Travel Model Development: Calibration and Validation

Technical Report

Metropolitan Transportation Commission
with PB Americas, Inc.

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1 Introduction

In 2005, the Metropolitan Transportation Commission (MTC) and Parsons Brinckerhoff, Inc. (PB) started development of an activity-based travel demand model (*Travel Model One*) for the nine-county San Francisco Bay Area using PB's Coordinated Travel – Regional Activity-Based Modeling Platform (CT-RAMP). Individual components of the model were transferred from models previously developed for the San Francisco County Transportation Authority and the Atlanta Regional Commission (ARC). Transferring these model components to the CT-RAMP system and to the Bay Area population and transportation environment required extensive calibration to match the local household travel survey summaries, observed highway counts, and transit system boardings. This document describes this calibration and validation; the resulting model system is referred to as version 0.1 of *Travel Model One*.

After applying and validating the population synthesizer, creating network skimming procedures, and developing aggregate model targets from the 2000 Bay Area Travel Survey (BATS), the US Census, transit operator system data, and Caltrans highway count database, the team progressed through each step in the *Travel Model One* system in order, adjusting or re-estimating model parameters until the aggregate outcomes from the model, when applied to the year 2000 synthetic population, matched the targets. Because certain model steps influence the results of models further up and down the stream, the team cycled through the model system in several iterations of model re-calibration, achieving increasingly precise matches each time. In the final iteration, results from highway and transit validations for years 2000 and 2005 were used to adjust key model components, where the household survey targets were at odds with the results from the validations, to achieve a compromise that agreed with all sources to the greatest extent possible.

The remainder of this section gives an overview of the *Travel Model One* system, model inputs, skimming procedures, and calibration targets. Section 2 describes the calibration process and results in detail for each model component. Section 3 presents year 2000 highway and transit validation results. Section 4 summarizes the validation results for year 2005. Section 5 provides conclusions and recommended improvements.

1.1 General Model Design

Travel Model One has its roots in a wide array of analytical approaches, including discrete choice forms (multinomial and nested logit models), activity duration models, time-use models, models of individual micro-simulation with constraints, entropy-maximization models, etc. These tools are combined in the model design to realistically represent travel behavior, adequately replicate observed activity-travel patterns, and ensure model sensitivity to infrastructure and policies. The model is implemented in a micro-simulation framework. Micro-simulation methods capture aggregate outcomes through the representation of the behavior of individual decision-makers. The following section describes the basic conceptual framework at which the model operates.

1.1.1 Treatment of space

The *Travel Model One* framework allows for explicit consideration of detailed spatial information, but the advantages of additional spatial detail must be balanced against the additional efforts required to develop zone and associated network information at this level of

detail, as well as against the increases in model runtime associated primarily with path-building and assignment to smaller zones.

Travel Model One uses the existing 1454-zone system developed for MTC's previous, trip-based model, and is shown in Figure 1[1]. The zones are fairly large, which may distort the representation of transit access in mode choice. To ameliorate this problem, the zones have been further sub-divided into three categories of transit access, as shown in Table 1. All destination choice models operate at the sub-zone level (some zones contain only one sub-zone, so the actual number of sub-zones is less than 1454 times 3). The sub-zone shares are created by buffering around all transit stops according to the walk distances and computing the percent of zonal area within the urban footprint within each buffer[2]. These percentages are then used to by assuming an even distribution of activities across the parent zone for the purposes of zonal attractiveness. Finally, the walk access and egress time for the transit alternatives in the mode choice model are based on the distance defining the subzones, while walking to transit is unavailable in the mode choice model for subzones where transit is not within walking distance.

Table 1: Transit Accessibility Sub-Zone Categories

Category	Description	Distance to Transit
Short walk	Within approximately 7 minutes walk to the nearest transit stop	Less than 1/3 mile
Long walk	Within approximately 13 minutes walk to the nearest transit stop	Between 1/3 and 2/3 mile
No transit	Not within walking distance to transit	More than 2/3 mile

[1] An interactive TAZ map is available here: http://geocommons.com/maps/58264.

[2] An interactive map of the walk shares is available here: http://geocommons.com/maps/62754.

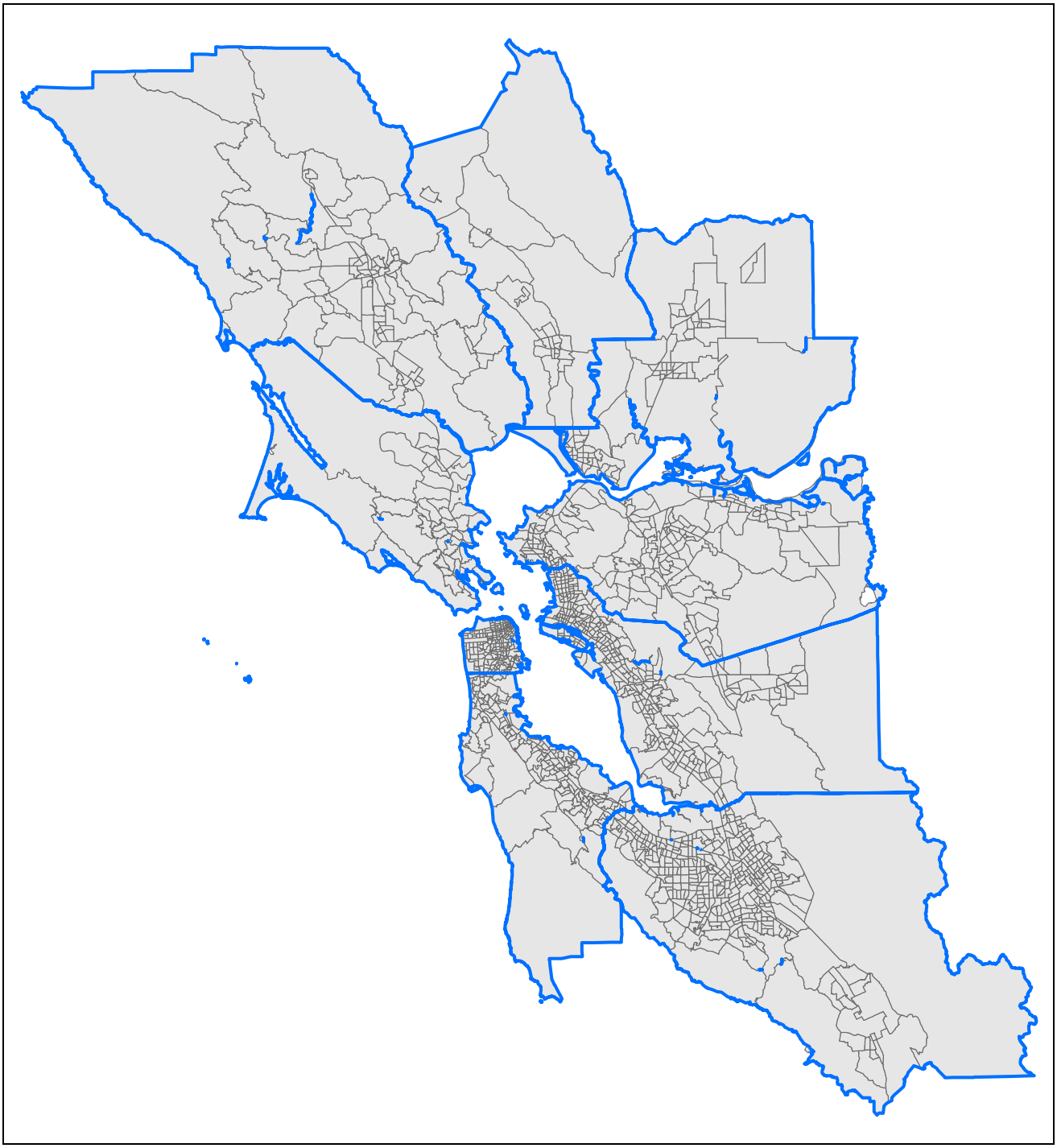


Figure 1: 1454 TAZ System with County Boundaries

1.1.2 Decision-making units

Decision-makers in the model system are households and persons. These decision-makers are created (synthesized) for each simulation year based on tables of households and persons from 2000 census data and forecasted TAZ-level distributions of households and persons by key socio-economic categories. The decision-makers are used in the subsequent discrete-choice models to select a single alternative from a list of available alternatives according to a probability distribution. The probability distribution is generated from a logit model which takes into account the attributes of the decision-maker and the attributes of the various alternatives. The decision-making unit is an important element of model estimation and implementation, and is explicitly identified for each model described in the following sections. For more information on the population synthesis procedure, see Section 1.2.1.

1.1.3 Person-type segmentation

Travel Model One is implemented in a micro-simulation framework. A key advantage of micro-simulation approach is that there are essentially no computational constraints on the number of explanatory variables can be included in a model specification. However, even with this flexibility, the model system will include some segmentation of decision-makers. Segmentation is a useful tool both to structure models and also as a way to characterize person roles within a household.

A total of eight segments of person-types, shown in Table 2, are used for the MTC model system. The person-types are mutually exclusive with respect to age, work status, and school status, and are based on tabulations of the relevant data items from the 2000 US Census Public Use Microdata Sample (PUMS).

Table 2: Person Types

Number	Person Type	Age	Work Status	School Status
1	Full-time worker*	18+	Full-time	None
2	Part-time worker	18+	Part-time	None
3	Non-working adult	18 – 64	Unemployed	None
4	Retired person	65+	Unemployed	None
5	College student†	18+	Any	College +
6	Driving age student	16-17	Any	Pre-college
7	Non-driving student	6 – 16	None	Pre-college
8	Pre-school child	0 – 5	None	None

* - Full-time employment is defined in the BATS 2000 survey as at least 30 hours/week; part-time is less than 30 hours/week but works on a regular basis.

† - Approximately 42% of the BATS 2000 college students were also full-time workers; only 1.5% of college students are less than 18 years of age, and only 2.8% of persons age 16-17 did not attend school.

1.1.4 Household-type segmentation

Household-type segments are useful for pre-defining certain data items (such as destination choice size terms) so that these data items can be pre-calculated for each segment. Pre-calculation of these data items reduces model complexity and runtime. The segmentation is based on household income, and includes four segments, as shown in Table 3.

Table 3: Household Types and Value of Time Distributions

Description		Household Income (1999 dollars)	Lognormal Value of Time Parameters		Mean Value of Time
			SD (log scale)	Median (log scale)	(nominal scale)
1	Low income	$0-30k	0.87	1.41	$6.01
2	Medium income	$30-60k	0.87	1.80	$8.81
3	High income	$60-100k	0.87	1.96	$10.44
4	Very high income	$100k+	0.87	2.18	$12.86

In the model, the persons in each household are assigned a simulated but fixed "value of time" that modulates the relative weight the decision-maker places on time and cost. The probability distribution from which the value of time is sampled was derived from a toll choice model estimated using data from a stated preference survey performed for the San Francisco County Transportation Authority's Mobility, Access, and Pricing Study, and is a lognormal distribution with a median that varies by income segment, as shown in the table. The distribution is truncated so that the maximum value of time is $50 per hour, illustrated by the modeled value of time distributions in Figure 2. The value of time of children in the household is assumed to be two-thirds the value for the adults in the household.

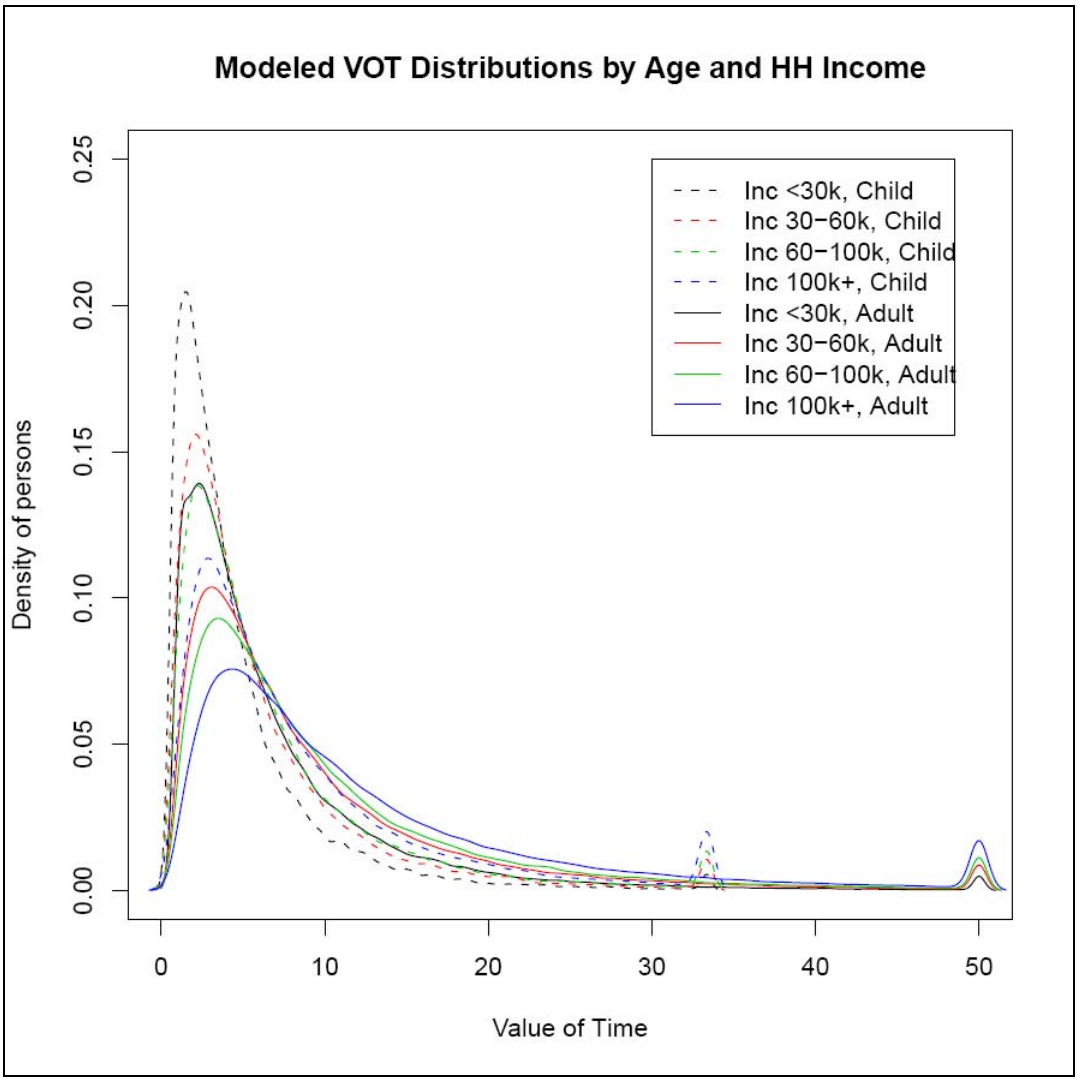


Figure 2: Modeled Value of Time (in 1999 dollars per hour) by Age and Household Income

1.1.5 Activity type segmentation

The 2000 BATS home-interview survey included sixteen different activity codes. Modeling each of the sixteen activity types would add significant complexity to the model system, so these detailed activity types are grouped into similar types. The activity types are used in most model system components, from developing daily activity patterns and to predicting tour and trip destinations and modes by purpose.

The set of activity types is shown in Table 4. The activity types are also grouped according to whether the activity is mandatory or non-mandatory and eligibility requirements are assigned determining which person-types can be used for generating each activity type. The classification scheme of each activity type reflects the relative importance or natural hierarchy of the activity, where work and school activities are typically the most inflexible in terms of generation, scheduling and location, and discretionary activities are typically the most flexible on each of these dimensions. Each out-of-home location that a person travels to in the simulation is assigned one of these activity types.

Table 4: Activity Types

Type	Purpose	Description	Classification	Eligibility
1	Work*	Working at regular workplace or work-related activities outside the home.	Mandatory	Workers and students
2	University	College or University	Mandatory	Age 18+
3	High School	Grades 9-12	Mandatory	Age 14-17
4	Grade School	Grades K-8	Mandatory	Age 5-13
5	Escorting	Pick-up/drop-off passengers (auto trips only).	Non-Mandatory	Age 16+
6	Shopping	Shopping away from home.	Non-Mandatory	Age 5+ (if joint travel, all persons)
7	Other Maintenance	Personal business/services and medical appointments.	Non-Mandatory	Age 5+ (if joint travel, all persons)
8	Social/ Recreational	Recreation, visiting friends/family.	Non-Mandatory	Age 5+ (if joint travel, all persons)
9	Eat Out	Eating outside of home.	Non-Mandatory	Age 5+ (if joint travel, all persons)
10	Other Discretionary	Volunteer work, religious activities.	Non-Mandatory	Age 5+ (if joint travel, all persons)

* - It is not possible to identify regular workplace from other work-related trips in the BATS activity diary; workplace was not collected during recruitment.

1.1.6 Treatment of time

The model system functions at a temporal resolution of one-hour. These one hour increments begin with 3 am. and end with 3 am the next day. Temporal integrity is ensured so that no activities are scheduled with conflicting time windows, with the exception of short activities/tours that are completed within a one-hour increment. For example, a person may have a short tour that begins and ends within the 8 am to 9 am period, as well as a second longer tour that begins within this time period, but ends later in the day.

A critical aspect of the model system is the relationship between the temporal resolution used for scheduling activities and the temporal resolution of the network assignment periods. Although each activity generated by the model system is identified with a start time and end time in one-hour increments, level-of-service matrices are only created for five aggregate time periods – early am, am peak, midday, pm peak, and evening. The trips occurring in each time period reference the appropriate transport network depending on their trip mode and the mid-point trip time. The definition of time periods for level-of-service matrices is given in Table 5.

Table 5: Time periods for level-of-service skims and assignment

Number	Description	Begin Time	End Time
1	Early AM	3:00 A.M.	5:59 A.M.
2	AM Peak	6:00 A.M.	9:59 A.M.
3	Midday	10:00 A.M.	2:59 P.M.
4	PM Peak	3:00 P.M.	6:59 P.M.
5	Evening	7:00 P.M.	2:59 A.M.

1.1.7 Trip Modes

Table 6 lists the trip modes defined in the MTC models. There are 18 modes, including auto by occupancy and toll/non-toll choice, walk and bike, and walk and drive access to five different transit line-haul modes. Note that the pay modes are those that involve paying a choice or "value" toll. Because drivers have little choice about paying tolls on the area bridges, those are counted as a cost, but the mode is considered "free". The number of the mode is given for reference, as numbers are used to identify modes in the software.

Table 6: Trip Modes for Assignment

Number	Mode
1	Auto SOV (Free)
2	Auto SOV (Pay)
3	Auto 2 Person (Free)
4	Auto 2 Person (Pay)
5	Auto 3+ Person (Free)
6	Auto 3+ Person (Pay)
7	Walk
8	Bike
9	Walk-Local Bus
10	Walk-Light-Rail Transit
11	Walk-Express Bus
12	Walk-Bus Rapid Transit
13	Walk-Heavy Rail
14	Drive-Local Bus
15	Drive-Light-Rail Transit
16	Drive-Express Bus
17	Drive-Bus Rapid Transit
18	Drive-Heavy Rail

1.1.8 Basic Design of *Travel Model One*

The general design of the travel demand model is presented in Figure 3 below. Choices that relate to the entire household or a group of household members and assume explicit modeling of intra-household interactions (sub-models 2.2, 3.1, 3.3.1, 3.3.2) are highlighted in green.

The model system uses synthetic household population as a base input (sub-model 1). It is followed by long-term choices that relate to the usual workplace/university/school for each worker and student (sub-model 2.1), household car ownership (sub-model 2.2), and the availability of free parking at workplaces (sub-model 2.3).

The daily activity pattern type of each household member (model 3.1) is the first travel-related sub-model in the modeling hierarchy. This model classifies daily patterns by three types:

1) **Mandatory**, which includes at least one out-of-home mandatory activity (work or school);
2) **Non-mandatory**, which includes at least one out-of-home non-mandatory activity, but does not include out-of-home mandatory activities; and
3) **Home,** which does not include any out-of-home activity or travel.

However, the pattern type sub-model leaves open the frequency of tours for mandatory and non-mandatory purposes since these sub-models are applied later in the model sequence. Daily pattern-type choices of the household members are linked in such a way that decisions made by some members are reflected in the decisions made by the other members.

After the frequency (3.2.1) and time-of-day (3.2.2) for work and school tours are determined, the next major model component relates to joint household travel. This component produces a number of joint tours by travel purpose for the entire household (3.3.1), travel party composition in terms of adults and children (3.3.2), and then defines the participation of each household member in each joint household tour. It is followed by choice of destination (3.3.4) and time-of-day (3.3.5).

The next stage relates to maintenance and discretionary tours that are modeled at the individual person level. The models include tour frequency (3.4.1), choice of destination (3.4.2) and time of day (3.4.3). Next, a set of sub-models relate tour-level details on mode (4.1), exact number of intermediate stops on each half-tour (4.2) and stop location (4.3). It is followed by the last set of sub-models that add details for each trip including trip departure time (5.1), trip mode details (5.2) and parking location for auto trips (5.3). The trips are then assigned to highway and transit networks depending on the trip mode (5.4).

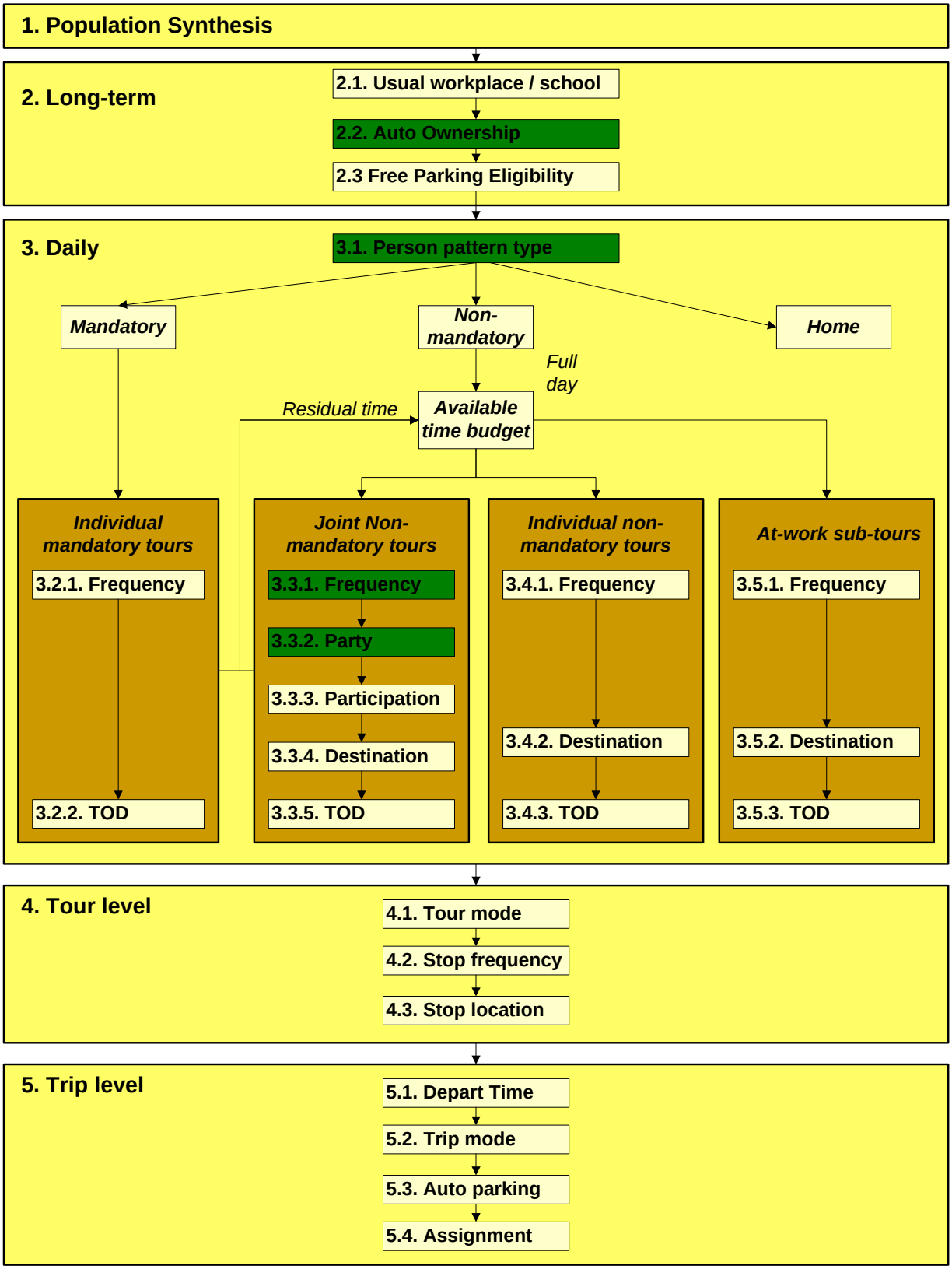


Figure 3: Basic Model Design and Linkage between Sub-Models

1.2 Model Inputs and Calibration Target Data

1.2.1 Inputs

Zonal Data

The aggregate socioeconomic data for each TAZ required by *Travel Model One* are not developed "in-house," but rather by the Association of Bay Area Governments (ABAG). The current demographic and employment inputs to *Travel Model One* are the total households in each of four income quartiles, the population in each of five age categories, high school and grade school enrollment, the number of jobs in each of six employment categories, by TAZ, shown in Table 7. County summaries of zonal demographic and employment data for the year 2000 appear in

Table 8 and Table 9.

