addition to K_NM)

Table A.3 Vehicle Sufficiency Mode Choice Alternative Specific Constants

PURP	VehSuf	K_DA	K_LCW	K_EXW	K_LCD	K_EXD	K_BIKE	K_WALK
HBW	1	-999	9.957136	9.957136	-999	-999	-7.32042	-7.32042
HBW	2	0	0	0	0	0	0	0
HBW	3	1.132273	-1.55729	-1.55729	1.328042	1.328042	-6.4286	-6.4286
HBED1	1	-999	10.50879	10.50879	-999	-999	3.765841	3.765841
HBED1	2	0	0	0	-999	-999	0	0
HBED1	3	1.905481	-2.65152	-2.65152	-999	-999	-3.6421	-3.6421
HBED2	1	-999	10.50879	10.50879	-999	-999	3.765841	3.765841
HBED2	2	0	0	0	0	0	0	0
HBED2	3	1.905481	-2.65152	-2.65152	-1.36801	-1.36801	-3.6421	-3.6421
HBSH	1	-999	10.50879	10.50879	-999	-999	3.765841	3.765841
HBSH	2	0	0	0	0	0	0	0
HBSH	3	1.905481	-2.65152	-2.65152	-1.36801	-1.36801	-3.6421	-3.6421
HBO	1	-999	10.50879	10.50879	-999	-999	3.765841	3.765841
HBO	2	0	0	0	0	0	0	0
HBO	3	1.905481	-2.65152	-2.65152	-1.36801	-1.36801	-3.6421	-3.6421
NHB	1	0	0	0	0	0	0	0
AIR	1	0	0	0	0	0	0	0

Note: K_LCW is the constant on walk to local bus; K_EXW is the constant on walk to express bus; K_LCD is the constant on drive to local bus; K_EXD is the constant on drive to express bus; K_WALK is the constant on walk; Vehicle sufficiency as defined in section 2.1.7.

Table A.4 Household Size Mode Choice Alternative Specific Constants

PURP	HH_LT_2	K_DA	K_SR3	K_LCW	K_EXW	K_LCD	K_EXD	K_BIKE	K_WALK
HBW	0	2.30686	-1.69732	0	0	0	0	0	0
HBW	1	0	0	0	0	0	0	0	0
HBED1	0	0	-4.98123	0	0	0	0	0	0
HBED1	1	0	0	0	0	0	0	0	0
HBED2	0	0	-4.98123	0	0	0	0	0	0
HBED2	1	0	0	0	0	0	0	0	0
HBSH	0	0	-4.98123	0	0	0	0	0	0
HBSH	1	0	0	0	0	0	0	0	0
HBO	0	0	-4.98123	0	0	0	0	0	0
HBO	1	0	0	0	0	0	0	0	0
NHB	1	0	0	0	0	0	0	0	0
AIR	1	0	0	0	0	0	0	0	0

Note: HH_LT_2 is 0 when the household size is >= 2; 1 otherwise.

Table A.5 Density Mode Choice Alternative Specific Constants

	Urban								Other		
PURP	K_SR2	K_SR3	K_EXD	K_EXW	K_LCD	K_LCW	K_BIKE	K_WALK	K_EXW	K_LCD	K_LCW
HBW	0	0	0.26057	0.26057	0.26057	0.26057	0.156285	0	0.26057	0	0.26057
HBNW	0.05279	0.05279	0.23418	0.23418	0.23418	0.23418	0.2787	0	0.23418	0	0.23418
NHB	0	0	0	0	0	0	0	0.22464	0	0	0
AIR	0	0	0	0.20471	0	0.20471	0	0.22464	0.20471	0	0.20471

Table A.6 Speed/Capacity Lookup Table

FTYPE	ATYPE	Speed	Capacity	Alpha	Beta
0	1	16	1,500	0.15	4
0	2	20	1,500	0.15	4
0	3	24	1,450	0.15	4
0	4	28	1,250	0.15	4
0	5	42	950	0.15	4
1	1	37	23,920	0.83	5.5
1	2	42	25,460	0.83	5.5
1	3	46	25,180	0.83	5.5
1	4	49	24,080	0.83	5.5
1	5	53	14,420	0.83	5.5
2	1	39	23,920	0.83	5.5
2	2	44	25,460	0.83	5.5
2	3	48	25,180	0.83	5.5
2	4	51	24,080	0.83	5.5