Table 7: NAICS-Based Employment Categories in MTC Data Inputs

Label	Category	NAICS	Descriptions
AGREMPN	Agricultural & Natural Resources	11	Agriculture/Forestry/Fishing/Hunting
		21	Mining
MWTEMPN	Manufacturing, Wholesale Trade & Transportation	22	Utilities
		31-33	Manufacturing
		42	Wholesale Trade
		48-49	Transportation & Warehousing
RETEMPN	Retail Trade	44-45	Retail Trade (excluding Eating & Drinking places)
FPSEMPN	Financial & Professional Services	52	Finance, Insurance
		53	Real Estate Rental & Leasing
		54	Professional, Scientific & Technical Services
		55	Management of Companies & Enterprises
		56	Administrative, Support, Waste Management
HEREMPN	Health, Educational and Recreational Services	61	Educational Services
		62	Health Care, Social Assistance
		71	Arts, Entertainment, Recreation
		72	Accommodation, Food Services
		81	Other Services
OTHEMPN	Other	23	Construction
		51	Information
		92	Public Administration

Table 8: Year 2000 Zonal Demographic Data Summarized by County

County	Households	Household Income Distribution				Persons	Person Age Distribution				
		$0-30k	$30-60k	$60-100k	$100k+		0-4	5-19	20-44	45-64	65+
San Francisco	329,698	32%	21%	22%	25%	776,733	4%	12%	48%	22%	14%
San Mateo	254,107	21%	20%	26%	32%	707,163	6%	19%	39%	23%	12%
Santa Clara	565,861	20%	19%	26%	35%	1,682,585	7%	20%	42%	21%	10%
Alameda	523,366	31%	22%	25%	22%	1,443,818	7%	20%	41%	22%	10%
Contra Costa	344,127	25%	22%	27%	27%	948,816	7%	22%	36%	24%	11%
Solano	130,404	30%	26%	28%	16%	394,542	7%	24%	38%	22%	9%
Napa	45,401	32%	25%	25%	19%	124,279	6%	21%	33%	24%	15%
Sonoma	172,400	31%	26%	26%	18%	458,614	6%	21%	35%	25%	13%
Marin	100,653	22%	20%	23%	35%	247,289	5%	16%	35%	30%	14%
All	2,466,017	26%	21%	25%	27%	6,783,839	6%	20%	40%	23%	11%

Table 9: Year 2000 Zonal Employment Data Summarized by County

County	School Enrollment		Employment					
	High School	College	RETEMPN	FPSEMPN	HEREMPN	OTHEMPN	AGREMPN	MWTEMPN
San Francisco	28,092	84,356	57,401	208,018	192,884	105,857	1,041	77,300
San Mateo	28,986	25,537	45,918	95,142	94,313	55,948	1,917	93,259
Santa Clara	84,401	141,056	100,563	211,232	247,544	133,698	4,556	346,515
Alameda	65,743	105,837	83,896	144,868	218,409	106,907	1,937	194,130
Contra Costa	46,267	39,723	46,721	89,510	115,930	60,472	2,545	56,105
Solano	22,241	11,723	17,593	18,354	47,009	29,677	2,058	22,040
Napa	6,090	8,044	7,019	8,627	24,146	8,784	3,097	14,688
Sonoma	21,333	31,123	26,883	38,980	72,511	31,035	6,513	45,575
Marin	9,920	10,287	16,628	36,861	43,258	22,748	810	13,801
All	313,072	457,686	402,622	851,592	1,056,004	555,126	24,474	863,413

The zonal data also includes transportation and land use characteristics such as the estimated parking cost, auto terminal time, and the land areas devoted to different uses. Each zone is also categorized into one of six area types. The area type is based on area density according to Table 10 where

Area Density = (Total Population + 2.5 * Total Employment) / (Residential Acres + Commercial/Industrial Acres).

Table 10: Zonal Area Type Definitions

Area Type	Description	Area Density
0	Regional Core	> 300
1	CBD	100 - 300
2	Urban Business	55 - 100
3	Urban	30 - 55
4	Suburban	6 - 30
5	Rural	< 6

A map of the zonal area types appears in Figure 4[3].

[3] An interactive area type map is available here: http://geocommons.com/maps/58712.

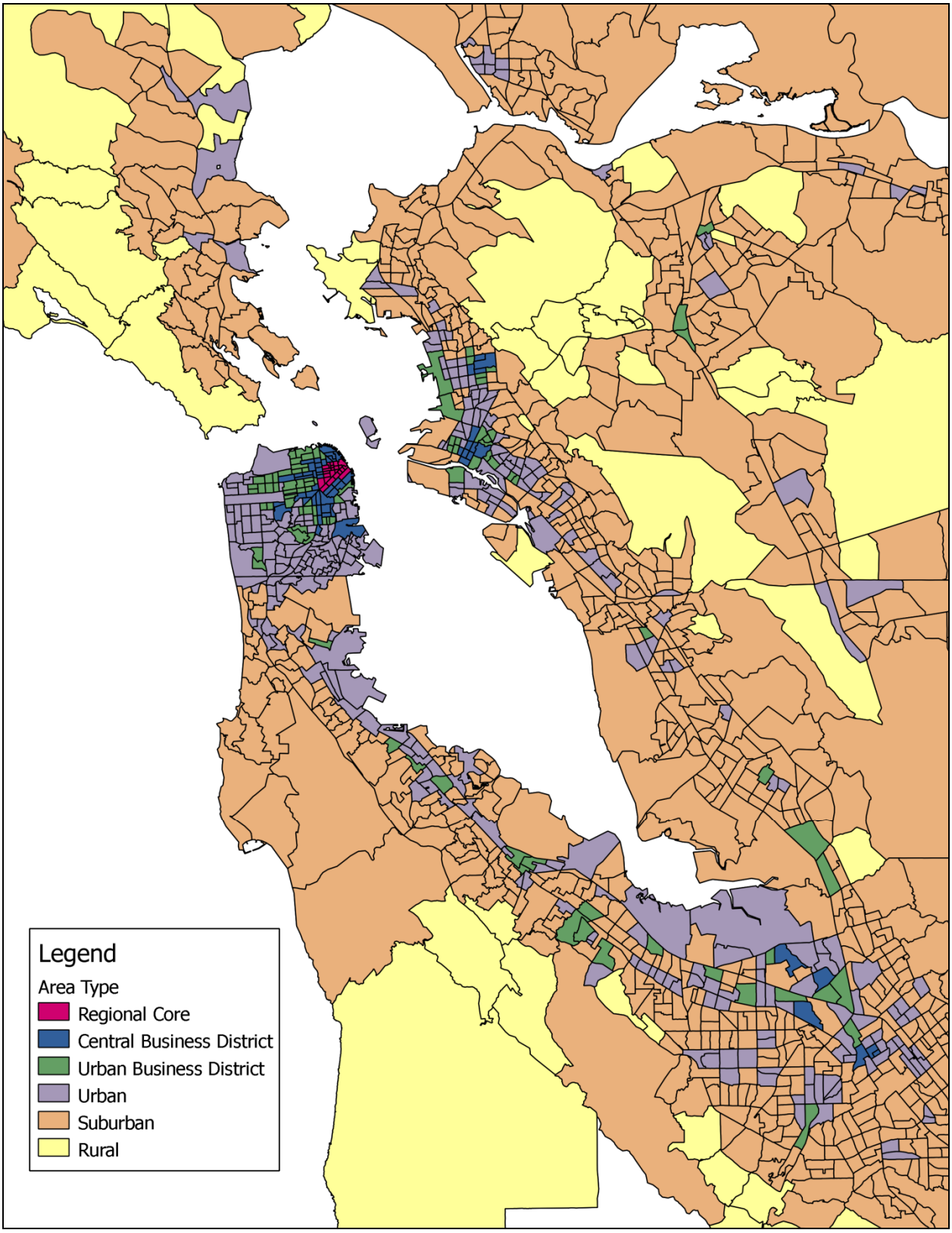


Figure 4: Zonal Area Type Map

Synthetic Population

A synthetic population is created using a modification of the open source PopSyn software originally designed for Atlanta Regional Commission (ARC). The population synthesizer takes as input Census data and zonal-level and regional marginal distributions of households by various characteristics that are used as controls which the synthetic population is forced to match.

The population synthesizer first develops a "base year" population distribution using year 2000 Census data. A set of controlled-for attributes are defined, and Census Summary File 1, Summary File 3, and the Census Transportation Planning Package information is used to develop single and multi-dimensional distributions of these attributes. These attributes include:

- Householder age
- Household size
- Household income
- Presence of children in household
- Number of workers in household
- Number of units in household structure
- Population group quarters type

Once this distribution is established, the population synthesis tool then samples PUMS records to create a fully enumerated representation of the population. The 2000 PUMS data are tabulated based on the variables above to generate a seed distribution with seven dimensions and 304 cells. This seed distribution is then adjusted using iterative proportional fitting (IPF) to a set of marginal control totals for one or more of the dimensions. For the base-year application, those control totals are derived entirely from 2000 Census data tabulated at the block-group level and converted to a TAZ-level.

When controlling to these base-year marginals, the IPF produces a base-year seed distribution for the 304 categories. This new seed distribution is then adjusted through a second IPF process to match a set of "forecast-year" marginal control totals. For the forecast years, a more limited set of control totals is available in the TAZ data files. Households are drawn from the PUMS sample to fill this integer distribution and create the synthetic population.

The population synthesizer was implemented to generate populations representing residents of the entire Bay Area. Table 11 shows the population synthesizer validation results for the 9-County area. The validation results compare the synthesized population to Census data or to the TAZ data at a PUMA level. All values are percents, unless the category label indicates that it is a total. Note that not all categories in the validation tables are controlled for, and it is expected that any controlled categories will fit better than the uncontrolled categories.

Table 11: Population Syn. PUMA-level Year 2000 Validation Results for Nine-County Bay Area

Label	Pop Syn %	Census %	Mean Diff. %	Std. Dev. %	Min. Diff. %	Max. Diff. %
TOTAL: Households	2,466,190	2,465,600	-0.1	2.5	-8.9	14.3
Family households	64.5	64.7	0.4	3.6	-6.4	9.6
Nonfamiliy households	35.5	35.3	0.4	8.1	-30.4	22.7
Households w/ householder age 15-64	81.6	81.6	0.0	0.4	-1.0	1.2
Households w/ householder age 65+	18.4	18.4	-0.2	1.8	-4.7	3.8
Households w/ 5+ persons	12.0	12.6	-3.9	8.2	-20.8	24.6
Households w/ 0 workers	20.1	21.8	-7.8	13.6	-42.7	31.0
Households w/ 3+ workers	9.9	9.1	10.6	18.3	-41.7	69.6
Households w/ income $100k+	27.8	26.9	4.0	2.6	0.8	14.7
TOTAL: Persons in households	6,533,110	6,639,830	-1.5	3.4	-12.9	10.3
Persons in family households	81.9	82.0	0.2	1.6	-2.5	6.3
Persons in nonfamily households	18.1	18.0	0.4	7.1	-19.2	21.9
TOTAL: Persons	6,672,830	6,782,620	-1.6	3.5	-12.9	10.8
Males	49.5	49.8	-0.7	1.3	-3.8	2.0
Females	50.5	50.2	0.7	1.3	-1.9	4.3
Persons age 65+	11.0	11.2	-1.5	3.1	-10.2	5.4
TazData: TOTAL: Households	2,466,190	2,466,200	0.0	0.1	-0.2	0.3
TazData: Households in single-family dwelling units	63.1	63.1	0.5	2.1	-1.1	9.8
TazData: Households in multi-family dwelling units	36.9	36.9	0.3	0.9	-1.7	3.5
TazData: Households w/ 5+ persons	12.0	11.4	5.0	12.1	-29.5	28.2
TazData: Households w/ 0 workers	20.1	20.1	0.0	1.6	-8.2	2.6
TazData: Households w/ 3+ workers	9.9	9.9	0.0	1.2	-4.1	2.7
TazData: Households w/ Income $100k+	27.8	27.8	0.2	1.3	-1.2	5.9
TazData: Households w/ householder age 65+	18.4	18.4	-0.1	1.7	-4.8	4.1
TazData: TOTAL: Persons	6,672,830	6,764,730	-1.2	2.5	-6.0	6.5
TazData: Persons in households	97.9	97.9	0.0	0.4	-0.1	2.7
TazData: Persons in group quarters	2.1	2.1	0.2	5.6	-30.8	6.1
TazData: Persons age 65+	11.0	11.2	-1.5	3.1	-9.3	5.4
TazData: TOTAL: Employed residents	3,389,000	3,394,820	-0.1	1.5	-2.3	5.8
TazData: Employed residents in households	99.4	99.4	0.0	0.0	-0.1	0.1
TazData: Employed residents in group quarters	0.6	0.6	-3.5	20.5	-100.0	22.7

Networks

The highway network in the MTC model contains all facilities with a functional classification of collector or higher (see Figure 5). The volume delay-functions for the highway network are based on a lookup table on the Area Type and the Facility Type, which is similar to a functional classification as shown in Table 12. High Occupancy Vehicle (HOV) and High Occupancy / Toll (HOT) lanes—of which the latter does not exist in the base years 2000 and 2005—are modeled as separate network links, parallel to the link representing general purpose lanes.

The network file that is input to the beginning of the model stream contains attributes that are generic to the five time periods. During a model run, this network is split into five copies, and a

series of TP+ scripts make changes that depend on the time period, such as setting tolls, changing the number of lanes on reversible facilities, and adding prescribed time delays to bridge toll plazas. These time-specific networks are then used for skimming and assignment for the five separate time periods.

Table 12: Facility Type Definitions

Facility Type	Description
1	Freeway-to-freeway connector
2	Freeway
3	Expressway
4	Collector
5	Ramp
6	Centroid connector
7	Major arterial

MTC also maintains a set of transit line files which contain the routing, access, and fare information for each transit line and each transit provider in the region. The transit data also includes auxiliary data, such as park and ride nodes, data showing to which highway links the park and ride nodes connect, and walk funnel links from park and ride nodes to corresponding station platforms. These auxiliary links and nodes are demonstrated in Figure 6. Before each model run, walk access links are generated from zone centroids to each transit stop within ¾ mile, and drive access links are generated to the four closest park and ride lots to each zone. In addition, drive access "kiss and ride" links are generated to each bus stop within ¾ mile, but these drive access links can be used only for local bus boardings.

The transit lines are divided into five modal groups: local bus, light rail/ferry, express bus, heavy rail, and commuter rail. Table 13 shows the correspondence between transit providers, and the mode codes for the different types of the auxiliary transit links.

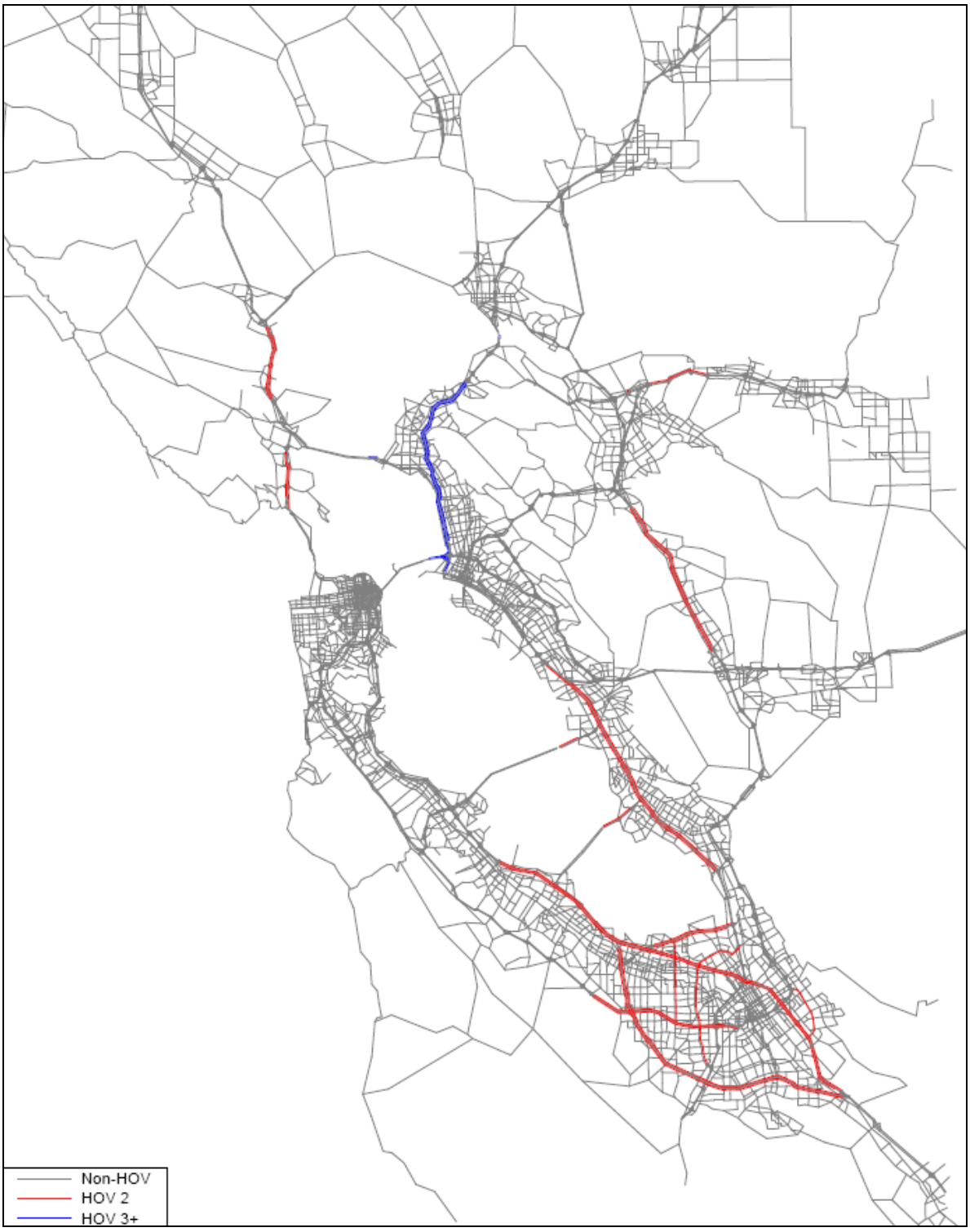


Figure 5: 2000 Highway Network

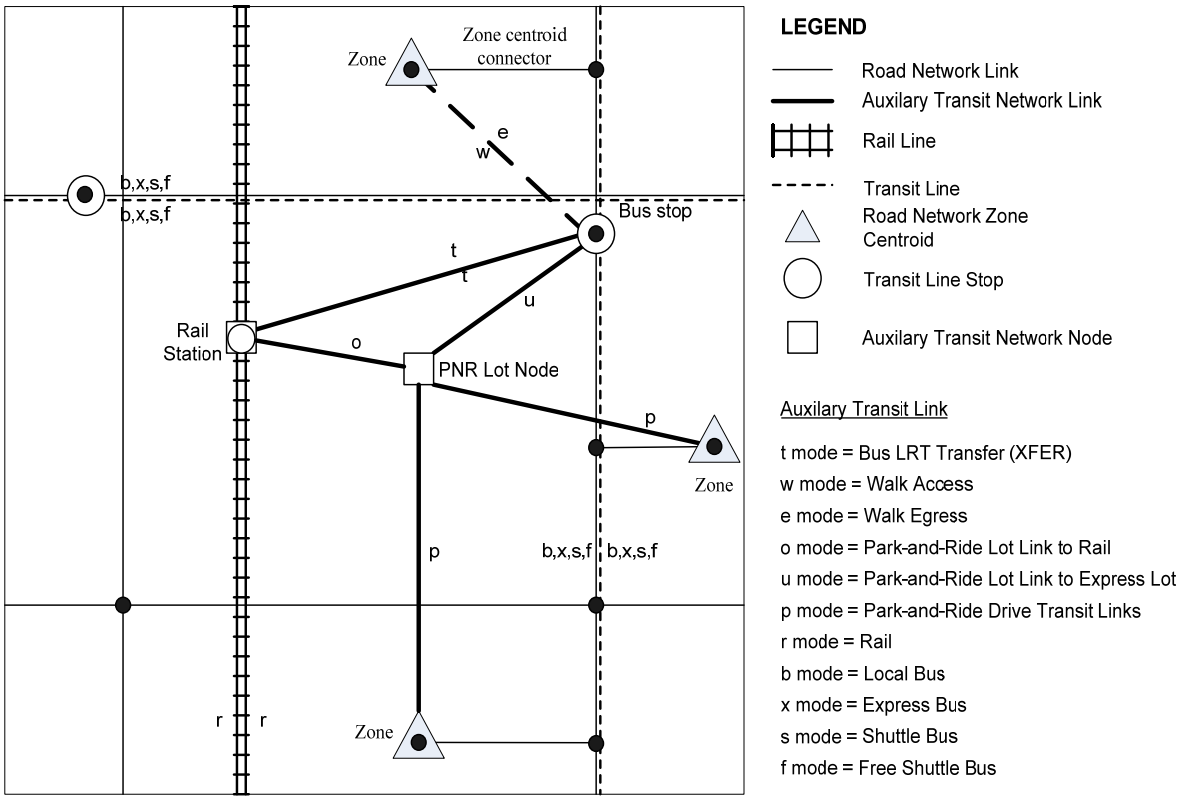


Figure 6: Auxiliary Transit Network Links

Table 13: Transit Network Modes

Network Mode	Name	Aggregate Mode
1	Walk access connectors	Auxiliary
2	Drive access connectors	Auxiliary
3	Stop-to-Stop and Stop-to-Station Aux nodes	Auxiliary
4	Drive access walk funnel (lot) links	Auxiliary
5	Walk access walk funnel links	Auxiliary
6	Walk egress connectors	Auxiliary
7	Drive egress connectors	Auxiliary
8	Not Used	Auxiliary
9	Not Used	Auxiliary
10	West Berkeley	Local
11	BWS	Local
12	Emery	Local
13	Stanford Shuttles	Local
14	Caltrain Shuttles	Local
15	VTA Shuttles	Local
16	Palo Alto/Menlo Park	Local
17	Wheels Ace Shuttles	Local
18	Amtrak Shuttles	Local
19	reserved	Local
20	MUNI Cable Cars	Local
21	MUNI Richmond Dist	Local
22	MUNI Mission Bayshore	Local
23	MUNI other	Local
24	SamTrans Coastal	Local
25	SamTrans North Bayside	Local
26	SamTrans South Bayside	Local

Network Mode	Name	Aggregate Mode
27	SamTrans Intercity	Local
28	SCVTA-Local	Local
29	SCVTA-Limited	Local
30	AC Local North	Local
31	AC Local South	Local
32	AC Fremont/Newark	Local
33	LAVTA-Dublin	Local
34	LAVTA-Pleasanton	Local
35	LAVTA-Livermore	Local
36	LAVTA-Intercity	Local
37	reserved	Local
38	Union City	Local
39	reserved	Local
40	AirBART	Local
41	reserved	Local
42	CCCTA-Local	Local
43	reserved	Local
44	Tri-Delta	Local
45	reserved	Local
46	WestCat	Local
47	ML30Z	Local
48	reserved	Local
49	Vallejo-Local	Local
50	Vallejo-BARTlink	Local
51	reserved	Local
52	Fairfield-local	Local
53	Fairfield-CityLink	Local
54	Fairfield-BARTlink	Local
55	American Canyon	Local
56	Vacaville	Local
57	reserved	Local
58	Benicia	Local
59	reserved	Local
60	NVT	Local
61	Vine	Local
62	reserved	Local
63	Sonoma-Local	Local
64	Sonoma-Intercity	Local
65	reserved	Local
66	Santa Rosa	Local
67	reserved	Local
68	Petaluma	Local
69	reserved	Local
70	GGT SF Ferry feeder	Local
71	GGT Ferry feeder	Local
72	GGT Marin/Sonoma	Local
73	GGT Richmond	Local
74-78	reserved	Local
79	Oakland Airport Connector	Local
80	SamTrans Express	Express
81	SCVTA-Express	Express
82	DB X	Express
83	reserved	Express
84	AC Transbay	Express
85	reserved	Express
86	CCCTA-Express	Express
87	GGT SF	Express
88-99	reserved	Express
100	East Bay Ferries	Ferry
101	GGT Larkspur Ferry	Ferry
102	GGT Sausalito	Ferry
103	Tiburon Ferry	Ferry
104	Vallejo Ferries	Ferry

Network Mode	Name	Aggregate Mode
105	reserved	LRT
106	reserved	LRT
107	MUNI Metro	LRT
108	SCVTA-LRT	LRT
109	reserved	LRT
110	BART	Heavy Rail
111-119	reserved	Heavy Rail
120	Caltrain	Commuter Rail
121	Amtrak-CAP	Commuter Rail
122	Amtrak-SJQ	Commuter Rail
123	ACE	Commuter Rail
124	DB Rail	Commuter Rail
125-129	reserved	Commuter Rail

Level-of-Service Matrices

Travel Model One runs in several iterations, with network supply conditions feeding back to the demand models to reach an equilibrium between highway and transit levels of service and the decision-makers' response to the options available to them. The method through which this feedback is achieved is through network skims. After the highway assignment (at the end of each iteration), auto and bus travel times on the highway network are fed back to the beginning of the model system, and the minimum generalized cost path is determined between each pair of zones for each mode – and each combination of walk and drive access and egress, in the case of transit. Characteristics of these shortest paths such as the travel time, in-vehicle time on different modes, fares and tolls, number of transfers are stored as TP+ matrices that are read in by *Travel Model One* for use in the demand models.

In future year scenarios, the initial skims for the first iteration are obtained by performing a highway assignment with the scenario networks and so-called "warm start" trip tables. For the year 2000 calibration, the highway skims were taken from the loaded network output by MTC's trip-based model. Table 14 describes the skimming procedures for the different modes. For the highway modes, separate free and pay paths are constructed for each vehicle occupancy (where free paths basically "turn off" all non-bridge toll lanes). Transit paths are built for each line-haul mode, including local bus, light rail/ferry, express bus, heavy rail, and commuter rail.

Because the best transit path available often involves transfers, we must allow combinations of submodes in the transit paths. In order to keep the separation of transit line-haul modes well defined, transit skims are based on a modal hierarchy in which modes that are ranked lower in the hierarchy may be used as feeder modes to modes ranked higher. In order to reveal a path that contains the primary submode whenever it is available, the perceived travel time on feeder modes is weighted at 1.5 times the time on the line-haul model in the generalized cost function. If the path found during this biased search does not contain any travel on the line-haul mode, the submode is considered unavailable in mode choice.

Table 14: Skimming Procedures by Mode

Mode	Skims
Drive-alone free	All general purpose lanes available. HOV lanes, HOT lanes, and toll lanes unavailable. Toll bridges are available.
Drive-alone pay	All general purpose lanes and toll lanes are available. HOV lanes are unavailable. HOT lanes are available for the SOV toll rate. Toll bridges are available.
Shared-2 free	All general purpose lanes available. 2+ occupancy HOV lanes available. Toll lanes unavailable. HOT lanes where 2+ occupant vehicles go free are available. Toll bridges are available.
Shared-2 pay	All general purpose lanes available. 2+ occupancy HOV lanes and HOT lanes where 2+ occupant vehicles go free are available for free. Toll lanes and HOT lanes where 2-occupant vehicles are tolled at the 2-occupant toll rate. Toll bridges are available.
Shared-3+ free	All general purpose lanes available. 2+ and 3+ occupancy HOV lanes available. Toll lanes unavailable. HOT lanes where 2+ or 3+ occupant vehicles go free are available. Toll bridges are available.
Shared-3+ pay	All general purpose lanes available. 2+ and 3+ occupancy HOV lanes and HOT lanes where 2 or 3+ occupant vehicles go free are available for free. Toll lanes and HOT lanes where 3+ occupant vehicles are tolled at the 3+ occupant toll rate. Toll bridges are available.
Walk	Highway distance, excluding freeways, but allowing select bridges with sidewalks
Bike	Highway distance, excluding freeways, but allowing select bridges with bike lanes
Walk-Local	Local Bus by walk access/egress
Walk-LRT/Ferry	LRT/Ferry by walk access/egress. Local bus included as a feeder mode.
Walk-Express	Express bus by walk access/egress. Local bus, LRT/Ferry included as feeder modes.
Walk-BART	BART by walk access/egress. Local bus, LRT/Ferry, and express bus included as feeder modes.
Walk-Commuter Rail	Commuter Rail by walk access/egress. Local bus, LRT/Ferry, express bus, and BART included as feeder modes.
Drive-Local	Local Bus by drive access/walk egress
Drive-LRT/Ferry	LRT/Ferry by drive access/walk egress. Local bus and express bus included as feeder modes.
Drive-Express	Express bus by drive access/walk egress. Local bus, included as a feeder mode.
Drive-BART	BART by drive access/walk egress. Local bus, LRT/Ferry, and express bus included as feeder modes.
Drive-Commuter Rail	Commuter Rail by drive access/walk egress. Local bus, LRT/Ferry, express bus, and BART included as feeder modes.

An additional set of generic transit skims is also used where the submode is unknown. These generic transit skims are generated by allowing all submodes and weighing the perceived travel time on each submode equally. The primary use of the generic transit skims are in the zonal accessibility calculations, the subject of the next section.

Zonal Accessibility Calculations

After the skim matrices are generated, a measure of the accessibility of each zone is calculated for three generic modes: auto, walk-transit, and non-motorized. The zonal accessibility is a measure of the ease with which one can reach destinations of interest using only the given travel mode. The accessibility of zone *i* is a simplified destination choice logsum defined as follows:

$$Accessibility_i = \log\left(\sum_{j \in Zones} A_j \cdot \exp(-0.05 \cdot T_{i,j})\right)$$

where $T_{i,j}$ is the perceived travel time from zone *i* to zone *j*, A_j is the number of attractions (jobs of a certain category) in zone *j*.

The zonal accessibility is calculated for both total and retail employment, with both am peak and midday skims. The auto skim is for drive alone, the transit skim is the generic walk-transit skim, and the non-motorized skim is the walk distance skim converted to travel time with the assumption of a 3 mph walking speed.

The difference between auto and transit accessibilities is a key input to the auto ownership model. Geographic plots of midday (or "off-peak") accessibility to all employment for auto, transit, and non-motorized modes appear in Figure 7 through Figure 10. The thematic mapping color ramp is presented on the same scale in each plot, so the levels are comparable. However, an additional auto accessibility plot has been provided (**Error! Reference source not found.**), with accessibility expressed as a percent of the maximum auto accessibility, in order to better explore the differentiation of auto accessibility by zone.

The auto accessibility does not vary much by zone because many destinations are reachable from each zone by car. On the other hand, transit accessibility varies greatly depending on the number of routes, speed, and frequency of transit service at the origin zone. Some locations have no transit accessibility. The non-motorized accessibility varies a lot, as well, but despite being low in several places, the non-motorized accessibility is higher in some places than the transit accessibility because intrazonal destinations are included in the non-motorized term. This inconsistency is not a problem for the auto ownership model, however, because the estimated coefficients on the accessibility terms will correct for the difference.

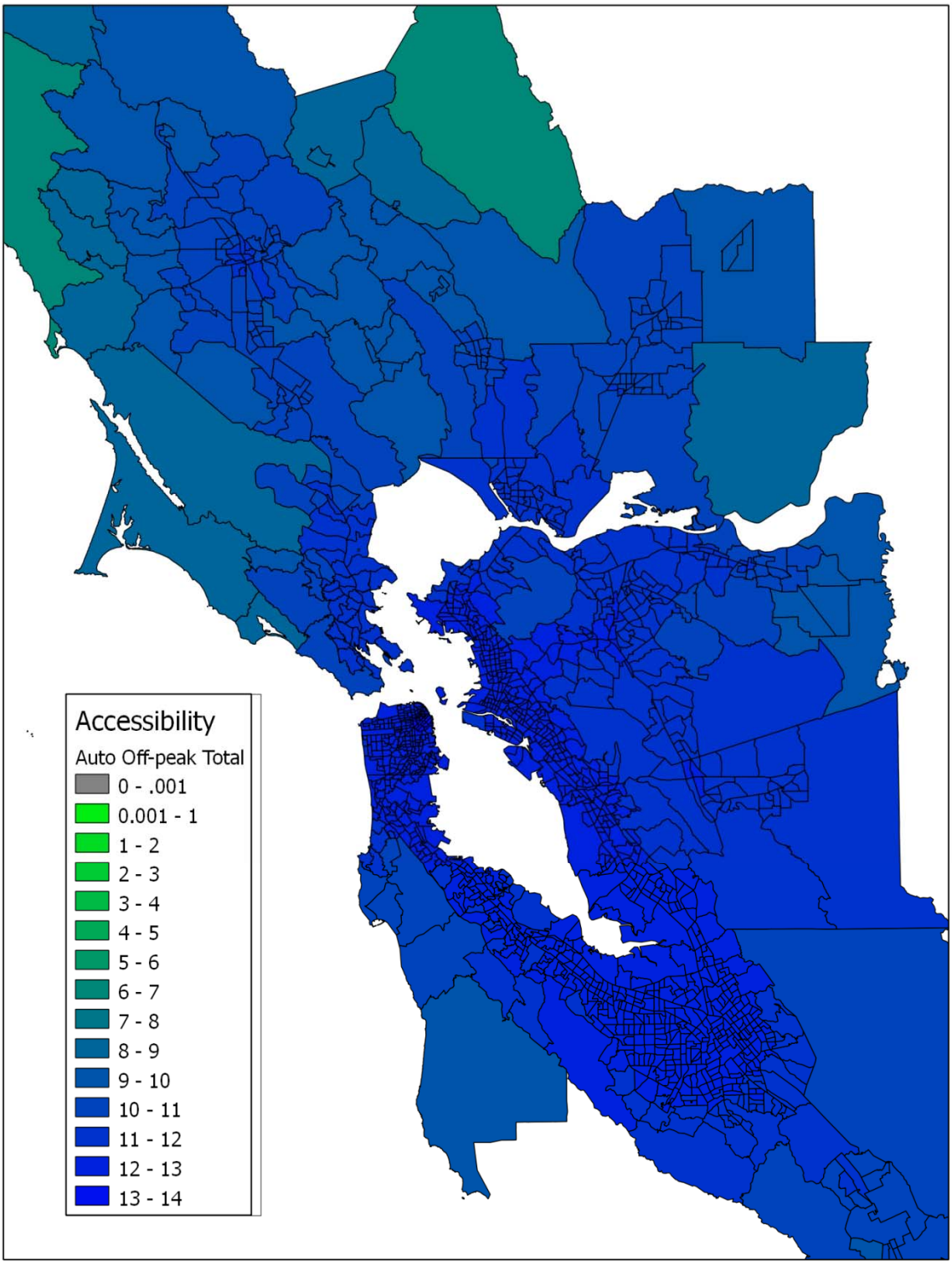


Figure 7: Auto Off-peak Accessibility to All Employment

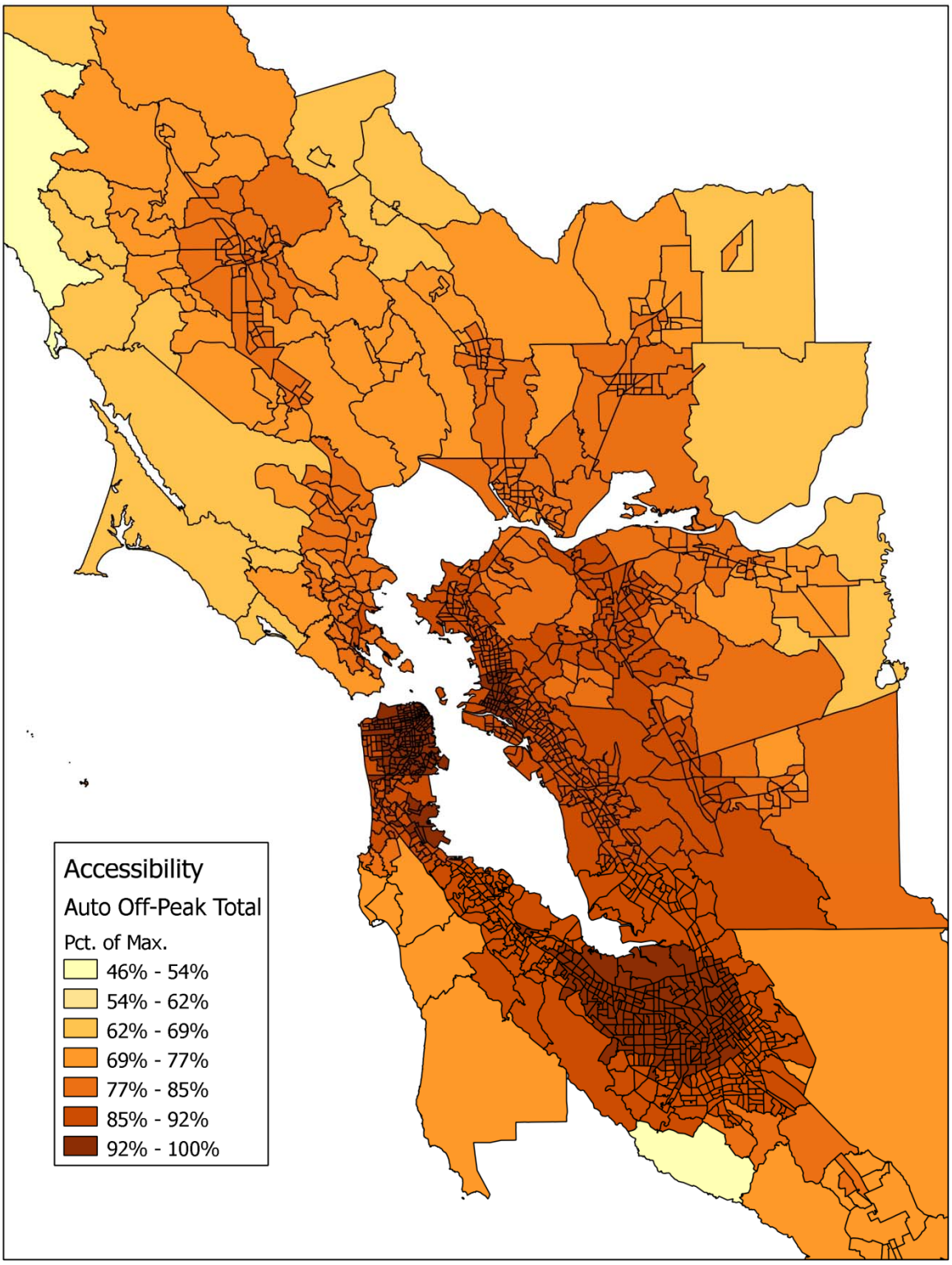


Figure 8: Auto Off-peak Accessibility to All Employment (As percent of maximum

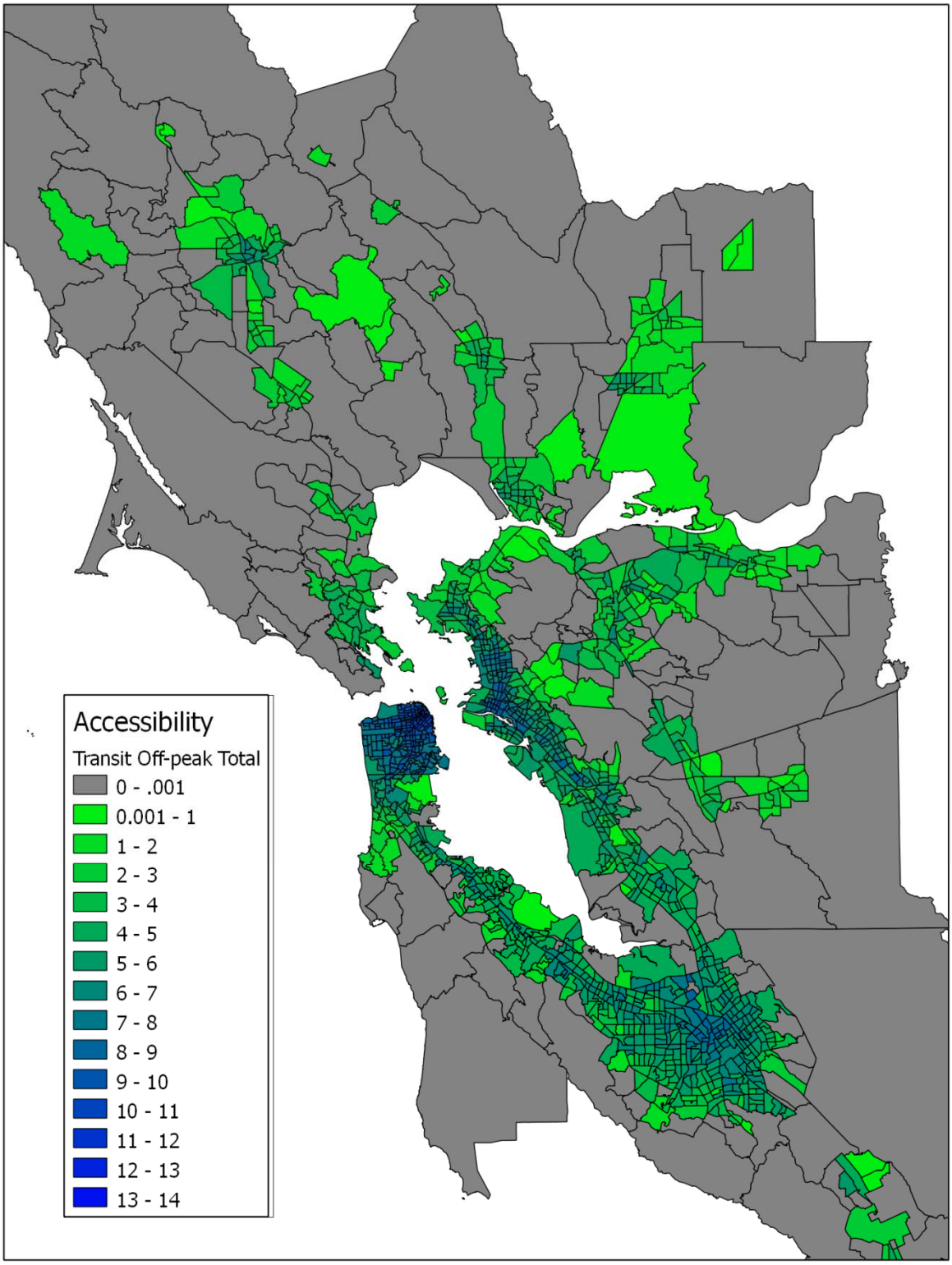


Figure 9: Transit Off-Peak Accessibility to All Employment

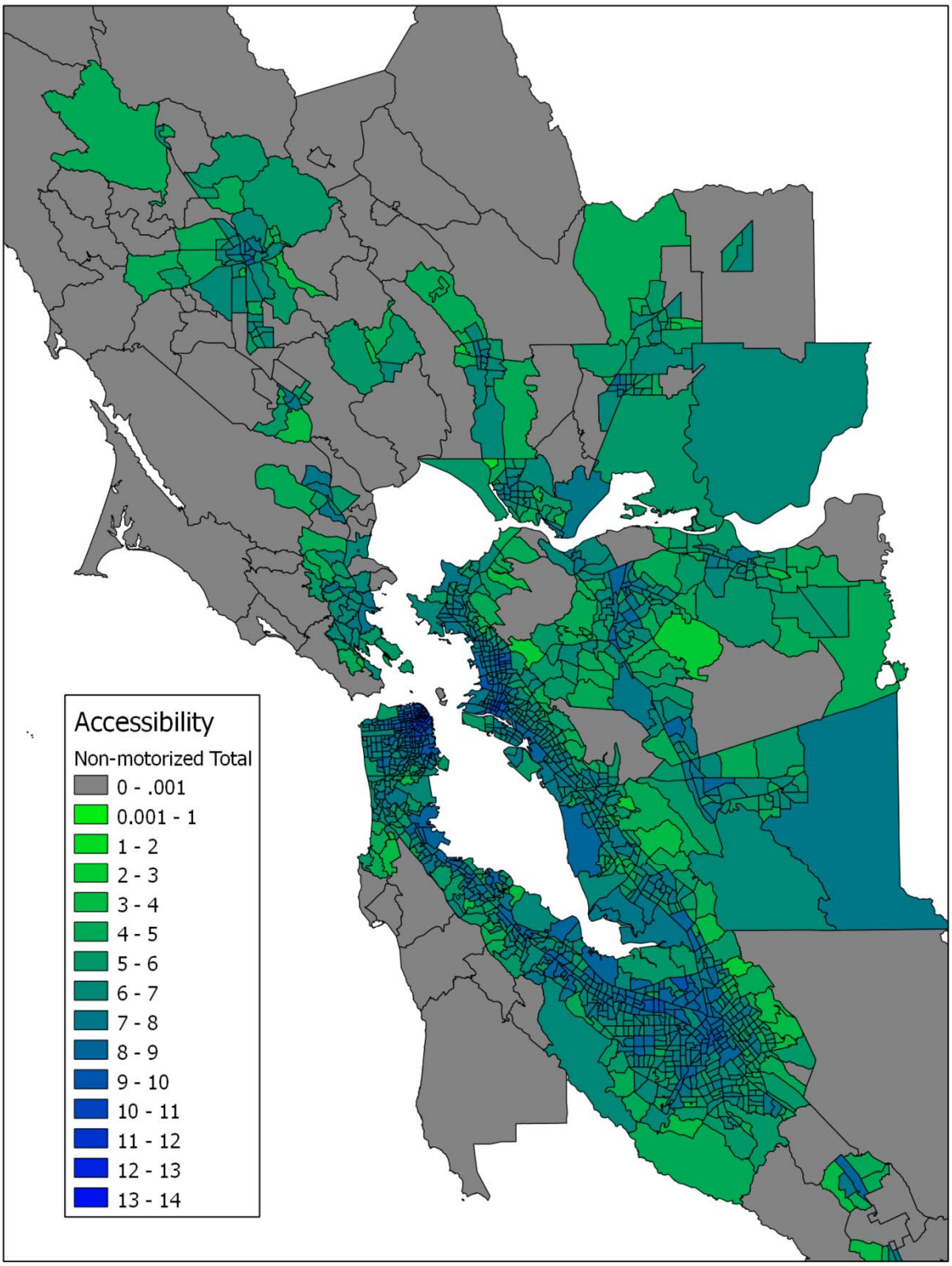


Figure 10: Non-motorized Accessibility to All Employment

1.2.2 Calibration Targets

Household Travel Survey

The majority of the calibration targets for the activity-based model were derived from the 2000 Bay Area Travel Survey (BATS 2000)[4]. This survey collected two-day travel diaries from 15,000 households throughout the Bay Area. The results have been weighted and expanded to the Census 2000 universe, and processed to produce the linked trips that were the final unit of analysis. Since reported rates of travel declined from the first to second day, the calibration targets were derived only from the first day of travel, and only for samples that occurred on a weekday.

The CT-RAMP system explicitly models joint travel of household members; however the survey did not specifically ask if trips were taken together, so joint travel had to be inferred. Because joint travel could only be inferred automatically when travel times and destinations between household members matched precisely, the rates of joint travel in the MTC model is lower than in other regions where joint travel was specifically elicited in the travel survey.

The raw data from the processes survey also had to be adjusted in cases to correct for common biases such as underreporting of non-mandatory travel. The rate of all-day at-home activity patterns reported by non-working adults was unreasonably high, and the rate of mandatory activity patterns reported by workers and students were too low. Therefore, several adjustments were made to the survey data to bring the amount of travel up to the level observed in other regions, and that would result in highway and transit assignment validations that would match the overall level of travel in the MTC region. These adjustments were based on the calibration targets that were developed for the SFCTA nine-county model (the RPM-9 model). The most significant adjustments made were as follows:

- The share of non-working adults with at-home activity patterns was reduce from approximately 36% to 20%; non-mandatory patterns were increased from 64% to 80% as a result.
- The share of workers with mandatory activity patterns was increased from 65% to 78%. The share of workers with non-mandatory patterns was reduced from 22% to 12%, and the share of workers with at-home patterns was reduced from 13% to 10%.
- The share of students with mandatory activity patterns was increased from 54% to 70%. The share of students with non-mandatory activity patterns was reduced from 31% to 20%, and the share of students with at-home activity patterns was reduced from 15% to 10%.

Census

The 2000 US Census was used for the targets in two long-term models. The usual work and school location choice model was validated against the worker and student flows from the Census for Transportation Planning Package (CTPP). The auto ownership model was validated against the tract-level distribution of household auto ownership from the Census Long Form. No adjustments to the Census data were necessary.

[4] For additional information, please refer to http://www.mtc.ca.gov.maps_and_data/datamart/survey.

Traffic Count Database

Caltrans collects automatic traffic counts on state highways throughout the Bay Area[5]. The database contains a time series of counts in fifteen-minute intervals. The data is reduced, summarized, and coded to links in the highway network; the data includes:

- Route Number, Post Mile, Direction, and Location Description
- Minimum, Maximum, Mean and Standard Deviation of Traffic Volumes
- Number of traffic counts at location
- Volumes by travel model time period
- 24-hour Daily Directional Volumes

The match between these observations and modeled traffic volumes was used to validate the model by comparing the highway assignment results to the observed counts for the years 2000 and 2005.

Transit Boardings

Approximately every year the Programming and Allocations Section of MTC releases the *Statistical Summary of Bay Area Transit Operators*. This report includes data on the average weekday ridership of every major transit operator in the region by year. These data were used to validate the transit assignment model by comparing the modeled and observed number of boardings for each mode.

In the year 2000, MTC collected detailed figures on the ridership for each operator. For the year 2005, complete data were not available for each transit operator. For operators on which MTC had no 2005 data, the 2000 values were scaled by the change in ridership reported in the National Transit Database.

In the year 2005 the San Francisco Municipal Transportation Agency also performed a thorough on-board survey of the Muni bus and light rail transit system. This on-board survey obtained estimates of the daily ridership for each line in the system. These data were used to validate the geographic distribution of the transit assignment in San Francisco.

[5] For additional information, please refer to http://www.mtc.ca.gov/maps_and_data/datamart/traffic.

2 Model Year 2000 Calibration

After building the model structure and implementing the initial specification, *Travel Model One* was calibrated to match observed data for the Bay Area. The section below discusses the calibration process, presents final model coefficients, and compares the results to observed data. In the table of utility function parameters for each model, **coefficients that were calibrated rather than estimated appear in bold**.

As noted in the previous section, the calibration targets were derived primarily from the 2000 Bay Area Travel Survey (BATS 2000) and the 2000 US Census; traffic volumes were validated using the Caltrans hourly count database; and, transit boardings were validated using boarding counts for each transit operator in the region.

Approach

The development and use of transportation system planning models can be divided into four stages: estimation, calibration, validation, and application. In *Travel Model One*, a system where the demand for transportation is represented with a series of disaggregate discrete choice models, these stages proceed as follows.

In model estimation, observations of individual travel behavior (primarily taken from surveys such as household travel surveys and transit on-board surveys) are used to fit statistical models that relate characteristics of the persons, transportation system, and land uses to the likelihood of observing the choices that were made. Every statistical model estimated using a sample of the population contains some error, which can be random if arising from chance or systematic if arising due to a mismatch between the sample and the population of interest or between the measurement of variables and their true values. In *Travel Model One*, several models were estimated using survey data from other regions or using different methods of measuring geographic variables, so the systematic differences between the estimated models and their intended uses could be large, depending on the differences between the regions in the measured and unobserved variables influencing the choice.

Model calibration is a method of adjusting model parameters such that, when the models are applied to input data for a recent "base year", the number of people making each particular travel decision matches an aggregate "target" that is prone to less measurement error than the disaggregate data that were used in model estimation. For discrete choice models, this match is achieved by adjusting a constant term (or terms) that is specific for each alternative (or group of alternatives). Adjusting these constants changes the total share of persons making each decision, but does not alter the relationship between the explanatory variables and the outcome that was determined in model estimation.

Each of the series of models in *Travel Model One* influences other models in the system. Not only are long-term decisions made in early models used to determine short-term decisions in later models, but the parameters in the later short-term decisions also influence long-term decisions through the inclusion of the maximum expected utility, or "logsum", from key short-term models as an explanatory variable in some of the long-term models. Therefore, several models must be calibrated in tandem.

Because of these influences between model components, calibration of *Travel Model One* was performed in an iterative, cyclic fashion. The calibration team progressed through each step in the model system in order, adjusting or re-estimating model parameters until the aggregate

outcomes from the model when applied to the year 2000 synthetic population matched the targets. Each cycle of re-calibration achieved increasingly precise matches between the modeled outcomes and the targets as the influences between model components reached an equilibrium.

After the model calibration stage, the model validation stage verifies the ability of the models to reproduce specific observations of travel patterns seen on the actual network that were not used in model calibration. Validation of *Travel Model One* was performed by comparing the results of the highway and transit assignments to highway counts and the number of boardings by transit system operator, for both the calibration base year 2000 and a more recent validation year 2005, for which the input data were not used in model estimation or calibration. After observing initial results from the highway and transit validations, final adjustments were made to key model components where the household survey targets were at odds with the results from the validations to achieve a compromise that agreed with all sources to the greatest extent possible.

The remainder of this section presents the adjustments made in model calibration and comparisons between the outcomes of individual model components and the targets derived from Census and BATS data. The 2000 and 2005 highway and transit validations appear in Sections 3 and 4, respectively.

2.1 Long-Term Models

Travel Model One simulates travel decision-making in two stages: long term and short term. The long-term models include decisions that are typically not changed for a period of months or years: the choice of work or school location, the number of vehicles to own, and the availability of free parking for workers. The results for these long-term models are crucial inputs to the short-term models, which include decisions that may change from day-to-day, such as the frequency of travel or the choice of travel mode.

The response of the long-term behavior to changes in policies or transportation system performance is typically less dramatic than the response of short-term behavior. Nonetheless, while long-term decisions influence short-term behavior in the model, and not vice versa, the quality of the available short-term options given a potential long-term choice does influence the likelihood of that choice through the feedback of accessibility terms and logsum variables.

The following description of the models proceeds in the sequential order in which they are applied in the model system. Long-term models are described in this section, and short-term models in the next.

2.1.1 Usual Work and School Location Choice

Number of Models:	Four (work, grade school, high school, university)
Decision-Making Unit:	Employed persons for work location choice, persons age 5-13 for grade school, persons age 14-17 for high school, university students for university model
Model Form:	Multinomial logit
Alternatives:	30 importance-sampled from 4362 = 1454 zones x 3 walk-transit proximity subzones
Source:	Size terms estimated using BATS 2000, mode choice logsum parameter taken from SFCTA RPM-9 Model

The usual work and school location choice models assign a usual location for the primary mandatory activity of each employed person, school-aged child, and university student in the synthetic population. The models are composed of a set of accessibility-based parameters (including one-way distance between home and primary destination and the tour mode choice logsum – the expected maximum utility in the mode choice model which is given by the logarithm of the sum of exponentials in the denominator of the logit formula) and size terms, which describe the quantity of work, grade-school, or university opportunities in each possible destination. The size terms were estimated using the BATS data and the MTC zonal data described above. The mode choice logsum parameters were borrowed from the SFCTA RMP-9 model. Distance correction factors were calibrated to match observed trip length frequency distributions from BATS, as described further below.