FTYPE	ATYPE	Speed	Capacity	Alpha	Beta
2	5	55	14,420	0.83	5.5
3	1	40	23,920	0.83	5.5
3	2	42	25,460	0.83	5.5
3	3	46	25,180	0.83	5.5
3	4	49	24,080	0.83	5.5
3	5	54	14,420	0.83	5.5
4	1	42	23,920	0.83	5.5
4	2	44	25,460	0.83	5.5
4	3	48	25,180	0.83	5.5
4	4	51	24,080	0.83	5.5
4	5	56	14,420	0.83	5.5
5	1	40	23,920	0.83	5.5
5	2	43	25,460	0.83	5.5
5	3	46	25,180	0.83	5.5
5	4	47	24,080	0.83	5.5
5	5	54	14,420	0.83	5.5
6	1	42	23,920	0.83	5.5
6	2	45	25,460	0.83	5.5
6	3	48	25,180	0.83	5.5
6	4	49	24,080	0.83	5.5
6	5	75	14,420	0.83	5.5
7	1	40	23,920	0.83	5.5
7	2	43	25,460	0.83	5.5
7	3	49	25,180	0.83	5.5
7	4	51	24,080	0.83	5.5
7	5	54	14,420	0.83	5.5
8	1	42	23,920	0.83	5.5
8	2	45	25,460	0.83	5.5
8	3	51	25,180	0.83	5.5
8	4	53	24,080	0.83	5.5
8	5	56	14,420	0.83	5.5
9	1	28	11,500	0.638	1.92
9	2	32	12,500	0.638	1.92
9	3	37	13,350	0.638	1.92
9	4	38	12,200	0.638	1.92
9	5	51	8,900	0.638	1.92
10	1	28	11,500	0.638	1.92
10	2	32	12,500	0.638	1.92
10	3	36	13,350	0.638	1.92
10	4	40	12,200	0.638	1.92
10	5	51	8,900	0.638	1.92
11	1	23	9,000	0.638	1.92
11	2	28	9,500	0.638	1.92
11	3	32	10,000	0.638	1.92
11	4	37	9,250	0.638	1.92
11	5	50	6,500	0.638	1.92
12	1	23	9,000	0.638	1.92
12	2	27	9,500	0.638	1.92
12	3	31	10,000	0.638	1.92
12	4	36	9,250	0.638	1.92
12	5	49	6,500	0.638	1.92
13	1	22	8,000	0.638	1.92
13	2	26	8,750	0.638	1.92
13	3	29	9,000	0.638	1.92
13	4	34	8,250	0.638	1.92
13	5	47	5,750	0.638	1.92
14	1	21	5,000	0.638	1.92

FTYPE	ATYPE	Speed	Capacity	Alpha	Beta
14	2	25	5,500	0.638	1.92
14	3	29	6,000	0.638	1.92
14	4	34	5,500	0.638	1.92
14	5	48	4,000	0.638	1.92
15	1	21	5,000	0.638	1.92
15	2	25	5,500	0.638	1.92
15	3	29	6,000	0.638	1.92
15	4	34	5,500	0.638	1.92
15	5	46	4,000	0.638	1.92
16	1	20	4,750	0.638	1.92
16	2	24	5,000	0.638	1.92
16	3	28	5,500	0.638	1.92
16	4	33	5,000	0.638	1.92
16	5	45	3,500	0.638	1.92
17	1	18	4,750	0.55	1.73
17	2	22	5,250	0.55	1.73
17	3	26	5,750	0.55	1.73
17	4	30	5,000	0.55	1.73
17	5	44	2,500	0.55	1.73
18	1	17	4,750	0.55	1.73
18	2	21	5,250	0.55	1.73
18	3	25	5,750	0.55	1.73
18	4	29	5,000	0.55	1.73
18	5	43	2,500	0.55	1.73
19	1	17	4,500	0.55	1.73
19	2	20	4,750	0.55	1.73
19	3	24	5,250	0.55	1.73
19	4	28	4,500	0.55	1.73
19	5	42	2,000	0.55	1.73
20	1	21	5,000	0.638	1.92
20	2	25	5,500	0.638	1.92
20	3	29	6,000	0.638	1.92
20	4	34	5,500	0.638	1.92
20	5	45	4000	0.638	1.92
21	1	26	15,000	0.638	1.92
21	2	30	15,000	0.638	1.92
21	3	34	15,000	0.638	1.92
21	4	39	15,000	0.638	1.92
21	5	50	15,000	0.638	1.92
22	1	28	15,000	0.638	1.92
22	2	32	15,000	0.638	1.92
22	3	36	15,000	0.638	1.92
22	4	41	15,000	0.638	1.92
22	5	52	15,000	0.638	1.92
23	1	28	15,000	0.638	1.92
23	2	32	15,000	0.638	1.92
23	3	36	15,000	0.638	1.92
23	4	41	15,000	0.638	1.92
23	5	50	15,000	0.638	1.92