Work Purpose

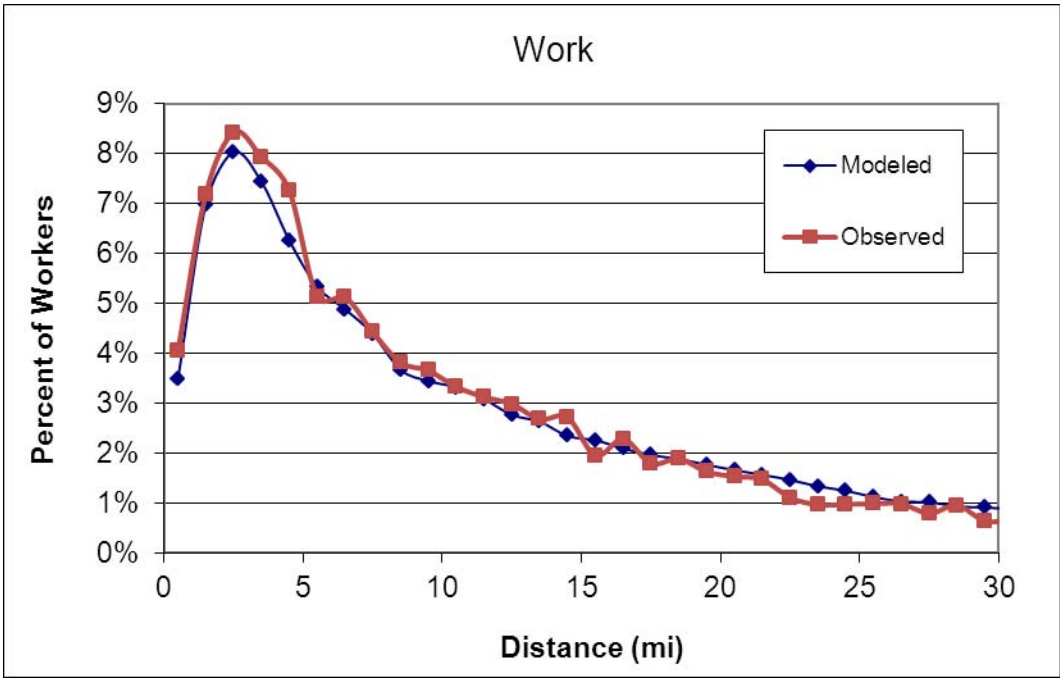
The utility function parameters for the work model appear in Table 15. The definitions of the size variables, which are linear combinations of employment by NAICS employment category for Work, were not changed from the original specification, and appear in Table 16.

Table 15: Usual Work Location Choice Utility Function Parameters

Variable	Work Coef.
Sample of alternatives correction factor	1.000
Distance, piecewise linear from 0 to 1 miles	**-0.843**
Distance, piecewise linear from 1 to 2 miles	**-0.310**
Distance, piecewise linear from 2 to 5 miles	**-0.378**
Distance, piecewise linear from 5 to 15 miles	**-0.129**
Distance, piecewise linear for 15+ miles	**-0.092**
Mode choice logsum	0.300
Size variable full-time worker, low income	1.000
Size variable full-time worker, medium income	1.000
Size variable full-time worker, high income	1.000
Size variable full-time worker, very high income	1.000
Distance 0 to 5 mi, high and very high income	**0.150**
Distance 5+ mi, high and very high income	**0.020**

Table 16: Definition of Size Variables for Work

	Household income range ($2000)			
Variable	**$0-30k**	**$30-60k**	**$60-100k**	**$100k+**
Retail Employment	0.129	0.120	0.110	0.093
Financial & Prof. Service Employment	0.193	0.197	0.207	0.270
Health, Edu., and Rec. Service Employment	0.383	0.325	0.284	0.241
Other Employment	0.120	0.139	0.154	0.146
Agricultural & Nat. Res. Employment	0.010	0.008	0.006	0.004
Manufacturing, Trade & Transport. Employment	0.164	0.210	0.239	0.246



	Observed	Modeled	Diff.	% Diff.
Avg. Dist (mi.):	11.9	12.7	0.9	7%

Figure 11: Origin-Destination Distance Frequency Distributions for Work Location Choice

Calibration of the mandatory activity location choice models focused on matching the observed origin-destination distance frequency distributions from the household survey. In order to achieve a good match, decision-makers' disinclination toward distant locations was adjusted by changing the form of a piece-wise linear distance term in the utility function. Comparisons between observed and modeled origin-destination distance frequency distributions for all work locations are shown in Figure 11.

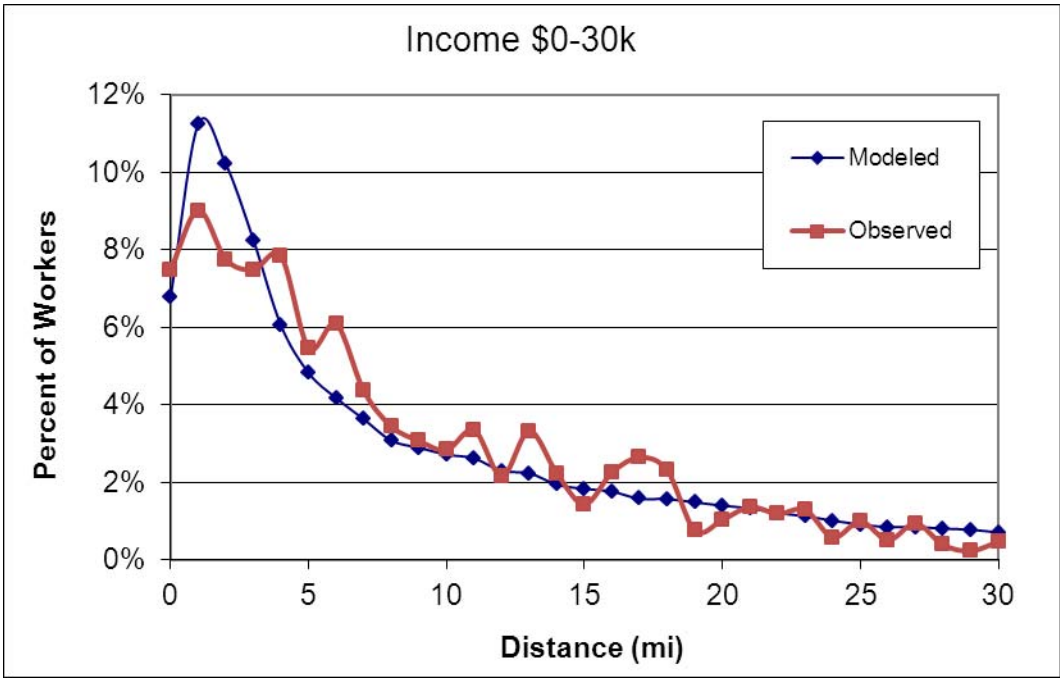
During calibration of the distance term for work tours, we observed that the model did not adequately represent commute distance by income group. Plotting the origin-destination distance frequency distribution for workers by income group revealed that higher-income workers traveled father distances to work than lower-income workers, on average. Since the locations of high-income jobs are differentiated in estimation only through the composition of the size terms, we reduced the dissuasive effect of distance for higher-income workers. Observed and modeled distance frequency distributions are broken out by worker household income in Figure 12.

Since the average pay of jobs located in downtown San Francisco is relatively high, this income segmentation of distance coefficients improved the match between the observed and modeled tour length frequency distributions of work tours with destinations in the San Francisco CBD (Figure 13) and the match between county-to-county worker flows and the CTPP (Table 17), obviating the need for county-to-county or intra-county constants.[6] This is encouraging, as the

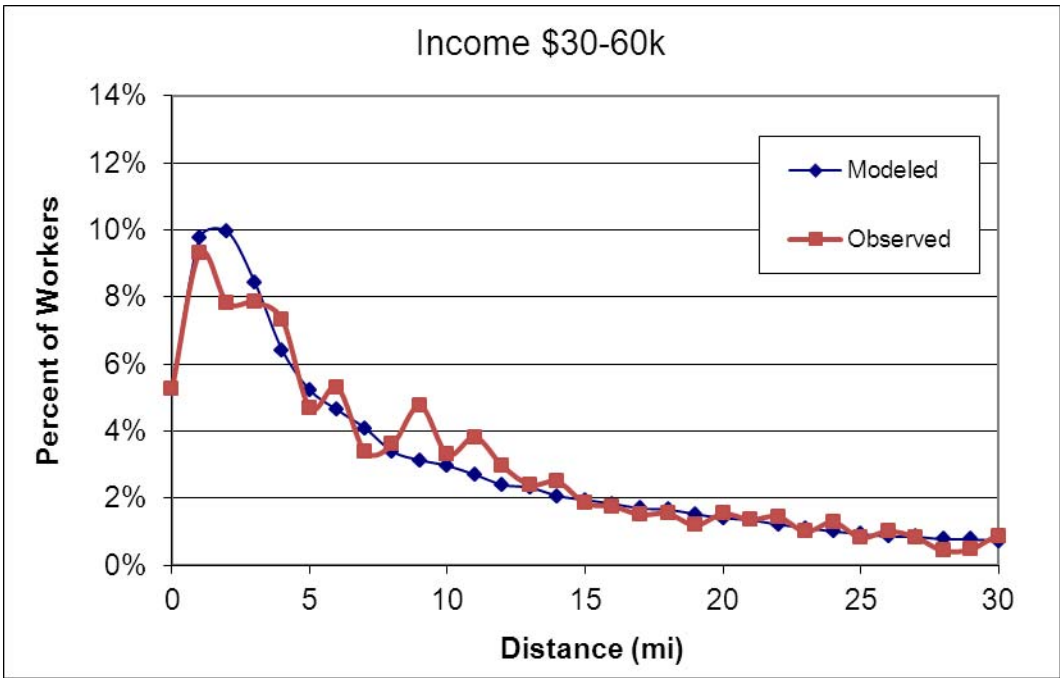
[6] Note that since the observed table was scaled to match the row totals for employed residents by county from the model TAZ data, the column totals do not necessarily match.

model is not dependent on political boundaries to control for errors in location choice, and would be expected to be more sensitive to its included variables as a result.

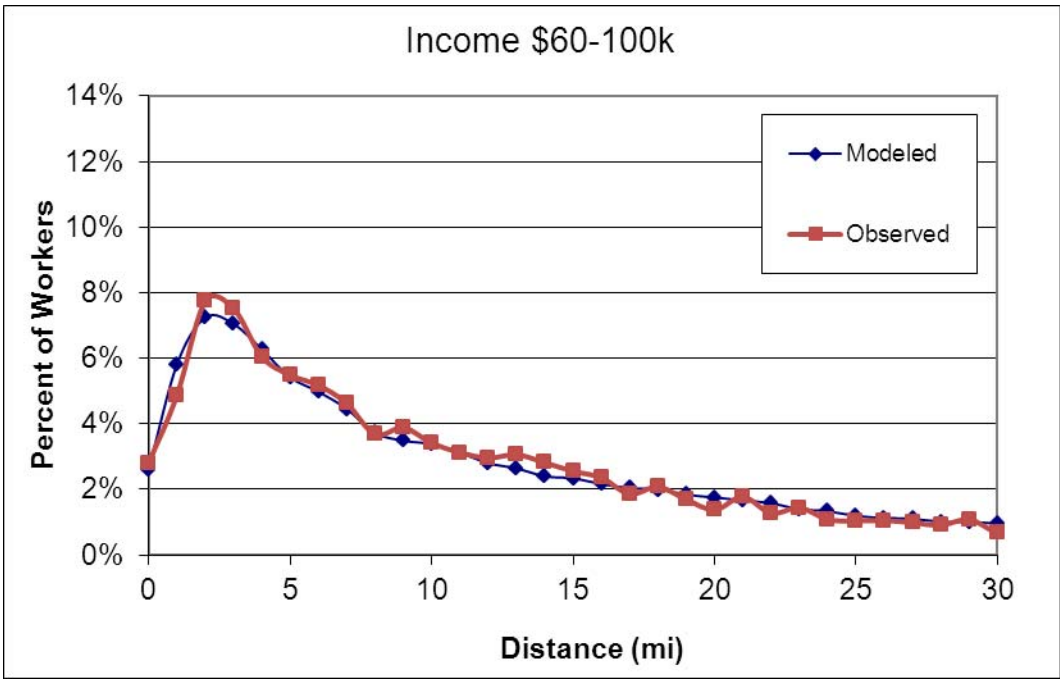
Figure 12: Work Location Distance Distribution by Household Income



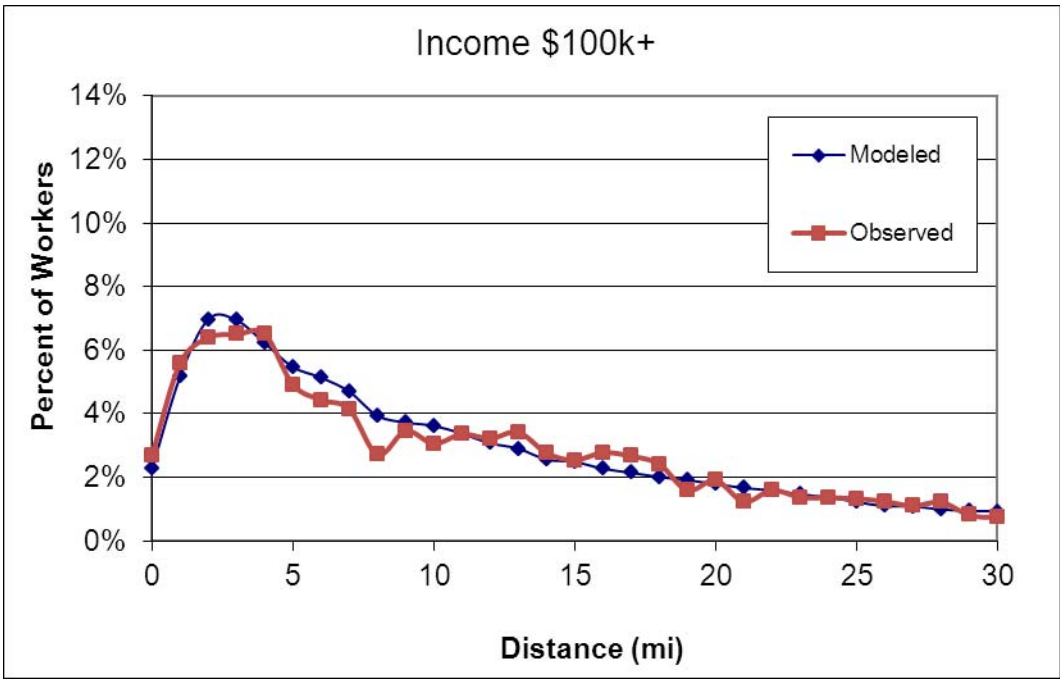
	Observed	Modeled	Diff.	% Diff.
Avg. Dist (mi.):	10.4	11.1	0.7	7%



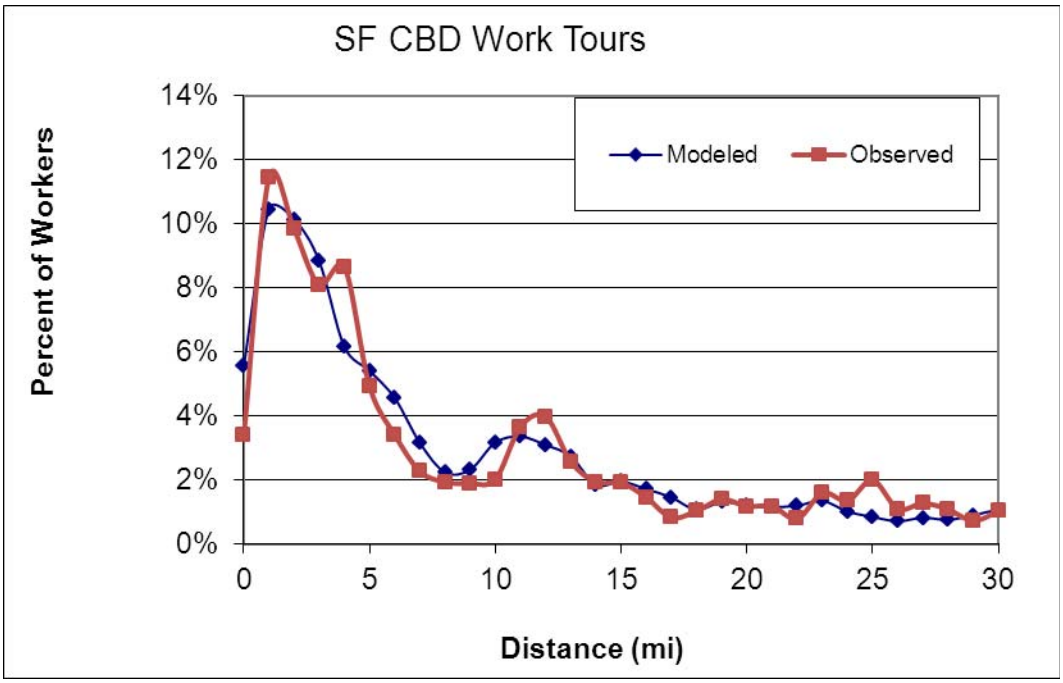
	Observed	Modeled	Diff.	% Diff.
Avg. Dist (mi.):	11.2	11.3	0.1	1%



	Observed	Modeled	Diff.	% Diff.
Avg. Dist (mi.):	13.3	13.6	0.3	2%



	Observed	Modeled	Diff.	% Diff.
Avg. Dist (mi.):	14.1	13.3	-0.8	-6%



	Observed	Modeled	Diff.	% Diff.
Avg. Dist (mi.):	12.3	11.4	-0.9	-7%

Figure 13: Tour Length Frequency Distribution for Destinations in San Francisco CBD

Table 17: County-to-County Worker Flows

Observed Worker Flows from 2000 CTPP Part 3

Scaled by Origin District to Match Employed Residents

Orig. \ Dest.	SF	SM	SC	ALA	CC	SOL	NAP	SON	MAR	Total
SF	342,532	46,065	16,881	22,163	4,861	447	250	888	6,861	440,949
SM	76,176	218,962	58,938	15,708	1,902	324	149	367	1,036	373,562
SC	8,499	43,500	778,671	39,596	3,022	620	171	540	620	875,240
ALA	75,992	35,340	73,498	478,852	37,466	1,989	359	913	3,951	708,359
CC	52,128	9,768	10,678	100,983	268,140	6,847	1,153	1,089	7,163	457,949
SOL	11,488	3,186	1,775	13,927	24,359	109,768	9,132	2,583	4,889	181,107
NAP	1,392	491	389	1,312	2,106	4,004	47,282	2,287	954	60,216
SON	8,635	1,724	1,313	2,493	1,871	1,371	3,194	194,435	19,330	234,366
MAR	32,457	2,747	998	4,969	2,879	641	399	3,672	82,659	131,421
Total	609,300	361,783	943,142	680,003	346,606	126,010	62,088	206,774	127,463	3,463,169

Modeled Worker Flows

Orig. \ Dest.	SF	SM	SC	ALA	CC	SOL	NAP	SON	MAR	Total
SF	335,097	46,342	8,951	31,502	7,294	733	304	1,012	9,714	440,949
SM	75,662	181,969	73,137	32,591	4,902	417	162	531	4,191	373,562
SC	9,741	50,038	744,125	64,790	5,240	355	101	128	722	875,240
ALA	82,094	47,900	102,772	414,740	49,428	2,845	937	872	6,769	708,359
CC	49,136	12,649	16,630	117,825	228,755	15,668	4,001	2,236	11,049	457,949
SOL	10,484	2,394	2,185	17,545	32,585	95,426	11,283	3,705	5,500	181,107
NAP	2,066	530	349	3,196	4,787	5,816	34,879	6,288	2,304	60,216
SON	7,885	1,953	556	3,369	3,251	2,578	9,068	186,122	19,583	234,366
MAR	31,045	6,065	1,418	10,294	6,538	1,588	1,114	7,606	65,755	131,421
Total	603,210	349,841	950,122	695,852	342,780	125,426	61,850	208,500	125,588	3,463,169

Difference (Modeled - Observed)

Orig. \ Dest.	SF	SM	SC	ALA	CC	SOL	NAP	SON	MAR	Total
SF	-7,435	278	-7,930	9,339	2,433	286	54	123	2,853	-
SM	-514	-36,993	14,198	16,883	3,000	93	14	165	3,155	-
SC	1,242	6,538	-34,545	25,194	2,218	-266	-70	-412	101	-
ALA	6,101	12,560	29,274	-64,112	11,962	857	579	-40	2,819	-
CC	-2,992	2,881	5,952	16,842	-39,385	8,821	2,849	1,146	3,887	-
SOL	-1,004	-792	409	3,618	8,227	-14,342	2,151	1,122	611	-
NAP	675	40	-40	1,885	2,681	1,812	-12,403	4,001	1,350	-
SON	-749	229	-756	875	1,380	1,207	5,874	-8,314	253	-
MAR	-1,412	3,317	420	5,324	3,659	947	715	3,934	-16,904	-
Total	-6,090	-11,942	6,981	15,849	-3,826	-584	-238	1,725	-1,876	-

School Purposes

The utility function parameters for the school location choice models appear in Table 18. Definitions of the size variables, which were not changed from their original specification, are in Table 19.

Table 18: School Location Choice Utility Function Parameters

Variable	University Coef.	HighSchool Coef.	GradeSchool Coef.
Sample of alternatives correction factor	1.000	1.000	1.000
Distance, piecewise linear from 0 to 1 miles	**-3.245**	**-0.952**	**-1.642**
Distance, piecewise linear from 1 to 2 miles	**-2.701**	**-0.570**	**-0.570**
Distance, piecewise linear from 2 to 5 miles	**-0.571**	**-0.570**	**-0.570**
Distance, piecewise linear from 5 to 15 miles	**-0.500**	**-0.193**	**-0.203**
Distance, piecewise linear for 15+ miles	**-0.073**	**-0.188**	**-0.046**
Mode choice logsum	0.536	0.536	0.536
Size variable	1.000	1.000	1.000

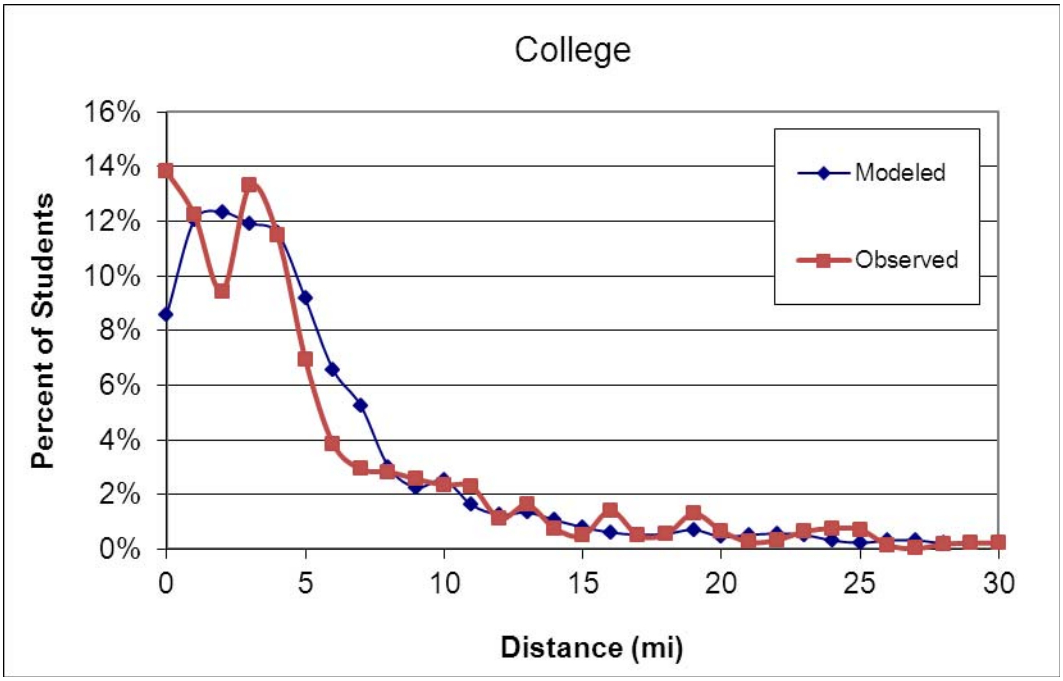
Table 19: Definition of Size Variables for School

Variable	College	Grade School	High School
Residents Age 5-18	0.000	1.0	0.0
High School Enrollment	0.000	0.0	1.0
College Enrollment, FTE	0.592	0.0	0.0
College Enrollment, PTE	0.408	0.0	0.0

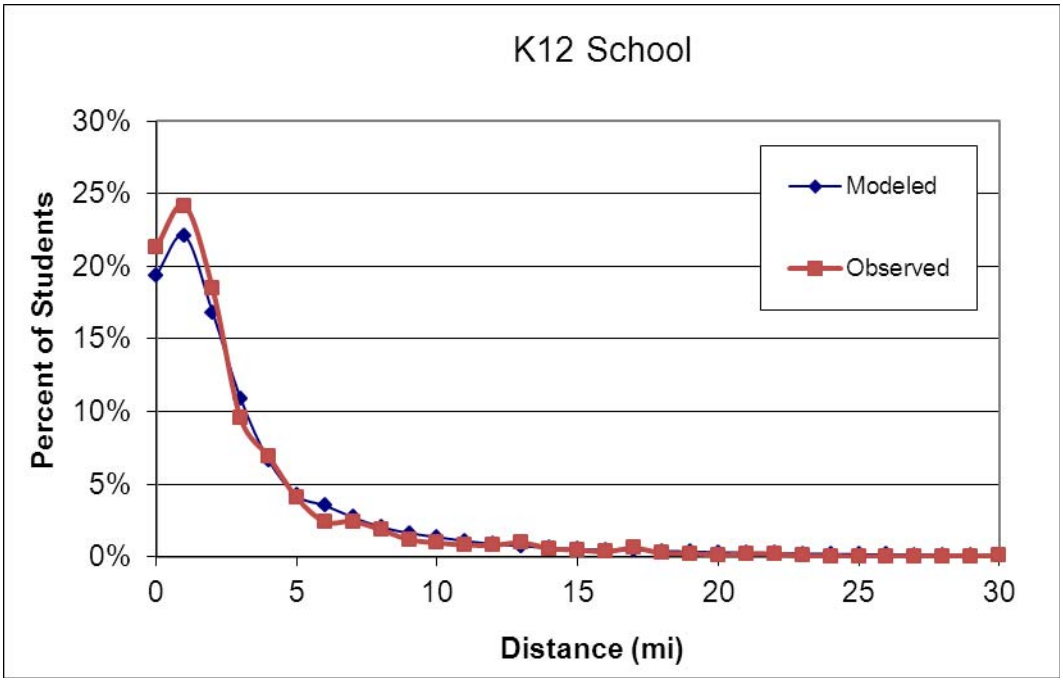
The school location choice models were adjusted only by changing the distance term in the utility function. The utility function for the college purpose was calibrated separately, while the functions for the grade school and high school purposes were calibrated together, with the coefficients for the distance term adjusted proportionally for each purpose.

Comparisons of modeled and observed origin-destination distance frequency distributions appear in Figure 14. The observed distribution for the college purpose is multimodal in the short distances because of the dormitory population on-campus and the preponderance of auxiliary non-residential uses in the immediate vicinity of campuses. Implementing a university student residential location choice model would be a possibility to improve the spatial distribution of college tours in the future. In the current model, we sought to achieve the best fit that could be attained with monotonically decreasing marginal disutility of distance. County-to-county student flows appear in Table 20 through Table 22.

Figure 14: Origin-Destination Distance Frequency Distributions for School Location Choice



	Observed	Modeled	Diff.	% Diff.
Avg. Dist (mi.):	7.1	6.6	-0.4	-6%



	Observed	Modeled	Diff.	% Diff.
Avg. Dist (mi.):	3.7	4.4	0.7	17%

Table 20: County-to-County College Student Flows

Observed College Student Flows

Scaled by Origin District to Match Students

Orig. \ Dest.	SF	SM	SC	ALA	CC	SOL	NAP	SON	MAR	Total
SF	50,439	715	997	3,536	-	-	-	-	218	55,904
SM	5,996	32,050	1,789	1,878	63	-	-	-	-	41,777
SC	1,605	718	109,190	2,560	-	-	-	-	-	114,073
ALA	4,550	1,783	2,452	85,231	3,715	148	-	117	-	97,996
CC	1,231	224	846	5,726	34,099	-	-	88	132	42,346
SOL	353	-	-	110	2,371	14,021	260	343	-	17,458
NAP	312	-	-	-	-	168	3,838	733	-	5,051
SON	243	-	-	-	-	-	-	21,021	339	21,603
MAR	304	-	-	233	43	557	-	546	7,137	8,820
Total	65,033	35,490	115,273	99,274	40,292	14,894	4,098	22,848	7,825	405,028

Modeled College Student Flows

Orig. \ Dest.	SF	SM	SC	ALA	CC	SOL	NAP	SON	MAR	Total
SF	55,479	151	47	189	16	-	-	3	19	55,904
SM	14,107	19,792	7,528	266	31	-	-	10	43	41,777
SC	134	244	112,130	1,546	14	-	1	-	4	114,073
ALA	1,705	332	5,570	89,341	949	10	4	12	73	97,996
CC	1,206	80	1,006	7,504	32,080	91	39	51	289	42,346
SOL	628	13	89	1,737	2,642	10,396	1,549	179	225	17,458
NAP	6	-	-	15	17	21	4,751	241	-	5,051
SON	170	3	7	58	24	34	319	20,824	164	21,603
MAR	647	12	9	158	46	9	25	668	7,246	8,820
Total	74,082	20,627	126,386	100,814	35,819	10,561	6,688	21,988	8,063	405,028

Difference (Modeled – Observed)

Orig. \ Dest.	SF	SM	SC	ALA	CC	SOL	NAP	SON	MAR	Total
SF	5,040	-564	-950	-3,347	16	-	-	3	-199	-
SM	8,111	-12,258	5,739	-1,612	-32	-	-	10	43	-
SC	-1,471	-474	2,940	-1,014	14	-	1	-	4	-
ALA	-2,845	-1,451	3,118	4,110	-2,766	-138	4	-105	73	-
CC	-25	-144	160	1,778	-2,019	91	39	-37	157	-
SOL	275	13	89	1,627	271	-3,625	1,289	-164	225	-
NAP	-306	-	-	15	17	-147	913	-492	-	-
SON	-73	3	7	58	24	34	319	-197	-175	-
MAR	343	12	9	-75	3	-548	25	122	109	-
Total	9,049	-14,863	11,113	1,540	-4,473	-4,333	2,590	-860	238	-

Table 21: County-to-County High School Flows

Observed High School Student Flows

Scaled by Origin District to Match Students

Orig. \ Dest.	SF	SM	SC	ALA	CC	SOL	NAP	SON	MAR	Total
SF	24,523	108	-	-	-	-	-	-	345	24,976
SM	1,495	23,749	665	266	-	-	-	-	-	26,175
SC	132	310	66,689	1,494	-	133	-	-	-	68,758
ALA	351	238	964	59,350	-	-	-	-	-	60,903
CC	509	-	-	3,849	41,946	-	-	64	-	46,368
SOL	181	-	-	-	763	20,769	457	-	152	22,322
NAP	-	-	-	-	-	118	6,854	55	-	7,028
SON	-	-	-	-	-	-	623	23,691	471	24,785
MAR	317	-	-	81	-	-	-	-	11,158	11,556
Total	27,508	24,405	68,318	65,040	42,708	21,020	7,935	23,811	12,126	292,871

Modeled High School Student Flows

Orig. \ Dest.	SF	SM	SC	ALA	CC	SOL	NAP	SON	MAR	Total
SF	23,034	1,703	3	181	30	1	-	-	24	24,976
SM	2,025	22,110	1,576	461	2	-	-	-	1	26,175
SC	1	812	67,191	750	4	-	-	-	-	68,758
ALA	719	369	737	56,243	2,805	13	-	-	17	60,903
CC	173	43	18	3,095	42,104	856	2	-	77	46,368
SOL	3	1	1	33	647	21,516	91	24	6	22,322
NAP	1	-	-	3	84	569	6,105	265	1	7,028
SON	2	-	-	-	5	13	105	24,476	184	24,785
MAR	821	102	-	59	136	17	6	176	10,239	11,556
Total	26,779	25,140	69,526	60,825	45,817	22,985	6,309	24,941	10,549	292,871

Difference (Modeled - Observed)

Orig. \ Dest.	SF	SM	SC	ALA	CC	SOL	NAP	SON	MAR	Total
SF	-1,489	1,595	3	181	30	1	-	-	-321	-
SM	530	-1,639	911	195	2	-	-	-	1	-
SC	-131	502	502	-744	4	-133	-	-	-	-
ALA	368	131	-227	-3,107	2,805	13	-	-	17	-
CC	-336	43	18	-754	158	856	2	-64	77	-
SOL	-178	1	1	33	-116	747	-366	24	-146	-
NAP	1	-	-	3	84	451	-749	210	1	-
SON	2	-	-	-	5	13	-518	785	-287	-
MAR	504	102	-	-22	136	17	6	176	-919	-
Total	-729	735	1,208	-4,215	3,109	1,965	-1,626	1,130	-1,577	-

Table 22: County-to-County Grade School Student Flows

Observed Grade School Student Flows

Scaled by Origin District to Match Students

	Dest.									
Orig.	SF	SM	SC	ALA	CC	SOL	NAP	SON	MAR	Total
SF	70,208	2,509	-	-	-	157	-	-	434	73,309
SM	6,987	82,643	1,070	102	-	-	-	106	-	90,908
SC	228	1,019	214,393	718	98	-	-	-	-	216,456
ALA	287	824	1,851	182,870	3,231	315	-	-	-	189,378
CC	2,349	588	-	6,390	134,826	8,428	-	-	-	152,581
SOL	261	-	-	298	1,410	64,659	319	-	-	66,947
NAP	221	-	-	266	657	44	18,084	124	-	19,396
SON	-	-	-	-	-	-	162	71,379	1,154	72,695
MAR	413	304	1,417	136	225	-	-	290	32,398	35,181
Total	80,955	87,886	218,731	190,780	140,447	73,602	18,565	71,898	33,986	916,851

Modeled Grade School Student Flows

	Dest.									
Orig.	SF	SM	SC	ALA	CC	SOL	NAP	SON	MAR	Total
SF	63,871	6,963	210	1,547	431	44	10	20	213	73,309
SM	4,580	77,447	5,251	3,249	281	22	4	11	63	90,908
SC	72	3,497	207,478	5,207	182	12	1	1	6	216,456
ALA	939	1,330	2,459	178,047	6,158	230	40	31	144	189,378
CC	514	544	454	9,684	138,705	2,099	172	86	323	152,581
SOL	60	54	35	476	1,975	63,089	1,068	108	82	66,947
NAP	14	16	14	110	264	1,382	17,160	396	40	19,396
SON	65	43	11	116	135	198	396	71,315	416	72,695
MAR	959	665	93	1,098	987	291	93	875	30,120	35,181
Total	71,074	90,559	216,005	199,534	149,118	67,367	18,944	72,843	31,407	916,851

Difference (Modeled - Observed)

	Dest.									
Orig.	SF	SM	SC	ALA	CC	SOL	NAP	SON	MAR	Total
SF	-6,337	4,454	210	1,547	431	-113	10	20	-221	-
SM	-2,407	-5,196	4,181	3,147	281	22	4	-95	63	-
SC	-156	2,478	-6,915	4,489	84	12	1	1	6	-
ALA	652	506	608	-4,823	2,927	-85	40	31	144	-
CC	-1,835	-44	454	3,294	3,879	-6,329	172	86	323	-
SOL	-201	54	35	178	565	-1,570	749	108	82	-
NAP	-207	16	14	-156	-393	1,338	-924	272	40	-
SON	65	43	11	116	135	198	234	-64	-738	-
MAR	546	361	-1,324	962	762	291	93	585	-2,278	-
Total	-9,881	2,673	-2,726	8,754	8,671	-6,235	379	945	-2,579	-

2.1.2 Auto Ownership

Number of Models: One

Decision-Making Unit: Households

Model Form: Multinomial logit

Alternatives: 5 (0, 1, 2, 3, or 4+ vehicles)

Source: Estimated using BATS 2000

The auto ownership model predicts the number of vehicles owned by each household, and was estimated using BATS 2000. The utility function parameters appear in Table 23. The primary drivers are household demographics, zonal density, and accessibility. The accessibility terms are a simplified destination choice logsum where the utility function is simply travel time. The density index is a measure of both residential density, non-residential density, and the mixture of uses defined by:

$$\text{Density Index} = \frac{\text{Households} / \text{Dev. Residential Acres} \times \text{Employment} / \text{Dev. Commercial Acres}}{\text{Households} / \text{Dev. Residential Acres} + \text{Employment} / \text{Dev. Commercial Acres}}$$

Table 23: Auto Ownership Utility Function Parameters

Variable	Number of Vehicles (Base: 0)							
	1		2		3		4+	
	Coef.	t-val.	Coef.	t-val.	Coef.	t-val	Coef.	t-val.
2 Adults (age 16+)	0.000		3.077	46.3	3.196	25.0	2.662	11.5
3 Adults (age 16+)	0.000		3.540	23.7	5.513	29.2	5.208	18.9
4+ Adults (age 16+)	2.011	1.8	6.366	5.7	8.515	7.6	9.581	8.4
Persons age 16-17	0.000		-0.881	-6.1	-1.731	-10.9	-1.731	-10.9
Persons age 18-24	-0.409	-3.6	-1.010	-8.1	-1.011	-7.5	-1.011	-7.5
Persons age 25-34	0.000		-0.485	-11.6	-0.860	-15.5	-0.860	-15.5
Presence of children age 0-4	0.367	1.3	0.763	2.6	0.763	2.6	0.763	2.6
Presence of children age 5-17	0.016	0.1	0.294	1.4	0.477	2.3	0.477	2.3
Number of workers, capped at 3	0.000		0.294	6.8	0.639	11.8	0.880	11.7
Piecewise linear income, $0-30k	0.038	15.0	0.054	18.6	0.056	16.7	0.062	13.7
Piecewise linear income, $30k+, capped at $125k	0.000		0.008	6.7	0.011	7.6	0.015	8.0
Density index up to 10	0.000		-0.203	-13.8	-0.365	-16.8	-0.365	-16.8
Density index above 10	-0.015	-4.0	-0.111	-15.5	-0.177	-14.3	-0.177	-14.3
Retail access. (2/3 pk, 1/3 op.) by auto, if 0 workers	0.063	0.5	0.063	0.5	0.063	0.5	0.063	0.5
Retail access. (2/3 pk, 1/3 op.) by auto, if 1+ workers	0.165	1.4	0.165	1.4	0.165	1.4	0.165	1.4
Retail access. (2/3 pk, 1/3 op.) by transit, if 0 workers	-0.305	-5.5	-0.305	-5.5	-0.305	-5.5	-0.305	-5.5
Retail access. (2/3 pk, 1/3 op.) by transit, if 1+ workers	-0.512	-10.0	-0.512	-10.0	-0.512	-10.0	-0.512	-10.0
Retail accessibility by non-motorized	-0.030	-0.6	-0.030	-0.6	-0.030	-0.6	-0.030	-0.6
Auto time savings / worker (over walk or transit, max 120)	0.471	2.9	0.614	3.5	0.571	3.0	0.769	3.2
Constant	**1.155**		**-1.161**		**-3.260**		**-5.313**	
San Francisco county	**0.380**		**0.431**		**0.158**		**0.158**	
Solano, Napa, Sonoma County	**-0.517**		**-0.452**		**-0.297**		**-0.297**	

Calibration of the model focused on matching the number of observed households by auto ownership level and by:

- County,
- Household Income, and
- Number of Workers in the Household.

The 2000 Census serves as the targets for calibration of the auto ownership model, rather than BATS 2000 because the census was performed with a higher sample rate and vehicle ownership estimates are available by census tract. In addition to calibrating overall alternative-specific constants, two sets of geographic constants were calibrated: one for San Francisco County, and one for the combined area of Solano, Napa, and Sonoma Counties. These constants allowed the model to better match the geographic distribution of zero-auto households, which are a particularly important part of the market for transit.

After applying the model using preliminary estimation results, the percentage of workers in zero auto households was very low. Utility expression calculation traces revealed that a few select variables had a dominant effect on differences in results between households with workers and households without workers: the home zone density index terms and the auto and transit accessibility terms.

Originally, the coefficients for both the density index terms and the accessibility terms were segmented by the presence of workers in the household. Excessive segmentation was problematic because density, auto accessibility, and transit accessibility are nearly multicollinear over zones. Further, the coefficients for auto accessibility for zero-worker households were constrained to be zero, while the coefficients for transit accessibility were not constrained. The effects of this constraint were that the differential importance of transit accessibility between households with workers and households without workers was smaller than it should be because auto accessibility was mediating the benefit of transit accessibility to zero-auto households with workers. The magnitude of the coefficients for the nearly collinear density index coefficients were inflated to compensate for this constraint.

Despite the near multicollinearity of the density, auto accessibility, and transit accessibility terms, we desired to retain each of these variables because each has a valuable explanation of behavior and implications for forecasting. The density variable can be considered a proxy for the walking environment and the cost or difficulty of storing vehicles at home, the transit accessibility provides a measure of the feasibility of meeting daily needs without a car, and the auto accessibility captures a portion of latent demand for auto travel when levels of service are improved. Therefore, we retained these three variables but reduced the over-specification by eliminating the segmentation of the density index variable by the number of workers. Segmentation of the density variable is harder to justify than segmentation of the accessibility terms because density describes only the home zone, while accessibility describes the ability to get to destinations, including work if there are workers in the household. Finally, we removed the constraint that the auto accessibility coefficient for zero auto households should be zero, to eliminate the over-compensation by the other correlated variables. As a result, the magnitude of the coefficients for these variables decreased, and the distribution of workers by auto ownership matched the observed data much more closely.

Comparisons between observed and modeled auto-ownership rates by county are shown in Figure 15, and the number of workers by vehicle availability of the household appears in Table 24. A geographic plot of the share of zero-auto households by zone appears in Figure 16. The deviation from the Census in the percent of zero-auto households by zone appears in Figure 17. The only significant systematic pattern in the deviations occurs within San Francisco and Alameda Counties, where the northern part of the counties have too many zero auto households, and the southern parts too few. The densest part of the San Francisco CBD has too few zero auto households, but the number of households in these zones is low.

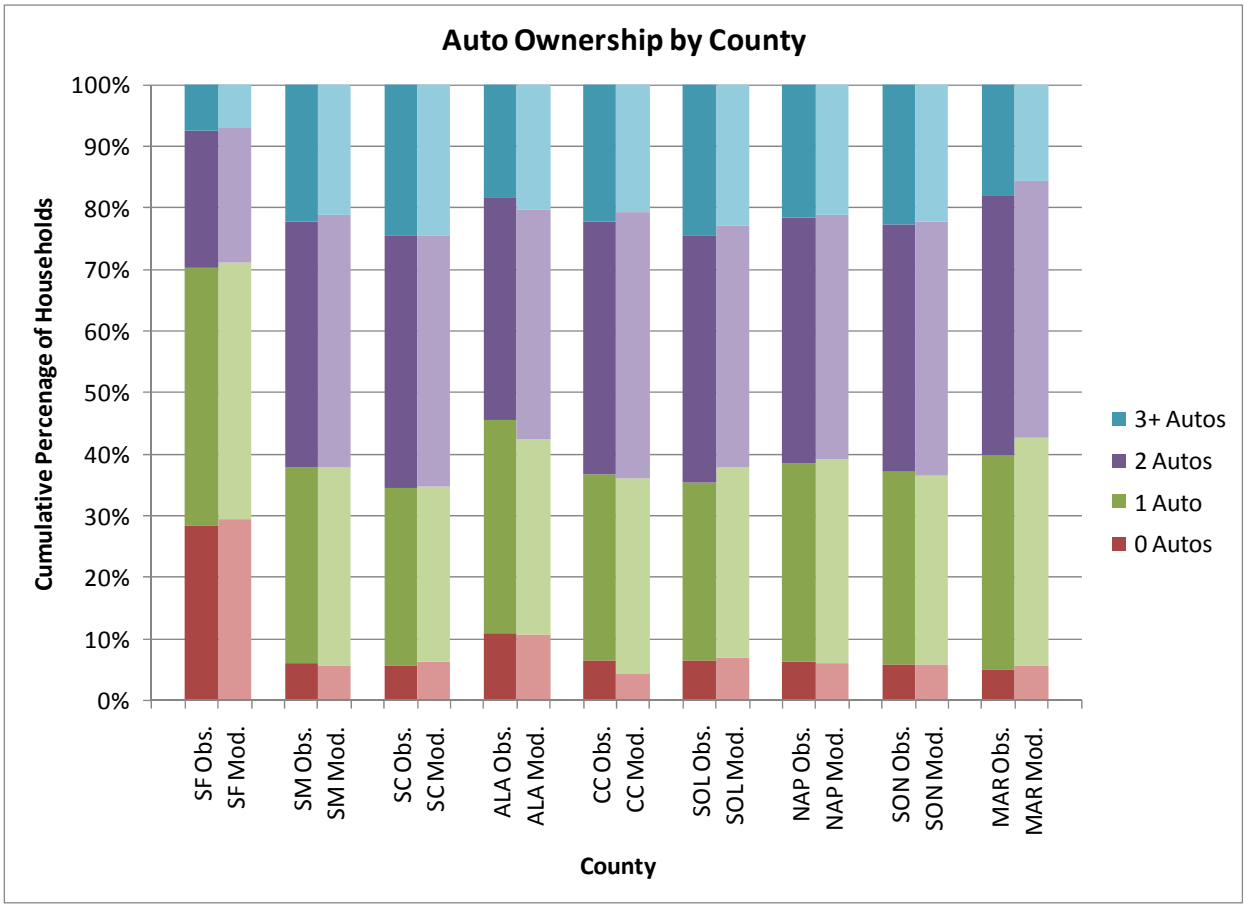


Figure 15: Household Auto Ownership by County

Table 24: Workers by Auto Sufficiency of Household

Auto Sufficiency	Distribution of Workers		
	Observed	Modeled	Difference (M-O)
0 Autos	5.3%	5.2%	-0.1%
Autos < Workers	14.7%	13.9%	-0.8%
Autos >= Workers	80.0%	80.9%	0.9%
Total	100.0%	100.0%	-

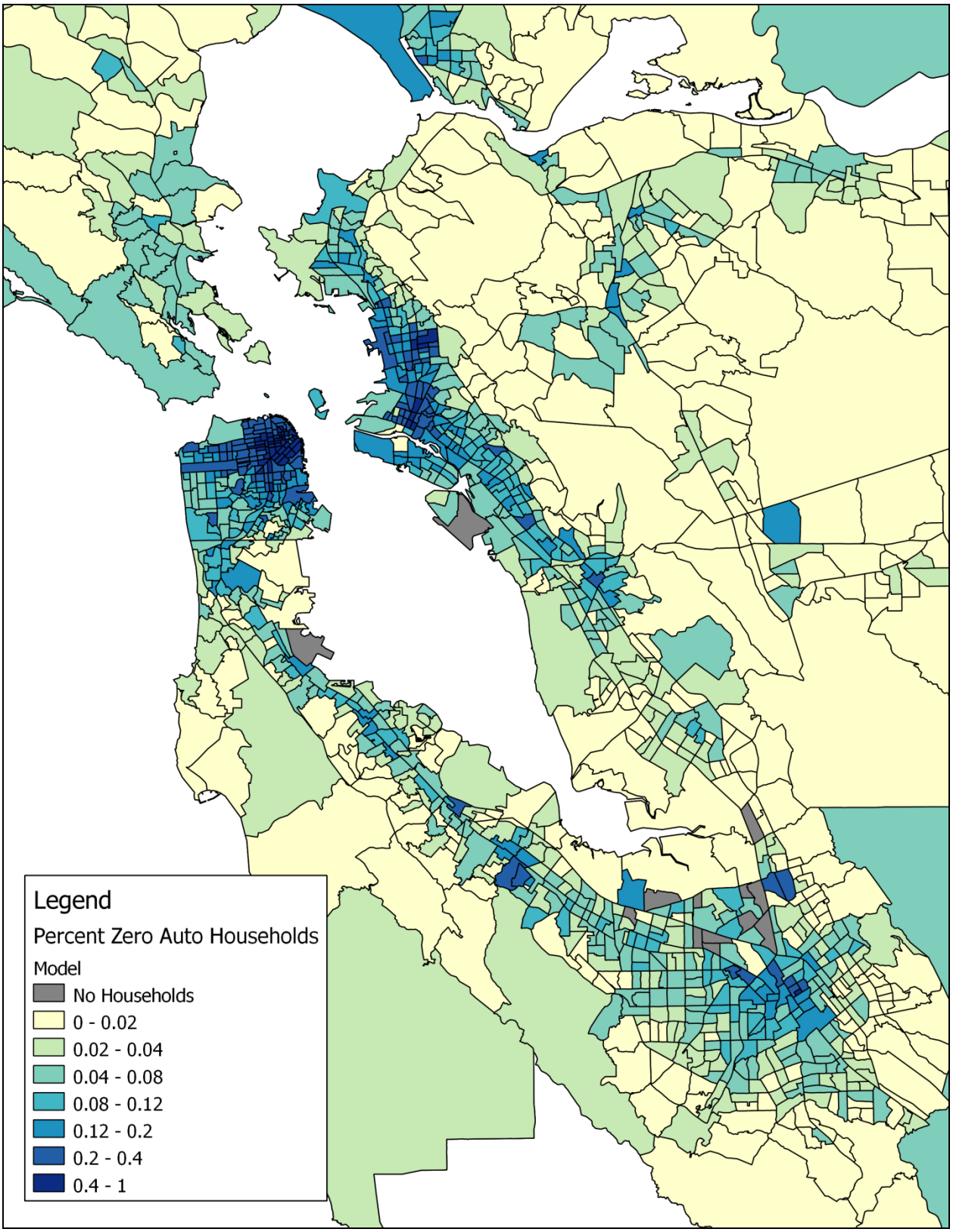


Figure 16: Geographic Distribution of Modeled Zero-Auto Households

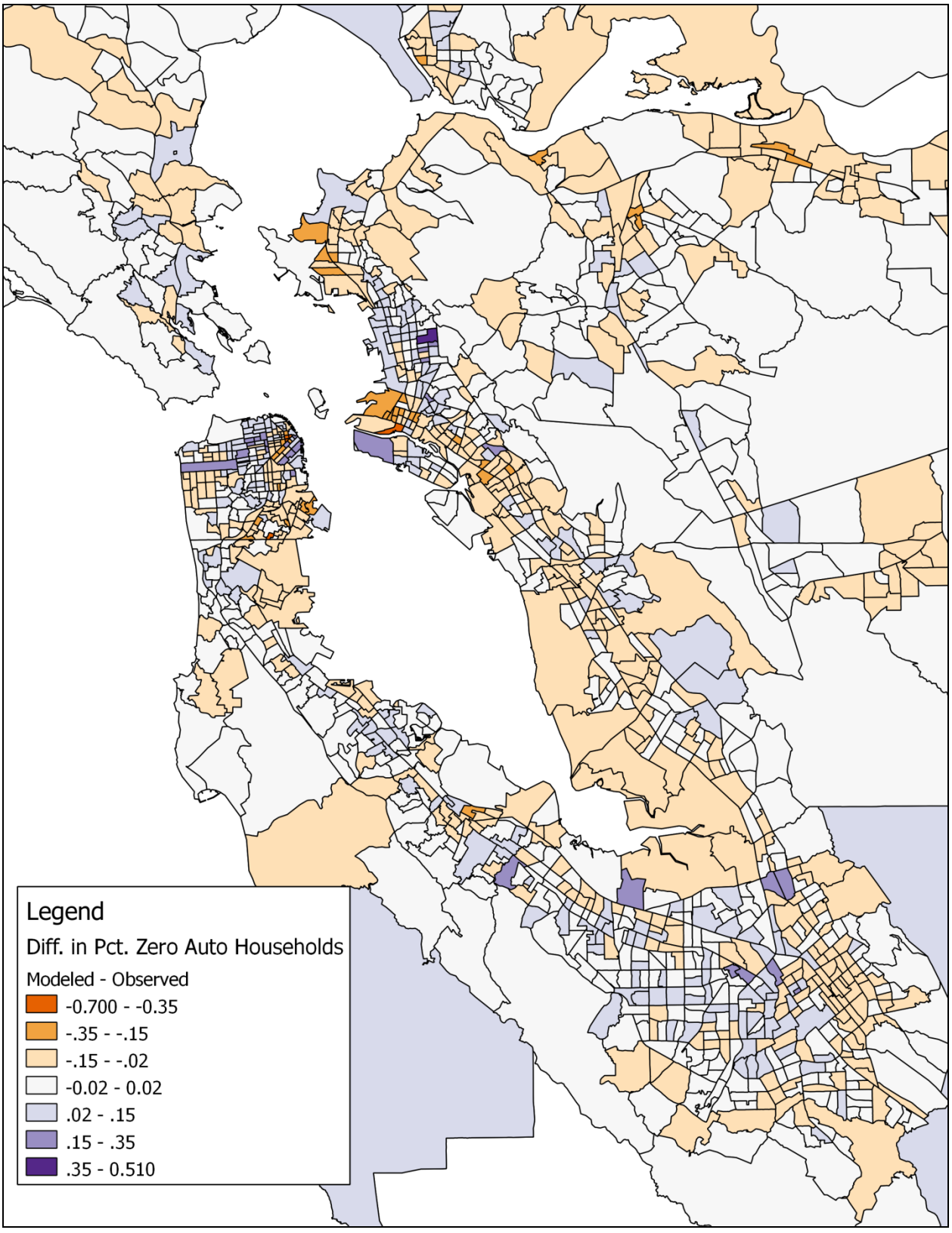


Figure 17: Geographic Distribution of Percent Zero-Auto Households, Deviation from Census

2.1.3 Free Parking Eligibility

Number of Models: 1

Decision-Making Unit: Workers

Model Form: Binary logit

Alternatives: 2 (Free parking available or unavailable at workplace if zone has pay parking)

Source: Transferred from the Mid-Ohio Regional Planning Commission (MORPC[7])

The Free Parking Eligibility model predicts the availability of free parking at a person's workplace for people who work in zones that have parking charges, which are located in the San Francisco, San Jose, Oakland, Berkeley, and Palo Alto Central Business Districts. The purpose of the model is to adequately reflect the cost of driving to work in subsequent models, particularly in mode choice. Calibration of the model focused on matching the percentage of employees in zones with parking charges that have free parking, with different constants for San Francisco, Santa Clara, and Alameda County. The utility function appears in Table 25. If a scenario involving parking charges in a new county is introduced, and it is not known to which of the counties with existing parking charges it most closely resembles, the constant for workplace locations in that new county should be set to zero.