Table A.7 PA to OD Conversion Time of Day Factors

Purpose	Period	Departure	Return
HBW	AM	0.49	0.02
HBW	PM	0.05	0.44
HBW	MD	0.29	0.19
HBW	NT	0.21	0.32
HBED1	AM	0.57	0.00
HBED1	PM	0.00	0.43
HBED1	MD	0.07	0.69
HBED1	NT	0.14	0.10
HBED2	AM	0.58	0.04
HBED2	PM	0.04	0.35
HBED2	MD	0.43	0.44
HBED2	NT	0.00	0.13
HBSH	AM	0.06	0.05
HBSH	PM	0.33	0.56
HBSH	MD	0.24	0.28
HBSH	NT	0.17	0.31
HBO	AM	0.27	0.11
HBO	PM	0.30	0.32
HBO	MD	0.27	0.19
HBO	NT	0.18	0.36
NHB	AM	0.14	0.14
NHB	PM	0.36	0.36
NHB	MD	0.34	0.34
NHB	NT	0.16	0.16
AIR	AM	0.27	0.11
AIR	PM	0.30	0.32
AIR	MD	0.27	0.19
AIR	NT	0.18	0.36
External	AM	0.06	0.06
External	PM	0.16	0.16
External	MD	0.20	0.20
External	NT	0.09	0.09
Truck	AM	0.06	0.06
Truck	PM	0.16	0.16
Truck	MD	0.20	0.20

Purpose	Period	Departure	Return
Truck	NT	0.09	0.09

Table A.8 Transit Path Parameter

Parameter	Value
Mode Table	
Mode Imp Weight	W_IVTT_+mode
Mode Impedance	per+_TRNT
Mode Used	MODE_USED_+mode
Mode Max Access	MAX_WALK *(TC 7)*
Mode Max Egress	MAX_WALK
Mode Xfer Table	
Inter-Mode Xfer From	FROM
Inter-Mode Xfer To	TO
Inter-Mode Xfer Stop	STOP
Inter-Mode Xfer Time	PENALTY
Inter-Mode Xfer Fare	FARE
Global Parameters	
Global Fare Value	3
Global Xfer Fare	0.15
Global Fare Weight	1
Global Imp Weight	1
Global Xfer Weight	2.5
Global IWait Weight	2.5
Global XWait Weight	2.5
Global Dwell Weight	1
Global Dwell On Time	0.33
Global Dwell Off Time	0
Global Xfer Time	-
Global Max IWait	60
Global Min IWait	0.01
Global Max XWait	60
Global Min XWait	0.01
Global Layover Time	0
Global Max WACC Path	10
Global Max Access	30
Global Max Egress	30
Global Max Transfer	10
Value of Time	0.167
Max Xfer Number	5
Walk Weight	2.5
Path Threshold	0.25
Flags	
Use All Walk Path	No
Use Mode	Yes
Use Mode Cost	Yes
Combine By Mode	No
Drive Access Fields	
Drive Time Weight	2.5
Max Drive Time	20
Max Access Drive Time	20
Use Park and Ride	Yes
Use P&R Walk Access	No
Use Transit Access	No