The calibration targets were calculated using two data sources, the zonal data file maintained by MTC, and BATS 2000, as follows. First, let $PctFreeSpaces_z$ be the estimated proportion of free parking spaces in a zone, the FREEPRK field in the zonal data. Next, let $Employment_z$ be the total employment in a zone, the TOTEMP field in the zonal data. Finally, let $PctDriving_c$ be the proportion work trips that are taken by car for workers traveling to the primary CBD of the county in which the zone lies, taken from BATS 2000 to be 20% for the San Francisco CBD, 89% for the San Jose CBD (Santa Clara County), and 74% for the Oakland CBD (Alameda County). Calculations for Palo Alto and Berkeley used the San Jose and Oakland rates, respectively. Then the estimated percentage of employees in the county who work in zones with paid parking but have free parking available is:

$$PctFreeEmployees_c = PctDriving_c \cdot \frac{\sum_z Employment_z \cdot PctFreeSpaces_z \cdot \delta_{\text{priced zone indicator}}}{\sum_z Employment_z \cdot \delta_{\text{priced zone indicator}}}$$

Comparisons between observed and modeled free parking shares appear in Table 26.

[7] Please see Stop Frequency, Stop-Location, and Trip Mode Choice Models. Technical Memorandum. MORPC Model Improvement Project. PB Consult (2003)

Table 25: Free Parking Eligibility Utility Function

Variable	Free Coeff.
Constant for workplace locations in SFCounty	**-2.640**
Constant for workplace locations in Santa Clara County	**0.212**
Constant for workplace locations in Alameda County	**-0.109**
very high income	0.230
high income	0.201
hhsize 4+	0.253
autos>workers	0.231
autos<workers	-1.479

Table 26: Percent of Employees with Free Parking in Zones with Parking Charges by County

Percent Free	County of Employment			
	San Francisco	Santa Clara	Alameda	Total
Observed	5.9%	57.4%	47.7%	20.8%
Modeled	6.0%	54.7%	45.9%	20.3%
Difference (M-O)	0.1%	-2.7%	-1.9%	-0.5%

2.2 *Daily Pattern and Scheduling Models*

This section describes the calibration of the short-term daily pattern and scheduling models, which simulate a household's decisions about how much and at what time to travel during a given day. It should be noted that the descriptions of some of the short-term models are combined into one section for the sake of parsimony, and therefore the order in which the calibration of the models are presented here deviates slightly from the order in which they run in the model system, as shown in section 1.1.8.

2.2.1 Coordinated Daily Activity Pattern

Number of Models: One

Decision-Making Unit: Households

Model Form: Multinomial logit

Alternatives: Depending on size of household, up to 363 = 3 ^ No. persons up to 5

Source: Transferred from the Atlanta Regional Commission (ARC)[8]

[8] See Progress Report for the Year 2004 Regional Transportation Plan Major Update Project for the Atlanta Regional Commission, General Modeling: Task 6 – Activity / Tour-Based Models, Prepared By Parsons Brinckerhoff/PB Consult, with John Bowman and Mark Bradley

The coordinated daily activity pattern model predicts the choice of Daily Activity Pattern (DAP) for each member in the household, simultaneously. The DAP is categorized in to three types as follows.

- Mandatory: the person engages in travel to at least one out-of-home mandatory activity – work, university, or school. The mandatory pattern may also include non-mandatory activities such as separate home-based tours or intermediate stops on the mandatory tours.
- Non-mandatory: the person engages in only maintenance and discretionary tours, which, by definition, do not contain mandatory activities.
- Home: the person does not travel outside the home.

The choice of DAP is represented as a decision for the household between combinations of patterns of individual members.

Calibration of the coordinated daily activity pattern model focused on matching the observed frequency distribution of DAP for each person type. Accomplishing this required adjustment of the alternative-specific constants for the individual contribution of each person type.

The calibrated utility function appears in Table 27. Mandatory activity patterns are not available for retired persons and non-workers. The utility function includes a contribution to the household's utility from each individual, and additive interaction terms for each combination of two or three people that engage in the same pattern. Individual terms are listed first, followed by the two-person and three-person interaction terms. Finally, the all-member interactions offset the two- and three-way interactions which are additive across all household members and would otherwise result in an excessive tendency toward the same activity patterns in the larger households.

Table 27: Coordinated Daily Activity Pattern Utility Function

Individual Terms

	Contribution to Household Daily Activity Pattern		
Variable	**Mandatory (M)**	**Non-Mandatory (N)**	**Home (H)**
Constants			
(FW) Full-time worker	**1.379**	**0.623**	-
(PW) Part-time worker	**-0.719**	**0.636**	-
(US) University student	**2.354**	**0.610**	-
(NW) Non-working adult	-	**0.595**	-
(RT) Retired	-	**0.408**	-
(SD) Driving age schoolchild	**2.331**	**-0.599**	-
(SP) Pre-driving age schoolchild	**3.296**	**0.571**	-
(PS) Pre-school child	**1.053**	**-0.838**	-
Age			
0 to 1	-0.452	-	-
4 to 5	0.611	-	-
6 to 9	-0.294	-	-
13 to 15	-0.714	-0.672	-
FW <40	0.209	-	-
RT >80	-	-	0.767
Gender			
FW Female	-0.126	-	-
NW Female	-0.743	-	-
RT Female	0.477	-	-
Auto ownership			
NW - autos > workers	0.652	0.817	-
RT - autos > workers	2.992	1.056	-
PS - autos > workers	-	0.299	-
FT - autos < workers	-	-	0.504
NW - autos < workers	-	-	0.897
RT - autos < workers	-	-	0.55
SD - autos < workers	-	-	0.648
SP - autos < workers	-	-	0.586
PS - autos < workers	-	-	0.506
Household income			
FW - income < $20,000	-	-	0.531
RT - income < $20,000	-	-	0.533
PW - income < $20,000	-	-	0.323
PW - income $50,000 to $100,000	-	-	-0.403
PW - income > $100,000	-	0.421	-0.353
NW - income $50,000 to $100,000	-	-	-0.560

NW - income > $100,000	-	-	-0.719
SD - income < $20,000	-	-	1.307
SD - income $50,000 to $100,000	-	-	-0.503
SD - income > $100,000	-	-	-2.046
SP - income $50,000 to $100,000	-	-	-0.571
SP - income > $100,000	-	-	-0.619
Accessibility			
FW - peak accessibility to all employment	0.121	-	-
PW - peak accessibility to all employment	0.200	-	-
NW - peak accessibility to all employment	0.231	-	-
RT - peak accessibility to all employment	0.279	-	-
Off-peak accessibility to retail - NW, RT, US	-	0.072	-
Off-peak accessibility to retail - NW, RT, US	-	0.082	-
Usual work or school location			
Work location is home - FW, PW	-1.758	-	0.181
No work location - FW, PW	-0.594	-	-
No school location - SD, SP	-0.866	-	-

Two-person interactions

	Contribution to Household Daily Activity Pattern		
Variable	**MM**	**NN**	**HH**
FW x FW	0.141	1.123	1.626
FW x PW	0.088	0.495	0.741
FW x US	0.427	0.552	1.183
FW x NW	-	0.022	0.944
FW x RT	-	0.312	1.298
FW x SD	0.384	0.410	2.064
FW x SP	0.262	0.601	1.501
FW x PS	0.512	0.751	0.991
PW x PW	1.135	1.032	0.891
PW x US	0.173	0.336	1.642
PW x NW	-	0.748	0.706
PW x RT	-	0.098	0.463
PW x SD	1.103	0.495	3.057
PW x SP	0.308	0.898	0.769
PW x PS	0.507	1.452	1.07
US x US	0.873	1.054	1.018
US x NW	-	0.193	1.781
US x RT	-	0.407	0.484
US x SD	-0.002	1.620	1.546
US x SP	0.298	0.517	1.552
US x PS	0.225	0.897	1.340
NW x NW	-	0.698	1.352
NW x RT	-	0.186	1.209

NW x SD	-	0.680	0.524
NW x SP	-	0.565	0.811
NW x PS	-	1.164	1.167
RT x RT	-	0.729	1.407
RT x SD	-	0.292	0.863
RT x SP	-	0.292	0.863
RT x PS	-	0.292	0.863
SD x SD	0.479	1.512	2.198
SD x SP	0.515	1.422	0.977
SD x PS	0.552	1.273	1.467
SP x SP	0.973	1.553	2.800
SP x PS	0.596	0.618	1.434
PS x PS	1.651	0.877	1.378

Three-person interactions

	Contribution to Household Daily Activity Pattern		
Variable	**MMM**	**NNN**	**HHH**
FW x FW x FW	0.313	-	-
FW x FW x PW/NW	0.350	0.464	-
FW x PW/NW x PW/NW	-	0.349	0.957
FW x PW/NW x SP/PS	-	-	0.294
FW x SP/PS x SP/PS	-	0.355	-
PW/NW x PW/NW x PW/NW	-	-1.386	0.988
PW/NW x PW/NW x SP/PS	-	-0.857	0.437
PW/NW x SP/PS x SP/PS	-	-	0.475
SP/PS x SP/PS x SP/PS	-0.391	-	-

All-member interactions

	Contribution to Household Daily Activity Pattern		
Variable	**All M**	**All N**	**All H**
Three-person household: all same pattern	-0.067	-0.365	-1.181
Four-person household: all same pattern	-0.610	-1.346	-3.733
Five-person household: all same pattern	-1.528	-3.453	-8.621

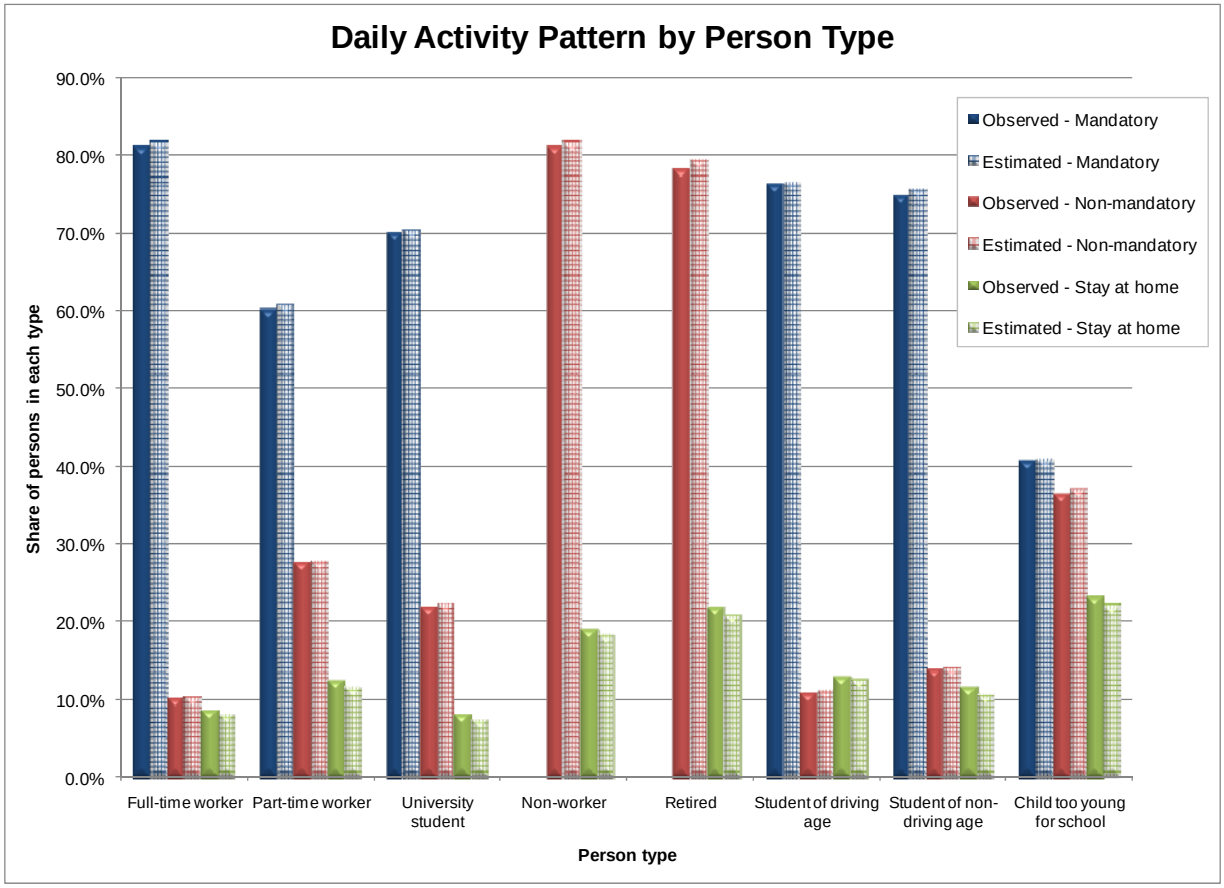


Figure 19: Daily Activity Pattern by Person Type

Comparisons between observed and modeled shares of each daily activity pattern by person type appear in Figure 19. The targets come from BATS 2000, but the frequency of mandatory and non-mandatory patterns was adjusted upward to offset respondents' underreporting of travel, as described in Section 1.2.2.

2.2.2 Individual Mandatory Tour Frequency

Number of Models: One

Decision-Making Unit: Persons with mandatory daily activity pattern

Model Form: Multinomial logit

Alternatives: 5 (1 work, 2 work, 1 school, 2 school, work & school)

Source: Transferred from ARC[9]

[9] See Progress Report for the Year 2003 Regional Transportation Plan Major Update Project for the Atlanta Regional Commission General Modeling: Task 2 – Activity / Tour-Based Models, by PB Consult with John Bowman and Mark Bradley

The individual mandatory tour frequency model predicts the number of work and school tours taken by each person with a mandatory DAP. The primary drivers of mandatory tour frequency are demographics, accessibility-based parameters such as drive time to work, and household auto ownership.

Calibration of the mandatory tour frequency model focused on matching the observed frequency of participation in work and school tours for each person type. Accomplishing this required adjustment of the alternative-specific constants for each person type. The available alternatives for each eligible person type appear in Table 28. Mandatory tours are not available for retired persons or non-workers, while pre-school children with a mandatory daily activity pattern must have one and only one school tour.

The calibrated utility function appears in Table 29. Comparisons between observed and modeled tour frequency distributions appear in Figure 20. Cases in the observed data with three or more mandatory tours are included in the 2 work, 2 school, and work & school alternatives, depending on the purposes of the tours.

Table 28: Availability of Mandatory Tour Frequency Alternatives by Person Type

Person Type	Alternative Availability				
	1 Work	2 Work	1 School	2 School	Work & School
(FW) Full-time worker	X	X			
(PW) Part-time worker	X	X			
(US) University student	X	X	X	X	X
(SD) Driving-age schoolchild			X	X	X
(SP) Pre-driving-age schoolchild			X	X	
(PS) Pre-school child			X		

Table 29: Mandatory Tour Frequency Utility Function

Variable	Mandatory Tour Frequency Alternative				
	1 Work	2 Work	1 School	2 School	Work & School
Constants					
Full-time worker	-	**-3.378**	-	-	-
Part-time worker	-	**-3.048**	-	-	-
University student	**2.166**	**-1.397**	-	**-3.743**	**0.107**
Driving-age schoolchild	-	-	-	**-3.136**	**-4.436**
Pre-driving-age schoolchild	-	-	-	**-3.97**	-
Female					
Full-time worker	-	-0.226	0.159	-	-0.344
Part-time worker	-	-0.226	0.159	-	-0.344
University student	0.174	-0.226	0.159	0.114	-0.344
Driving-age schoolchild	0.174	-	-	0.114	-0.344
Pre-driving-age schoolchild	0.174	-	-	0.114	-

Variable	Mandatory Tour Frequency Alternative				
	1 Work	2 Work	1 School	2 School	Work & School
Under 35					
Full-time worker	-	-0.138	0.722	-	0.976
Part-time worker	-	-0.138	0.722	-	0.976
University student	-0.463	-0.138	-	1.275	0.976
Walk distance to work < 3 mi.					
Full-time worker	-	0.527	-	-	-
Part-time worker	-	0.527	-	-	-
University student	-	0.527	-	-	-
Walk distance to school < 3 mi.					
University student	-	-	-	0.711	-
Driving-age schoolchild	-	-	-	0.711	-
Pre-driving-age schoolchild	-	-	-	0.711	-
Walk distance to work or school < 3 mi.					
Full-time worker	-	-	-	-	0.139
Part-time worker	-	-	-	-	0.139
University student	-	-	-	-	0.139
Driving-age schoolchild	-	-	-	-	0.139
Round trip peak auto time to work, min.					
Full-time worker	-	-0.004	-	-	-0.003
Part-time worker	-	-0.004	-	-	-0.003
University student	-	-0.004	-	-	-0.003
Round trip peak auto time to school, min.					
University student	-	-	-	-0.003	-0.003
Driving-age schoolchild	-	-	-	-0.003	-0.003
Pre-driving-age schoolchild	-	-	-	-0.003	-
Student is employed					
University student	3.014	3.014	-	-	3.014
Driving-age schoolchild	3.014	3.014	-	-	3.014
No cars in household					
Full-time worker	-	-1.306	-	-	-1.302
Part-time worker	-	-1.306	-	-	-1.302
University student	-	-1.306	-	-1.413	-1.302
Driving-age schoolchild	-	-	-	-1.413	-1.302
Pre-driving-age schoolchild	-	-	-	-1.413	-
Fewer cars than driving-age persons					
University student	-	-	-	-0.576	-
Driving-age schoolchild	-	-	-	-0.576	-
Pre-driving-age schoolchild	-	-	-	-0.576	-
Number of preschool children in household					
Full-time worker	-	-0.148	-0.134	-	-0.125
Part-time worker	-	-0.148	-0.134	-	-0.125

Variable	Mandatory Tour Frequency Alternative				
	1 Work	2 Work	1 School	2 School	Work & School
University student	0.219	-0.148	-	-0.558	-0.125
Driving-age schoolchild	0.219	-	-	-0.558	-0.125
Pre-driving-age schoolchild	0.219	-	-	-0.558	-
Number of non-workers in household					
Full-time worker	-	-	0.257	-	-
Part-time worker	-	-	0.257	-	-
Household income > $50k					
Full-time worker	-	-	0.035	-	0.035
Part-time worker	-	-	0.035	-	0.035
University student	-0.053	-0.053	-	-	-0.053
Driving-age schoolchild	-0.053	-	-	-	-0.053
Pre-driving-age schoolchild	-0.053	-	-	-	-
Non-family household					
Full-time worker	-	-	-0.250	-	-0.250
Part-time worker	-	-	-0.250	-	-0.250
University student	-0.179	-0.179	-	-	-0.179
Driving-age schoolchild	-0.179	-	-	-	-0.179
Pre-driving-age schoolchild	-0.179	-	-	-	-
Num. children under 16 not at school					
Full-time worker	-	0.180	-	-	-0.196
Part-time worker	-	0.180	-	-	-0.196
University student	-	0.180	-	0.087	-0.196
Driving-age schoolchild	-	-	-	0.087	-0.196
Pre-driving-age schoolchild	-	-	-	0.087	-
Home in urban area					
Full-time worker	-	0.231	-0.136	-	-0.351
Part-time worker	-	0.231	-0.136	-	-0.351
University student	-0.283	0.231	-	0.317	-0.351
Driving-age schoolchild	-0.283	-	-	0.317	-0.351
Pre-driving-age schoolchild	-0.283	-	-	0.317	-

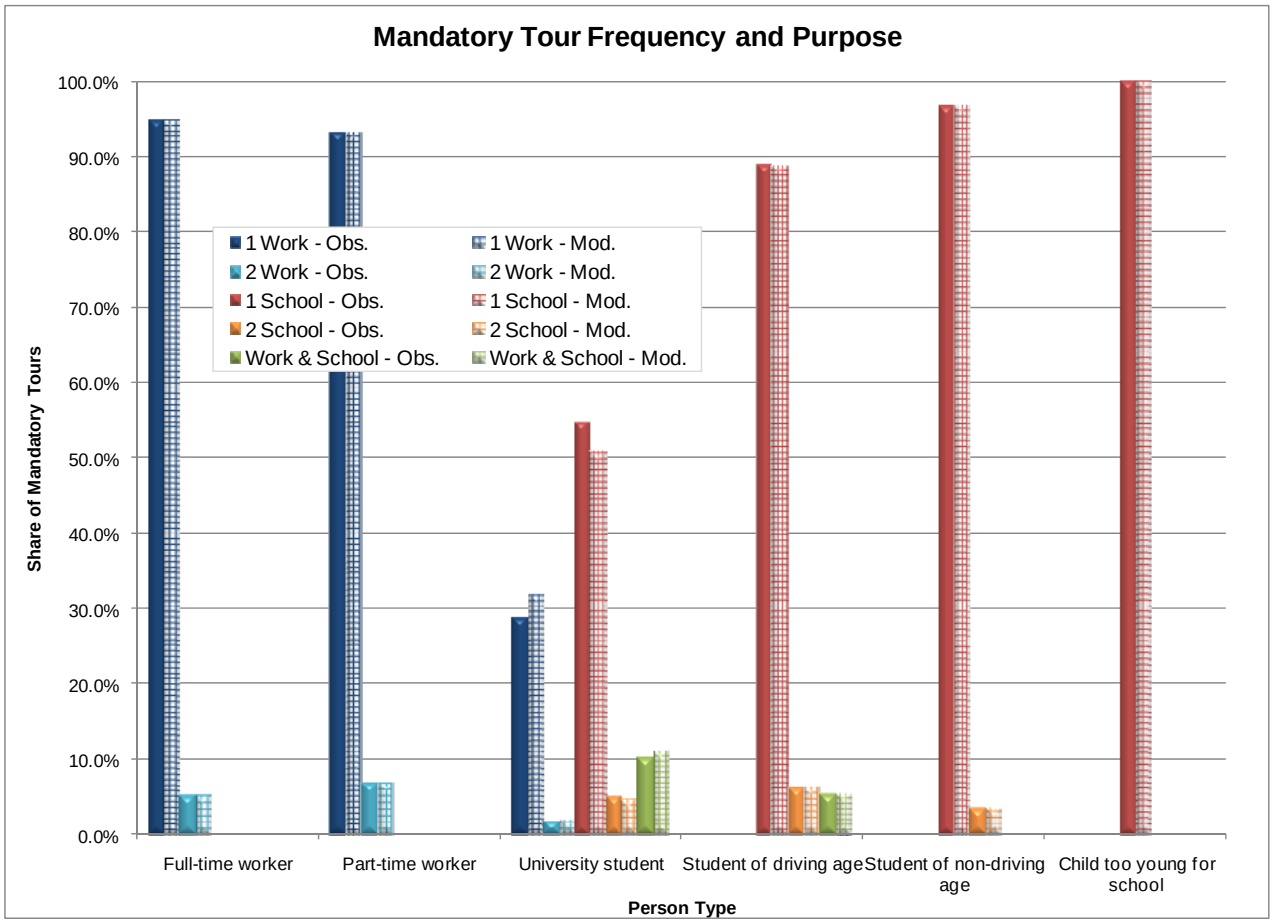


Figure 20: Mandatory Tour Frequency by Person Type

2.2.3 Individual Mandatory Tour Departure Time and Duration

Number of Models: Two (Work, School

Decision-Making Unit: Mandatory tours

Model Form: Multinomial logit

Alternatives: 190 (combinations of departure hour and arrival hour back at home)

Source: Transferred from ARC[10]

The individual mandatory tour departure time and duration model selects the time of departure and arrival back at home for each work and school tour. The primary drivers in the model are accessibility-based parameters such as the mode choice logsum for the departure/arrival hour combination, demographics, and time pattern characteristics such as the time windows available

[10] See Progress Report for the Year 2003 Regional Transportation Plan Major Update Project for the Atlanta Regional Commission General Modeling: Task 2 – Activity / Tour-Based Models, by PB Consult with John Bowman and Mark Bradley

from previously scheduled tours. The models were originally estimated using the Atlanta household travel survey for the Atlanta Regional Council.

Calibration of the models focused on matching the observed frequency distribution of times of departure, duration, and arrival back at home for work and school tours. Accomplishing this required adjustment of constants for bands of the departure, duration and arrival times that define the alternative outcomes of the model. The departure time and duration constants were adjusted first, and the arrival constants were only adjusted if needed. The calibrated utility functions for work and school appear in Table 30 and Table 31, respectively. Comparisons between modeled and observed distributions of tour departure and arrival times for work and school appear in Figure 21 through Figure 24. Data for the distribution of duration times appear in Appendix A.

Table 30: Work Tour Departure Time and Duration Utility Function Parameters

Variable	Coefficient
Travel time shift effects	
Free-flow round trip auto time (min) -- departure hour	-0.001
Free-flow round trip auto time (min) -- duration (hrs)	0.002
Mode choice logsum	
Tour mode choice logsum for departure/arrival combination	1.027
Demographic & tour characteristic shift effects	
Part-time worker -- departure	0.067
University worker -- departure	0.057
Household income ($1,000s) -- departure	0.000
Destination in CBD (Area Type < 2) -- departure	0.047
Destination in CBD (Area Type < 2) -- duration (in hours)	0.087
Pattern-specific shift effects	
First to be scheduled of two work tours -- departure	-0.303
First to be scheduled of two work tours -- duration	-0.186
Subsequently scheduled of two work tours -- departure	-0.538
Subsequently scheduled of two work tours -- duration	-0.317
Dummy variables for early & late travel	
Household income > $100k -- departure before 06:00	-0.485
Household income > $100k -- arrival after 22:00	-0.384
Destination in CBD -- departure before 06:00	-0.457
Destination in CBD -- arrival after 22:00	-0.233
Origin in rural area (Area Type > 6) -- departure before 06:00	0.404
Origin in rural area (Area Type > 6) -- arrival after 22:00	-0.345
Additional dummy variable effects	
Full-time worker -- duration less than 9 hours	-1.257
Full-time worker -- departure from 10:00 to 12:00	-0.518
Part-time worker -- arrival from 13:00 to 15:00	0.543
First of two work tours -- duration less than 8 hours	1.980
Subseqeuent of two work tours -- duration less than 8 hours	2.582
Worker has school tour -- duration less than 8 hours	0.913
Student has school tour -- duration less than 8 hours	2.582
Available time window effects	
Previously-scheduled tour ends in this departure hour	-0.894
Previously-scheduled tour begins in this arrival hour	-1.334
Hours in adjacent window before departure -- first tour	0.177
Hours in adjacent window after arrival -- first tour	0.363

Variable	Coefficient
Hours in adjacent window before departure -- subsequent tour	-0.212
Hours in adjacent window after arrival -- subsequent tour	-0.101
Remaining mandatory tours / number of remaining hours	-18.680
Departure constants	
00:00 to 05:00	**-0.953**
06:00	**-0.616**
07:00	**0.000**
08:00	**-0.255**
09:00	**-1.251**
10:00 to 12:00	**-1.706**
13:00 to 15:00	**-1.694**
16:00 to 18:00	**-1.440**
19:00 to 21:00	**-1.611**
22:00 to 23:00	**-2.883**
Arrival constants	
00:00 to 06:00	**0.000**
07:00 to 09:00	**-1.855**
10:00 to 12:00	**-0.496**
13:00 to 14:00	**-0.379**
15:00	**0.000**
16:00	**0.276**
17:00	**0.700**
18:00	**0.799**
19:00 to 21:00	**0.104**
22:00 to 23:00	**-0.966**
Duration constants	
0 to 2 hours	**-2.528**
3 to 4 hours	**-0.919**
5 to 6 hours	**-0.719**
7 to 8 hours	**-0.140**
9 hours	**0.056**
10 hours	**0.000**
11 hours	**-0.348**
12 to 13 hours	**-1.008**
14 to 18 hours	**-1.702**

Table 31: School Tour Departure Time and Duration Utility Function Parameters

Variable	Coefficient
Travel time shift effects	
Free-flow round trip auto time (min) - duration (hrs)	0.003
Mode choice logsum	
Tour mode choice logsum for departure/arrival combination	2.127
Demographic & tour characteristic shift effects	
Full-time worker -- departure hour	0.397
Full-time worker -- duration	-0.191
University student -- departure	0.280
University student -- duration	-0.291
Student of driving age -- duration	0.035
All adults in household work full-time -- duration	0.109
Pattern-specific shift effects	
First to be scheduled of two school tours -- departure	-0.300
First to be scheduled of two school tours -- duration	-0.159
Subsequent to be scheduled of two school tours -- duration	-0.234
Dummy variables for early & late travel	
Household income > $100k -- departure before 06:00	-0.884
Household income > $100k -- arrival after 22:00	-0.353
Additional dummy variable effects	
First of two school tours -- duration < 6 hours	1.487
Subsequent of two school tours -- duration < 6 hours	2.142
Student has work tour -- duration < 6 hours	1.730
Worker has work tour -- duration < 6 hours	2.142
Available time window effects	
Previously-scheduled tour ends in this departure hour	-0.600
Previously-scheduled tour begins in this arrival hour	-1.102
Hours in adjacent window before departure -- first tour	0.090
Hours in adjacent window after arrival -- first tour	-0.003
Hours in adjacent window before departure -- subsequent tour	-0.440
Hours in adjacent window after arrival -- subsequent tour	-0.527
Remaining mandatory tours / number of remaining hours	-16.670
Departure constants	
00:00 to 05:00	**-3.821**
06:00	**-1.618**
07:00	**0.000**
08:00	**-0.074**
09:00	**-2.081**
10:00 to 12:00	**-2.986**
13:00 to 15:00	**-3.628**
16:00 to 18:00	**-3.103**
19:00 to 21:00	**-5.230**
22:00 to 23:00	**-11.886**
Arrival constants	
00:00 to 06:00	**-2.429**
07:00 to 09:00	**-2.429**
10:00 to 12:00	**-1.238**
13:00 to 14:00	**-0.540**

Variable	Coefficient
15:00	**0.000**
16:00	**-0.389**
17:00	**-0.198**
18:00	**-0.254**
19:00 to 21:00	**-0.870**
22:00 to 23:00	**-1.752**
Duration constants	
0 to 2 hours	**-1.410**
3 to 4 hours	**-0.746**
5 to 6 hours	**-0.568**
7 to 8 hours	**0.000**
9 hours	**-0.651**
10 hours	**-0.905**
11 hours	**-1.521**
12 to 13 hours	**-2.418**
14 to 18 hours	**-2.503**

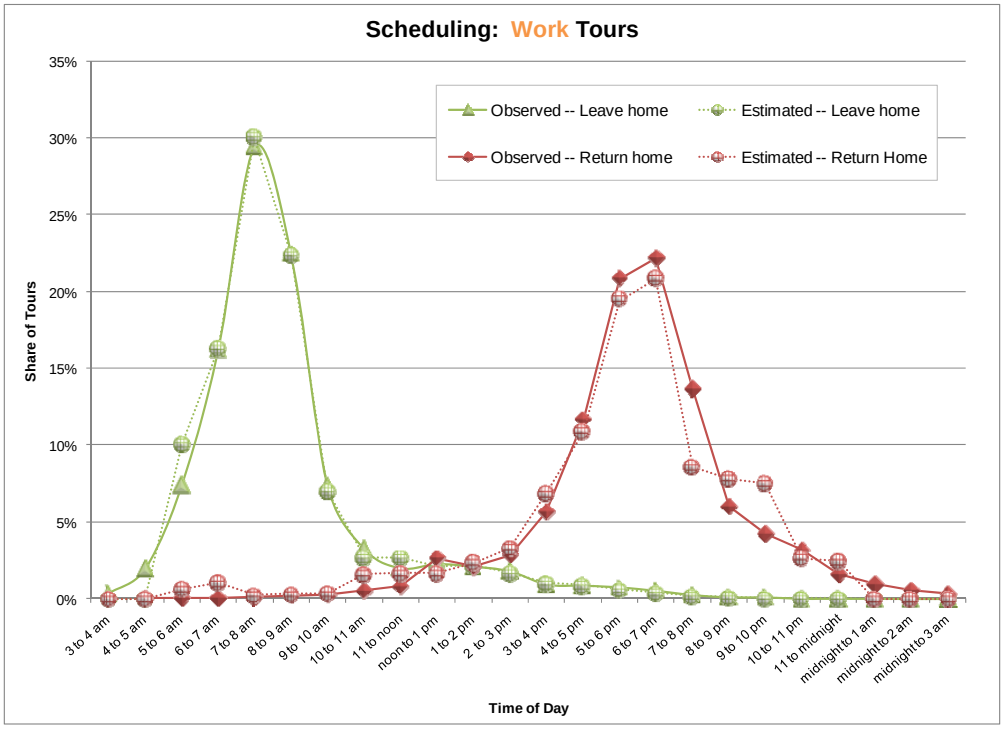


Figure 21: Work Tour Departure and Arrival Times

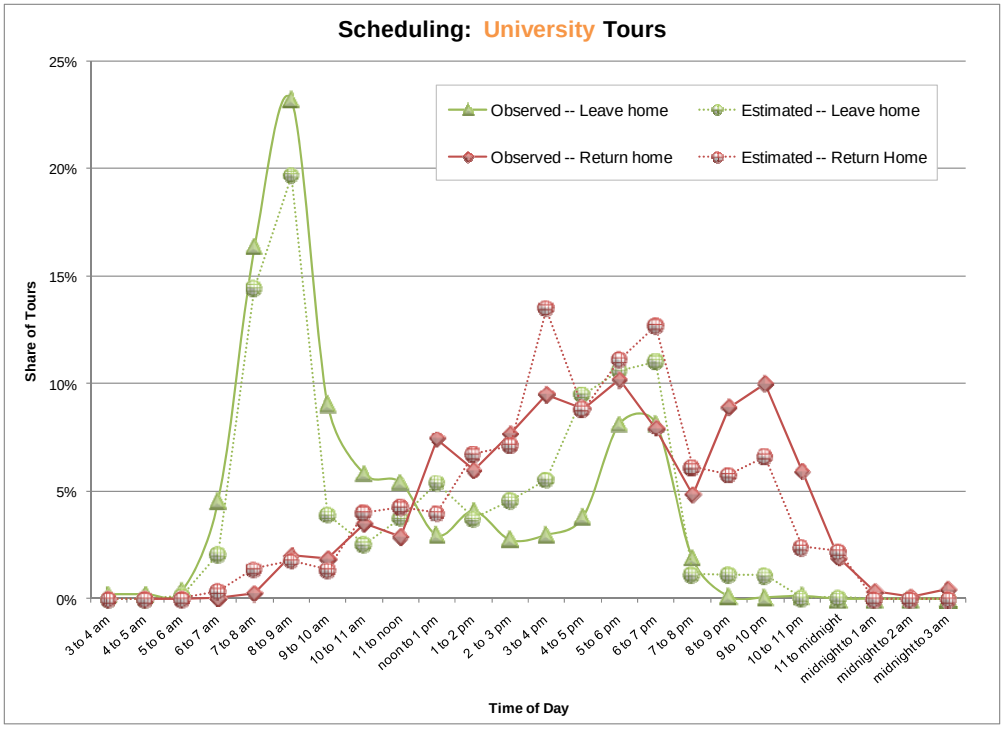


Figure 22: University Tour Departure and Arrival Times

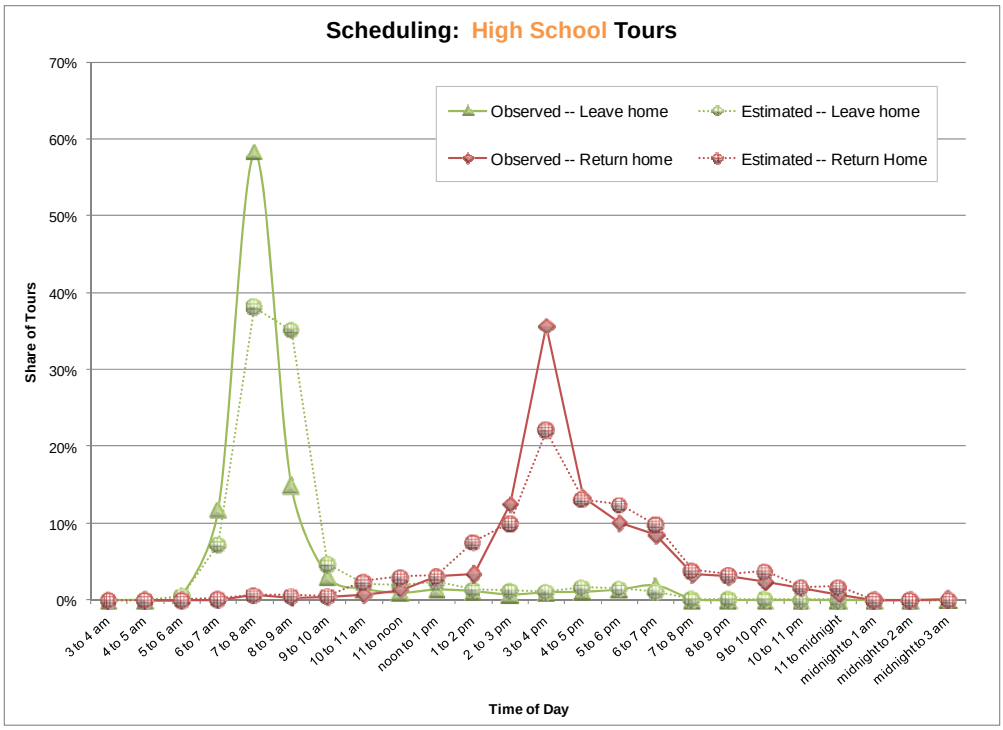


Figure 23: High School Departure and Arrival Times

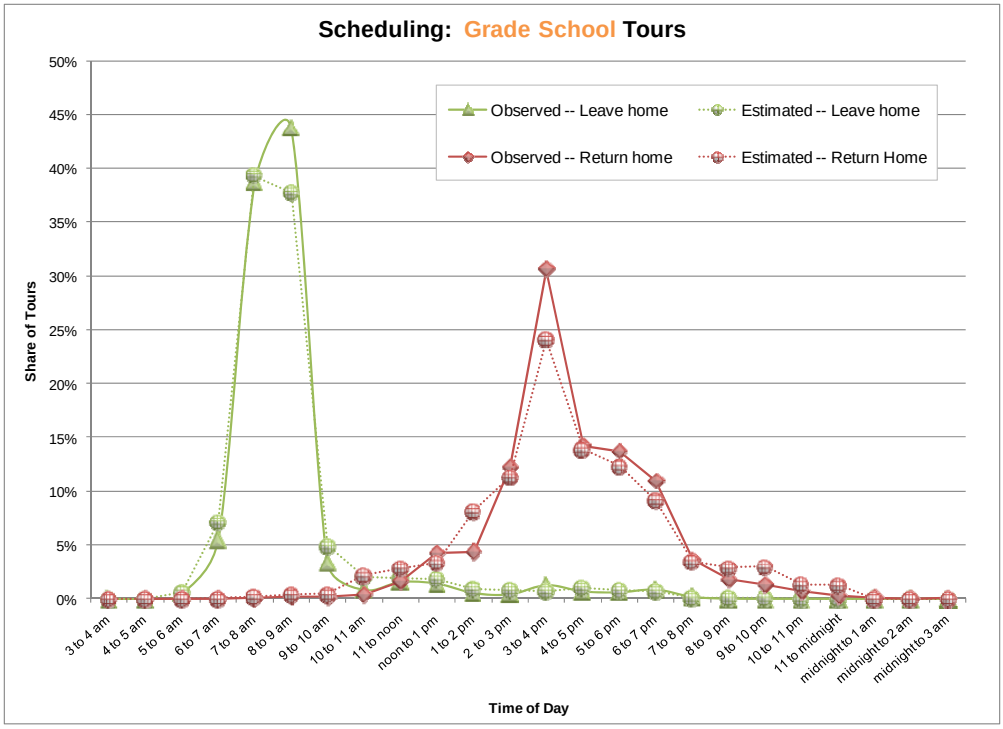


Figure 24: Grade School Departure and Arrival Times

2.2.4 Joint Tour Generation

The joint tour generation models are divided into three sub-models: the joint tour frequency model, the party composition model, and the person participation model. In the joint tour frequency model, the household chooses the purposes and number (up to two) of its fully joint travel tours. In the party composition model, the makeup of the travel party (adults, children, or "mixed" – adults and children) is determined for each joint tour. In the person participation model, each eligible person sequentially makes a choice to participate or not participate in each joint tour. The models were originally estimated using the Atlanta household travel survey for the Atlanta Regional Council.

Joint Tour Frequency

Number of Models:	One
Decision-Making Unit:	Households
Model Form:	Multinomial logit
Alternatives:	21 (1 with zero tours, 5 with one tour of different purposes, and 15 with two tours of different combinations of purposes)
Source:	Transferred from ARC[11]

[11] See Progress Report for the Year 2003 Regional Transportation Plan Major Update Project for the Atlanta Regional Commission General Modeling: Task 2 – Activity / Tour-Based Models, by PB Consult with John Bowman and Mark Bradley

Calibration of the joint tour frequency model focused on matching the observed frequency of tours by purpose. Accomplishing this required adjustment of purpose-specific constants for alternatives containing at least one tour of each purpose, and purpose-generic constants for alternatives containing two tours of different and identical purposes. The utility function parameters for the joint tour frequency model appear in Table 32. A comparison between modeled and observed frequencies of joint tours by purpose appears in Table 33.

Joint Tour Party Composition

Number of Models:	1
Decision-Making Unit:	Joint tours
Model Form:	Multinomial logit
Alternatives:	3 (Adults, children, mixed)
Source:	Transferred from ARC[12]

The party composition determines the general makeup of the party of participants in each joint tour in order to allow the microsimulated results to represent faithfully the prevalence of adult-only, children-only, and mixed joint travel tours for each purpose while permitting simplicity in the subsequent person participation model. The utility function parameters for the model appear in Table 34. The model was not calibrated using local data.

[12] Ibid

Table 32: Joint Tour Frequency Utility Function Parameters

Purpose-specific effects

	Units of utility per joint tour of each purpose				
Variable	**Shop**	**Maint.**	**Eat Out**	**Visit**	**Discr.**
Number of non-mandatory patterns in household					
Full-time workers, max 3	0.205	0.317	0.228	0.645	0.128
Part-time workers, max 3	0.187	0.245	0.377	0.133	0.498
Non-workers, max 3	0.708	0.464	0.182	0.548	0.287
Retired persons, max 3	0.941	0.905	0.426	0.558	0.614
University or driving-age students, max 3	0.765	0.264	0.41	0.281	0.755
Pre-driving and pre-school childrens, max 3	0.547	0.648	0.385	0.601	0.533
Number of mandatory patterns in household					
Full-time workers, max 3	-0.242	-0.301	-	-	-
Driving-age children, max 3	-	-0.324	-	-	0.193
Pre-driving and pre-school children, max 3	-	0.230	-	-	0.386
Overlapping available time windows					
Log max overlapping hours, adults	0.595	0.371	0.486	-	0.343
Log max overlapping hours, adults and children	0.142	0.176	-	-	0.116
Log max overlapping hours, children	0.109	0.244	0.092	-	0.221
Other household variables					
Income $50-100k	-	-	0.298	-	0.317
Income > $100k	-	-	0.449	-	0.486
Household has no autos	-	-	-	-0.980	-0.909
Household has autos, but fewer than drivers	0.252	0.461	-	-	-
Household has more autos than workers	-0.303	-	0.383	-	-
Zonal walk accessibility to retail employment	-	-	0.062	-	-
Constants					
Alternatives with one joint tour	**-6.015**	**-5.739**	**-6.376**	**-5.882**	**-5.481**

Purpose-generic effects

	Units of utility		
Variable	**No tours**	**Two same purp.**	**Two diff. purp.**
Constants			
Alternatives with two joint tours		**-14.458**	**-14.458**
Number of stay-at-home patterns in household			
Full-time workers, max 3	1.175		
Part-time workers, max 3	1.447		
Non-workers, max 3	1.514		
Retired persons, max 3	0.605		
University or driving-age students, max 3	0.569		
Pre-driving and pre-school children, max 3	0.531		

Table 33: Joint Tour Frequency Calibration Results

Joint Tours	Observed	Model	Difference
None	94.66%	92.87%	-1.79%
1 Shop	1.75%	1.62%	-0.13%
1 Maint.	1.00%	1.48%	0.48%
1 Eat out	0.58%	0.81%	0.24%
1 Visit	0.50%	0.78%	0.28%
1 Discr.	1.43%	2.21%	0.78%
2: Shop, Shop	0.00%	0.04%	0.04%
2: Shop, Maint.	0.01%	0.03%	0.01%
2: Shop, Eat out	0.00%	0.01%	0.01%
2: Shop, Visit	0.00%	0.01%	0.01%
2: Shop, Discr.	0.00%	0.02%	0.01%
2: Maint., Maint.	0.01%	0.02%	0.01%
2: Maint., Eat out	0.00%	0.01%	0.01%
2: Maint., Visit	0.00%	0.01%	0.01%
2: Maint., Discr.	0.01%	0.02%	0.01%
2: Eat out, Eat out	0.00%	0.01%	0.01%
2: Eat out, Visit	0.00%	0.00%	0.00%
2: Eat out, Discr.	0.04%	0.01%	-0.03%
2: Visit, Visit	0.00%	0.00%	0.00%
2: Visit, Discr.	0.00%	0.01%	0.01%
2: Discr, Discr.	0.00%	0.02%	0.02%
Total	100.00%	100.00%	0.00%

Table 34: Joint Tour Party Composition Utility Function

	Party composition		
Variable	**Adults**	**Children**	**Mixed**
Constants			
Alternative-specific constant	-	5.352	5.629
Tour purpose			
Tour purpose is Eating out	-	-0.968	-0.803
Tour purpose is Discretionary	-	0.765	0.510
Household composition			
Number of Full-time workers in household	1.024	-	0.362
Number of Part-time workers in household	0.541	-	0.316
Number of University students in household	0.825	-	-
Number of Non-workers in household	0.626	-	-0.372
Number of Pre-school children in household	-	0.731	0.791
Number of Pre-driving-age schoolchildren in household	-	0.731	0.353
Number of driving-age schoolchildren in household	-	-0.267	-0.94
Other household variables			
Income < $30k	1.248	-	0.576
Income $30-60k	0.837	-	-
More cars than workers	1.386	-	0.751
Home zone is in urban area type	0.574	-	-
Home zone is in suburban area type	0.511	-	0.128
Available time windows			
Log max overlapping hours, adults	1.192	-	-
Log max overlapping hours, adults and children	-	1.841	-
Log max overlapping hours, children	-	-	1.958

Joint Tour Person Participation

Number of Models: One
Decision-Making Unit: Persons
Model Form: Binary logit
Alternatives: 2 (participate, don't participate)
Source: Transferred from MORPC[13]

The person participation model determines which household members participate in each joint tour. Since the party composition model determines what types of people are eligible to join a

[13] Modeling Joint Travel by Household Members. Technical Memorandum. MORPC Model Improvement Project. PB Consult (2002).

given tour, the person participation model can operate in an iterative fashion, with each household member choosing to join or not to join a travel party independent of the decisions of other household members. In the event that the constraints posed by the result of the party composition model are not met, the person participation model cycles through the household members multiple times until the required types of people have joined the travel party. The utility function parameters for the person participation model appear in Table 35. The model was not calibrated using local data.

Table 35: Joint Tour Person Participation Utility Function

Variable	Participation
Person type - party composition interactions	
Full-time worker, mixed party	-4.066
Part-time worker, adult party	-0.366
Part-time worker, mixed party	-3.041
University student, mixed party	-3.164
Non-worker, adult party	0.715
Non-worker, mixed party	-2.786
Preschool child, children party	-1.893
Preschool child, mixed party	-0.722
Pre-driving age schoolchild, children party	-1.752
Pre-driving age schoolchild, mixed party	-1.822
Driving-age schoolchild, children party	-1.353
Driving-age schooolchild, mixed party	-2.041
Person type - tour purpose interactions	
Full-time worker, Eating out purpose	0.216
Full-time worker, Discretionary purpose	-0.061
Part-time worker, Eating out purpose	2.188
Part-time worker, Discretionary purpose	0.285
University student, Eating out purpose	-0.820
Non-worker, Eating out purpose	0.162
Non-worker, Discretionary purpose	-0.184
Preschool child, Eating out purpose	0.659
Preschool child, Discretionary purpose	0.128
Pre-driving-age schoolchild, Eating out purpose	1.391
Pre-driving-age schoolchild, Discretionary purpose	0.663
Driving-age schoolchild, Eating out purpose	2.344
Driving-age schoolchild, Discretionary purpose	-0.668
Area type - party composition interactions	
Urban area, adult in adult party	-
Urban area, adult in mixed party	-0.137
Urban area, child in children party	1.210
Urban area, child in mixed party	0.627
Suburban area, adult in adult party	-
Suburban area, adult in mixed party	-0.060

Variable	Participation
Suburban area, child in children party	-
Suburban area, child in mixed party	-
Auto ownership - party composition interactions	
More cars than workers, adult in adult party	-0.213
More cars than workers, adult in mixed party	-0.603
More cars than workers, child in children party	-0.421
More cars than workers, child in mixed party	-0.378
Income - party composition interactions	
Income > $60k, adult in adult party	-0.168
Income > $60k, adult in mixed party	-0.026
Income > $60k, child in children party	-0.562
Income > $60k, child in mixed party	-0.153
Number of joint tours - party composition interactions	
Number of joint tours , adult in adult party	-0.324
Number of joint tours, adult in mixed party	-0.358
Number of joint tours, child in children party	0.105
Number of joint tours, child in mixed party	-0.509
Other available participants - party composition interactions	
Number of other adults, adult in adult party	-0.424
Number of other adults, adult in mixed party	-0.406
Number of other children, child in children party	-0.289
Number of other children, child in mixed party	-0.439
Available time windows - party composition interactions	
Log max overlapping hours between adult and other adults, adult party	0.844
Log max overlapping hours between adult and children, mixed party	2.189
Log max overlapping hours between child and adults, mixed party	1.538
Log max overlapping hours between child and other children, children party	1.296

2.2.5 Individual Non-mandatory Tour Frequency

Number of Models: Eight (one for each person type)

Decision-Making Unit: Persons

Model Form: Multinomial logit

Alternatives: 96 (combinations of 0 or 1 shopping, maintenance, discretionary, eat out, and social tours with 0, 1, or 2 escort tours)

Source: Transferred from ARC[14]

[14] See Progress Report for the Year 2003 Regional Transportation Plan Major Update Project for the Atlanta Regional Commission General Modeling: Task 2 – Activity / Tour-Based Models, by PB Consult with John Bowman and Mark Bradley.

The individual non-mandatory tour frequency model operates in two stages. First, a choice is made using a random utility model between combinations of tours containing zero, one, and two or more escort tours, and between zero and one or more tours of each other purpose. Second, up to two additional tours of each purpose are added according to fixed extension probabilities.

Calibration of the model focused on the first model, matching the observed frequency distribution of tour combinations by person type, where extra tours in observations from the household survey that contained more than two escort tours or more than one tour of other purposes were truncated to fit the model's constraints. Achieving the match required adjustment of dummy variables for the presence of one or two escort tours, and the presence of tours for each other purpose. The extension probabilities in the second stage were not adjusted.

The calibrated utility function appears in Table 36. Comparisons between modeled and observed tour frequency distributions appear in Table 37.

Table 36: Individual Non-mandatory Tour Frequency Utility Function Parameters

	Person Type							
Variable	**Full-time worker**	**Part-time worker**	**University student**	**Non-worker**	**Retired person**	**Driving-age schoolchild**	**Pre-driving schoolchild**	**Preschool child**
Tour frequency								
Zero (only available with mandatory or joint tours)	-	-	-	-	-	-	-	-
1	-7.357	-7.639	-6.214	-8.979	-8.568	-7.151	-7.486	-5.759
2	-10.647	-10.456	-8.908	-12.025	-12.742	-11.121	-10.718	-11.517
3	-13.5	-14.018	-12.326	-14.852	-15.098	-13.175	-13.788	-17.276
4	-16.396	-16.972	-15.811	-17.704	-19.544	N/A	N/A	-23.035
5	-19.684	N/A	N/A	N/A	-20.790	N/A	N/A	N/A
6+	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Number of mandatory tours								
Tour frequency =0	-	-	-	-	-	-	-	
Tour frequency =1	-	-0.239	-0.185	-0.677	-	-0.234	-1.033	
Tour frequency =2	-0.889	-1.821	-0.875	-1.052	-5.020	-0.923	-2.745	
Tour frequency =3	-2.334	-2.592	-1.616	-1.052	-5.020	-6.583	-2.745	
Tour frequency =4	-2.334	-2.592	N/A	N/A	N/A	N/A	N/A	
Tour frequency =5	-2.334	-2.592	N/A	N/A	N/A	N/A	N/A	
Number of joint tours								
Tour frequency =0	-	-	-	-	-	-	-	-
Tour frequency =1	-	-	-	-0.170	-	-0.216	-0.615	-
Tour frequency =2	-	-1.199	-0.315	-0.428	-0.950	-0.359	-0.615	-
Tour frequency =3	-	-1.199	-0.735	-0.655	-7.143	-4.27	N/A	-
Tour frequency =4	-	-1.199	N/A	-1.041	N/A	N/A	N/A	-
Tour frequency =5	-	N/A	N/A	-1.041	N/A	N/A	N/A	-
Number of joint tours with same purpose as alternative								
Shop	-	-	-0.713	-0.239	-0.807	-	-	-
Maintenance	-	-	-	-	-	-	-1.348	-
Eating Out	-0.587	-	-	-0.773	-	-	-	-
Visit	-	-	-	-	-	-	-	-
Discretionary	-	-	0.671	-	-	-	-	-
Log max available time window								
Tour frequency =0	-	-	1.186	-	-	-	-	-

Variable	Person Type							
	Full-time worker	Part-time worker	University student	Non-worker	Retired person	Driving-age schoolchild	Pre-driving schoolchild	Preschool child
Tour frequency =1	1.256	1.575	1.484	1.764	1.836	1.330	1.560	-
Tour frequency =2	1.287	2.003	1.484	1.793	2.271	1.376	1.560	-
Tour frequency =3	1.399	2.003	1.484	1.793	4.402	3.281	1.560	-
Tour frequency =4	1.399	2.003	1.484	1.793	4.402	3.281	1.560	-
Tour frequency =5	1.399	2.003	1.484	1.793	4.402	3.281	1.560	-
Income $20-50k								
Tour frequency =1	0.498	0.598	-	0.571	-	-	1.087	-
Tour frequency =2	0.835	0.918	-	0.831	-	-	1.087	-
Tour frequency =3	1.021	1.754	-	0.831	-	-	1.087	-
Tour frequency =4	1.021	1.754	-	0.831	-	-	1.087	-
Tour frequency =5	1.021	1.754	-	0.831	-	-	1.087	-
Income $50-100k								
Tour frequency =1	0.498	0.868	0.111	0.743	-	-	1.520	-
Tour frequency =2	0.835	1.536	0.391	0.855	-	-	1.520	-
Tour frequency =3	1.021	1.933	0.614	1.079	-	-	1.520	-
Tour frequency =4	1.021	1.933	0.614	1.079	-	-	1.520	-
Tour frequency =5	1.021	1.933	0.614	1.079	-	-	1.520	-
Income more than $100k								
Tour frequency =1	0.519	0.868	0.399	1.063	-	-	2.018	-
Tour frequency =2	1.134	1.536	0.801	1.063	-	-	2.018	-
Tour frequency =3	1.390	1.933	0.825	1.774	-	-	2.018	-
Tour frequency =4	1.390	1.933	0.825	2.394	-	-	2.018	-
Tour frequency =5	1.390	1.933	0.825	2.394	-	-	2.018	-
Alternative contains shop tour								
Income $20-50k	-	0.442	0.569	0.773	1.095	-	-0.651	-
Income $50-100k	-	0.442	0.569	0.891	1.095	0.244	-0.651	-
Income more than $100k	-	0.707	0.569	0.978	1.095	0.244	-0.651	-
Alternative contains maintenance tour								
Income $20-50k	-	0.676	-	-	0.765	-	-	-
Income $50-100k	-	0.676	-	-	0.765	0.398	-	-
Income more than $100k	-	0.676	-	-	1.379	0.398	-	-

Variable	Person Type							
	Full-time worker	Part-time worker	University student	Non-worker	Retired person	Driving-age schoolchild	Pre-driving schoolchild	Preschool child
Alternative contains eating out tour								
Income $20-50k	-	-	-	0.277	0.977	-	-0.701	-
Income $50-100k	0.558	-	-0.721	0.463	1.181	0.492	-0.701	-
Income more than $100k	0.558	-	-0.721	0.709	1.484	0.492	-0.701	-
Alternative contains discretionary tour								
Income $20-50k	-	0.296	-	0.171	1.009	0.917	-	-
Income $50-100k	0.257	0.296	-	0.501	1.009	1.405	-	-
Income more than $100k	0.257	0.296	-	0.885	1.009	2.327	-	-
Alternative contains visiting tour								
Income $20-50k	-	-0.687	-	-0.267	-	-	-	-
Income $50-100k	-0.242	-0.687	-0.369	-0.267	-0.437	0.286	-	-
Income more than $100k	-0.242	-0.687	-0.369	-0.945	-0.514	0.286	-	-
Person is female								
Tour frequency =1	-0.077	-	0.097	0.39	-0.935	-	-	-
Tour frequency =2	-0.106	-	0.236	0.532	-1.303	-	-	-
Tour frequency =3	-0.327	-	1.900	0.745	-2.266	-	-	-
Tour frequency =4	-0.327	-	1.900	1.129	-2.266	-	-	-
Tour frequency =5	-0.327	-	1.900	1.129	-2.266	-	-	-
Alternative contains escort tour	0.182	-	-	-	-	-	-	-
Alternative contains shop tour	-	0.452	-	-	0.969	-	-	-
Alternative contains maintenance tour	-	-	-	-0.246	0.742	-	-	-
Alternative contains eating out tour	-	-	-0.657	-	-	-	-	-
Alternative contains discretionary tour	-	0.307	-0.327	-	0.495	-	-	-
Household has zero cars								
Tour frequency =1	-0.349	-0.55	-0.581	-0.362	-	-0.637	-	-
Tour frequency =2	-0.349	-0.55	-0.581	-1.272	-	-0.637	-	-
Tour frequency =3	-0.349	-0.55	-0.581	-1.931	-	-0.637	-	-
Tour frequency =4	-0.349	-0.55	-0.581	-1.931	-	-0.637	-	-
Tour frequency =5	-0.349	-0.55	-0.581	-1.931	-	-0.637	-	-
Alternative has escort tour	-2.000	-2.000	-2.000	-2.000	-2.000	-2.000	-2.000	-2.000
Household has fewer cars than workers								

Variable	Person Type							
	Full-time worker	Part-time worker	University student	Non-worker	Retired person	Driving-age schoolchild	Pre-driving schoolchild	Preschool child
Tour frequency =1	-	-0.550	-0.581	-0.362	-	-0.637	-	-
Tour frequency =2	-	-0.550	-0.581	-1.272	-	-0.637	-	-
Tour frequency =3	-	-0.550	-0.581	-1.931	-	-0.637	-	-
Tour frequency =4	-	-0.550	-0.581	-1.931	-	-0.637	-	-
Tour frequency =5	-	-0.550	-0.581	-1.931	-	-0.637	-	-
Household has more cars than workers								
Tour frequency =1	0.130	-	-	0.774	0.797	0.29	-	-
Tour frequency =2	0.130	-	-	0.774	2.130	2.035	-	-
Tour frequency =3	0.130	-	-	0.774	2.130	2.035	-	-
Tour frequency =4	0.130	-	-	0.774	2.130	2.035	-	-
Tour frequency =5	0.130	-	-	0.774	2.130	2.035	-	-
Presence of non-worker in household								
Tour frequency =1	-	-	-0.851	-0.376	0.224	-	0.218	-
Tour frequency =2	-	-	-1.180	-0.719	0.244	-0.657	0.218	-
Tour frequency =3	-	-	-1.180	-1.023	0.620	-1.404	0.218	-
Tour frequency =4	-	-	-1.180	-1.023	3.374	-1.404	0.218	-
Tour frequency =5	-	-	-1.180	-1.023	3.374	-1.404	0.218	-
Presence of retired person in household								
Tour frequency =1	-	-	-	-0.464	-0.446	-	-	-
Tour frequency =2	-	-	-	-0.479	-0.531	-	-	-
Tour frequency =3	-	-	-	-0.479	-0.531	-	-	-
Tour frequency =4	-	-	-	-0.479	-0.531	-	-	-
Tour frequency =5	-	-	-	-0.479	-0.531	-	-	-
Presence of preschool child in household								
Tour frequency =1	-	-0.156	-0.996	-0.716	-	-	-0.444	-
Tour frequency =2	-	-0.568	-1.910	-0.716	-	-	-0.444	-
Tour frequency =3	-	-0.568	-2.847	-0.716	-	-	-0.444	-
Tour frequency =4	-	-0.568	-2.847	-0.716	-	-	-0.444	-
Tour frequency =5	-	-0.568	-2.847	-0.716	-	-	-0.444	-
Presence of pre-driving-age schoolchild in houeshold								
Tour frequency =1	-	-	-	0.149	-	-0.322	-0.226	-

Variable	Person Type							
	Full-time worker	Part-time worker	University student	Non-worker	Retired person	Driving-age schoolchild	Pre-driving schoolchild	Preschool child
Tour frequency =2	-	-	-	0.484	-	-1.087	-0.226	-
Tour frequency =3	-	-	-	0.484	-	-1.087	-0.226	-
Tour frequency =4	-	-	-	0.484	-	-1.087	-0.226	-
Tour frequency =5	-	-	-	0.484	-	-1.087	-0.226	-
Alternative has escort tour								
Presence of full-time worker in household	-	-	-	0.395	-	-	-	-0.893
Presence of part-time worker in household	-	-	-1.821	-0.586	-	-	-	-
Presence of non-worker in household	-0.482	-0.526	-	-	-	-	-	0.890
Presence of retired person in household	-0.808	-0.752	-	-	-	-	-	-
Presence of university student in household	-	-	-	-	-	-	-	-
Presence of driving-age schoolchild in household	0.360	0.416	-	-	-	-	-	-
Presence of pre-driving-age schoolchild in household	1.397	1.579	0.949	1.377	1.490	-	-	-
Presence of preschool child in household	0.684	0.541	2.146	0.719	0.503	-	-	-
Presence of driving-age child with at-home pattern	-0.275	-	-	-1.148	-	-	-	-
Presence of preschool child with at-home pattern	-1.568	-	-	-0.137	-	-	-	-
Alternative has shop tour								
Presence of full-time worker in household	-0.306	-	-0.773	-	-0.361	-	-	-
Presence of part-time worker in household	-0.154	-	-0.520	-	-	-	-	1.155
Presence of non-worker in household	-0.416	-	-	-	-	-	-0.645	0.808
Presence of retired person in household	-	-	-	-	-	-	-	-
Presence of university student in household	-	-	-	-	-	-	-	-
Presence of driving-age schoolchild in household	-	-	-	-	-	-	-	-
Presence of pre-driving-age schoolchild in household	-	-	-	-	-	-	0.937	-
Presence of preschool child in household	-0.208	-	1.314	-	-	-	-	-
Presence of driving-age child with at-home pattern	-	-	-	-	-	-	-	-
Presence of preschool child with at-home pattern	-	-	-	-	-	-	-	-
Alternative has maintenance tour								
Presence of full-time worker in household	-0.168	-0.313	-	-	-	-	-	-
Presence of part-time worker in household	-0.158	-0.562	-	-	-	-	-	-
Presence of non-worker in household	-0.324	-	-	-	-	-	-	-
Presence of retired person in household	-	-	-	-	-	-	-	-

Variable	Person Type							
	Full-time worker	Part-time worker	University student	Non-worker	Retired person	Driving-age schoolchild	Pre-driving schoolchild	Preschool child
Presence of university student in household	-	-	-	-	-	-	-	-
Presence of driving-age schoolchild in household	-	-	-	-	-	-	-	-
Presence of pre-driving-age schoolchild in household	-	-	0.386	-	-	-	-	-
Presence of preschool child in household	-	-	0.969	-	-	-	-	-
Presence of driving-age child with at-home pattern	-	-	-	-	-	-	-	-
Presence of preschool child with at-home pattern	-	-	-	-	-	-	-	-
Alternative has eating out tour								
Presence of full-time worker in household	-0.357	-	-0.525	-0.467	-0.788	-	-	-
Presence of part-time worker in household	-	-	-1.980	-	-0.788	-	-	1.037
Presence of non-worker in household	-0.201	-0.654	-	-0.498	-0.788	-	-1.307	1.157
Presence of retired person in household	-0.571	-1.389	-	-0.691	-0.928	-	-	-
Presence of university student in household	-	-1.432	-0.653	-	-	-	-	-
Presence of driving-age schoolchild in household	-	-	-	-	-	-0.638	-	-
Presence of pre-driving-age schoolchild in household	-	-	-	-	-	-1.570	-	-
Presence of preschool child in household	-0.423	-	-	-	-	-0.299	-	-
Presence of driving-age child with at-home pattern	-	-	-	-0.393	-	-	-	-
Presence of preschool child with at-home pattern	-	-	-	-0.393	-	-	-	-
Alternative has discretionary tour								
Presence of full-time worker in household	-0.667	-	-0.483	-0.355	-0.484	-	0.753	-
Presence of part-time worker in household	-0.210	-	-	-0.355	-	-	0.372	-
Presence of non-worker in household	-0.428	-1.037	0.978	-	-0.560	-	-	0.791
Presence of retired person in household	-0.910	-	-	-	-	-	-	-
Presence of university student in household	-0.855	-	-0.654	-	-	-1.283	-	-
Presence of driving-age schoolchild in household	-0.396	-	-	-	-	-0.920	-	-
Presence of pre-driving-age schoolchild in household	-0.396	-	-	-	-	-	-	-
Presence of preschool child in household	-0.508	-	-	-	-	-	-	-
Presence of driving-age child with at-home pattern	-0.470	-	-	-	-	-	-	-
Presence of preschool child with at-home pattern	-0.470	-	-	-	-	-	-	-
Zonal walk accessibility to retail employment								
Tour frequency =1	-	0.090	-	0.071	0.062	-	-	-
Tour frequency =2	-	0.145	-	0.126	0.062	-	-	-

Variable	Person Type							
	Full-time worker	Part-time worker	University student	Non-worker	Retired person	Driving-age schoolchild	Pre-driving schoolchild	Preschool child
Tour frequency =3	-	0.348	-	0.151	0.062	-	-	-
Tour frequency =4	-	0.348	-	0.151	0.062	-	-	-
Tour frequency =5	-	0.348	-	0.151	0.062	-	-	-
Zonal off-peak transit accessibility to retail employment								
Tour frequency =1	0.023	-	0.066	-	-	-	-	-
Tour frequency =2	0.023	-	0.066	-	-	-	-	-
Tour frequency =3	0.023	-	0.066	-	-	-	-	-
Tour frequency =4	0.023	-	0.066	-	-	-	-	-
Tour frequency =5	0.023	-	0.066	-	-	-	-	-
Zonal off-peak auto accessibility to retail employment								
Tour frequency =1	-	-	-	-	-	0.100	-	-
Tour frequency =2	-	-	-	-	-	0.100	-	-
Tour frequency =3	-	-	-	-	-	0.100	-	-
Tour frequency =4	-	-	-	-	-	0.100	-	-
Tour frequency =5	-	-	-	-	-	0.100	-	-
Alternative has escort tour								
Zonal walk accessibility to retail employment	0.045	-	-	-	-	-	-	-
Zonal off-peak transit accessibility to retail employment	-	-	-	-	-	-	-	-
Zonal off-peak auto accessibility to retail employment	-	-	-	-	-	-	0.063	-
Alternative has shop tour								
Zonal walk accessibility to retail employment	0.033	-	0.097	0.060	-	-	-	-
Zonal off-peak transit accessibility to retail employment	-	-	-	-	-	-	-	-
Zonal off-peak auto accessibility to retail employment	0.107	-	-	-	-	-	-	-
Alternative has maintenance tour								
Zonal walk accessibility to retail employment	-	-	-	-	-	-	-	-
Zonal off-peak transit accessibility to retail employment	-	-	0.031	-	-	-	-	-
Zonal off-peak auto accessibility to retail employment	0.075	-	-	0.096	-	-	-	-
Alternative has eat out tour								
Zonal walk accessibility to retail employment	0.145	-	-	-	-	-	0.074	-
Zonal off-peak transit accessibility to retail employment	-	-	-	-	-	-	-	-
Zonal off-peak auto accessibility to retail employment	-	-	0.102	-	-	-	-	-

Variable	Person Type							
	Full-time worker	**Part-time worker**	**University student**	**Non-worker**	**Retired person**	**Driving-age schoolchild**	**Pre-driving schoolchild**	**Preschool child**
Alternative has discretionary tour								
Zonal walk accessibility to retail employment	0.057	-	-	0.077	-	-	-	-
Zonal off-peak transit accessibility to retail employment	-	-	-	-	-	-	-	-
Zonal off-peak auto accessibility to retail employment	0.084	-	0.094	-	-	-	-	-
Home zone is in urban area type								
Tour frequency =1	-	-	-1.165	-	-	-	-	-
Tour frequency =2	-	-	-2.318	-	-	-	-	-
Tour frequency =3	-	-	-2.503	-	-	-	-	-
Tour frequency =4	-	-	-2.503	-	-	-	-	-
Tour frequency =5	-	-	-2.503	-	-	-	-	-
Home zone is in urban area type								
Alternative has escort tour	-0.432	-0.393	0.852	-	-	-	0.435	-
Alternative has shop tour	-	-	0.533	-	-	-	-	-
Alternative has maintenance tour	-	-	1.032	-	-	1.039	-	-
Alternative has eat out tour	-	-	0.68	-	-	-	-	-
Alternative has discretionary tour	-	-	0.956	-	-	-	-	-
Constants								
Alternative has 1 escort tour	**0.030**	**0.527**	**1.703**	**-0.063**	**-0.399**	**-0.493**	**-0.755**	**0.362**
Alternative has 2+ escort tours	**0.740**	**1.599**	**2.838**	**0.927**	**0.517**	**1.415**	**-0.009**	**2.222**
Alternative has shop tour	**0.477**	**0.757**	**1.840**	**0.468**	**0.595**	**0.532**	**0.478**	**1.692**
Alternative has maintenance tour	**0.120**	**0.553**	**0.335**	**-0.065**	**0.105**	**-0.434**	**-0.506**	**0.679**
Alternative has eating out tour	**0.010**	**0.691**	**2.072**	**-0.143**	**0.024**	**-0.024**	**1.115**	**0.961**
Alternative has visit tour	**0.052**	**0.140**	**1.217**	**-0.127**	**0.279**	**0.237**	**-0.401**	**0.442**
Alternative has discretionary tour	**0.741**	**0.799**	**1.339**	**0.333**	**0.428**	**-0.260**	**0.463**	**1.494**

Table 37: Individual Non-mandatory Tour Frequency

HOUSEHOLD SURVEY (PERCENT)

	Escorting				Shopping				Maintenance				Eating Out				Visiting				Other Discretionary			
Person Type	0	1	2	3+	0	1	2	3+	0	1	2	3+	0	1	2	3+	0	1	2	3+	0	1	2	3+
Full-time Worker	93.8	4.9	1.0	0.3	91.1	8.4	0.5	0.0	95.4	4.3	0.3	0.0	94.8	5.2	0.1	0.0	97.8	2.1	0.1	0.0	92.2	7.5	0.3	0.0
Part-time Worker	79.1	12.9	6.4	1.6	75.3	22.7	1.9	0.1	87.1	11.7	1.2	0.0	91.8	7.6	0.5	0.0	96.4	3.5	0.1	0.0	83.8	14.6	1.3	0.2
University Student	89.5	7.9	2.5	0.1	85.6	13.6	0.8	0.0	94.5	5.2	0.2	0.0	93.4	6.5	0.1	0.0	95.0	4.5	0.0	0.4	87.0	12.3	0.7	0.0
Non-worker	71.2	16.7	10.1	2.1	57.5	38.3	4.0	0.3	80.1	18.0	1.8	0.1	92.1	7.6	0.3	0.0	93.9	6.0	0.2	0.0	77.2	20.8	1.8	0.3
Retired	93.5	5.2	1.1	0.2	53.8	42.8	3.1	0.2	77.1	20.7	2.0	0.1	91.8	7.9	0.3	0.0	92.7	7.1	0.3	0.0	76.3	21.4	2.2	0.1
Driving Child	97.7	1.9	0.1	0.3	93.5	6.2	0.3	0.0	96.2	3.8	0.0	0.0	97.6	2.4	0.0	0.0	95.2	3.5	1.3	0.0	90.5	8.8	0.7	0.0
Pre-driving Child	96.6	3.1	0.3	0.0	95.8	4.1	0.1	0.0	98.1	1.9	0.1	0.0	95.4	4.4	0.1	0.0	97.8	2.2	0.0	0.0	88.0	11.2	0.7	0.0
Pre-school Child	88.8	8.6	2.3	0.3	91.8	7.7	0.5	0.0	96.7	3.2	0.1	0.0	95.5	4.4	0.1	0.0	98.0	2.0	0.0	0.0	89.5	9.9	0.6	0.0

MODEL RESULTS

	Escorting				Shopping				Maintenance				Eating Out				Visiting				Other Discretionary			
Person Type	0	1	2	3+	0	1	2	3+	0	1	2	3+	0	1	2	3+	0	1	2	3+	0	1	2	3+
Full-time Worker	94.4	4.4	1.0	0.2	91.7	7.4	0.9	0.0	95.7	3.9	0.3	0.0	95.1	4.8	0.0	0.0	98.0	1.8	0.2	0.0	92.7	6.8	0.3	0.1
Part-time Worker	79.6	12.7	5.6	2.1	75.1	19.9	4.9	0.1	86.8	12.5	0.7	0.0	91.8	8.1	0.1	0.0	96.3	3.2	0.5	0.0	83.8	14.8	1.4	0.0
University Student	91.6	6.2	2.0	0.2	86.9	12.7	0.4	0.0	95.9	4.1	0.1	0.0	94.0	5.8	0.1	0.0	95.5	4.4	0.1	0.0	88.2	11.8	0.0	0.0
Non-worker	71.5	16.1	9.5	2.8	55.7	43.0	1.3	0.0	79.2	19.4	1.4	0.0	92.0	8.0	0.0	0.0	93.6	6.0	0.3	0.0	76.5	23.3	0.2	0.0
Retired	93.6	5.1	1.1	0.2	50.7	43.2	5.9	0.3	76.1	21.7	2.0	0.2	91.7	8.3	0.0	0.0	92.2	6.9	0.9	0.0	75.2	23.0	1.4	0.5
Driving Child	97.6	1.9	0.3	0.1	93.4	5.8	0.8	0.0	96.2	3.3	0.5	0.0	97.3	2.6	0.1	0.0	95.0	4.4	0.5	0.1	90.5	9.0	0.5	0.0
Pre-driving Child	96.6	3.1	0.3	0.1	95.8	4.2	0.1	0.0	98.1	1.9	0.0	0.0	95.3	4.7	0.0	0.0	97.8	2.1	0.1	0.0	88.1	9.9	2.0	0.0
Pre-school Child	88.1	9.3	2.1	0.5	91.1	8.4	0.5	0.0	96.3	3.5	0.3	0.0	95.1	4.4	0.4	0.0	97.7	2.1	0.2	0.0	88.4	11.2	0.4	0.0

MODEL - SURVEY

	Escorting				Shopping				Maintenance				Eating Out				Visiting				Other Discretionary			
Person Type	0	1	2	3+	0	1	2	3+	0	1	2	3+	0	1	2	3+	0	1	2	3+	0	1	2	3+
Full-time Worker	0.6	-0.5	0.0	-0.1	0.6	-1.0	0.4	0.0	0.3	-0.4	0.0	0.0	0.4	-0.3	0.0	0.0	0.1	-0.3	0.1	0.0	0.5	-0.7	0.1	0.1
Part-time Worker	0.4	-0.2	-0.8	0.5	-0.2	-2.8	3.0	0.0	-0.3	0.7	-0.5	0.0	0.0	0.5	-0.4	0.0	-0.1	-0.3	0.4	0.0	0.0	0.1	0.1	-0.2
University Student	2.1	-1.6	-0.6	0.1	1.3	-0.9	-0.4	0.0	1.4	-1.2	-0.1	0.0	0.6	-0.6	0.0	0.0	0.5	-0.1	0.1	-0.4	1.2	-0.5	-0.7	0.0
Non-worker	0.3	-0.5	-0.6	0.7	-1.7	4.7	-2.7	-0.3	-0.9	1.4	-0.4	-0.1	-0.2	0.5	-0.3	0.0	-0.3	0.1	0.2	0.0	-0.6	2.5	-1.6	-0.3
Retired	0.1	-0.2	0.0	0.0	-3.1	0.3	2.7	0.1	-1.0	1.0	0.0	0.0	-0.2	0.5	-0.3	0.0	-0.5	-0.2	0.7	0.0	-1.1	1.6	-0.8	0.3
Driving Child	0.0	0.0	0.2	-0.2	-0.1	-0.4	0.5	0.0	0.0	-0.5	0.5	0.0	-0.2	0.2	0.0	0.0	-0.2	0.9	-0.8	0.1	0.0	0.2	-0.2	0.0
Pre-driving Child	0.0	0.0	-0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.3	-0.1	0.0	0.0	-0.1	0.1	0.0	0.1	-1.3	1.3	0.0
Pre-school Child	-0.7	0.6	-0.2	0.2	-0.7	0.7	0.0	0.0	-0.4	0.2	0.2	0.0	-0.3	0.0	0.3	0.0	-0.3	0.1	0.2	0.0	-1.0	1.3	-0.2	0.0

2.2.6 At-Work Sub-tour Frequency

Number of Models:	One
Decision-Making Unit:	Work tours
Model Form:	Multinomial logit
Alternatives:	6 (no sub-tours, 1 eat, 1 business, 1 maintenance, 2 business, 2 eat/business)
Source:	Transferred from MORPC[15]

After the frequency, location, departure and duration time, and mode of work tours, joint tours, and individual non-mandatory home-based tours are determined, the *Travel Model One* system adds to the work tours a number of at-work sub-tours. These at-work sub-tours are travel tours taken during the workday with their origin at the work location, rather than from home. This section describes the at-work sub-tour frequency model, which predicts the number of these additional travel tours that workers undertake. Explanatory variables include employment status, income, auto ownership, the frequency of other tours, characteristics of the parent work tour, and characteristics of the workplace zone.

Calibration of the model focused on matching the observed distribution of tour frequencies and purposes, globally for all person types. Achieving this required adjustment of the alternative-specific constants for the tour frequency and purpose combinations that make up the available choices in the model. The utility function parameters appear in Table 38.

Comparisons between observed and model tour frequency distributions appear in Figure 25. The targets were taken from BATS 2000, but the tour frequencies were adjusted upward to correct for underreporting biases typically found in household travel surveys. The share with no at-work sub-tours was decreased from 86% to 70%, with the remainder and at-work sub-tours for purposes other than the five most common alternatives redistributed proportionally into the modeled alternatives.

[15] Individual Tour Generation Model for Non-Mandatory Activity. Technical Memorandum. MORPC Model Improvement Project. PB Consult (2002)

Table 38: At-work Sub-tour Frequency Utility Function Parameters

	At-work Sub-tour Frequency Alternative					
Variable	**Zero**	**One Eat**	**One Business**	**One Maint.**	**Two Business**	**Eat & Business**
Alternative-specific constants, segmented by employment status						
Person works full-time (may not be FW person type)	**-0.600**	-7.280	-7.375	-8.093	-14.28	-14.79
Person works part-time (may not be PW person type)	**-0.600**	-8.604	-8.319	-8.214	-14.28	-14.79
Household variables						
Household income $30-60k	-	0.61	0.556	0.153	1.111	1.166
Household income $60k+	-	0.869	1.066	0.165	2.132	1.935
Household owns zero autos	-	-0.339	-	0.176	-	-0.339
Frequency of other tours						
Num. indiv. Discr. tours, Person works full-time	-	0.233	0.705	0.506	1.409	0.938
Num. indiv. Discr. tours, Person works part-time	-	0.678	0.705	0.506	1.409	1.382
Num. indiv. Eat Out tours	-	0.549	0.543	0.917	1.087	1.093
Num. indiv. Maint., Shop & Escort tours, works full-time	-	-0.052	-0.190	0.145	-0.381	-0.242
Num. indiv. Maint., Shop & Escort tours, works part-time	-	-0.310	-0.190	-0.272	-0.381	-0.50
Participates in at least one Joint Maint., Shop, or Eat Out tour	-	0.246	0.083	0.08	0.166	0.329
Participates in at least one Joint Discr. tour	-	0.359	-0.264	0.582	-0.527	0.095
Person has at least one indiv. Non-mandatory tour	-	-	-	-0.357	-	-
Work tour characteristics						
Log of work tour duration	-	1.550	1.142	1.659	2.284	2.692
Work tour mode is Drive Alone	-	0.480	0.990	1.153	1.980	1.471
Person has two Work tours	-	-0.986	0.375	-0.231	0.751	-0.611
Work zone characteristics						
Workplace in zone with Urban Area Type	-	-0.418	-0.224	-0.148	-0.447	-0.642
Workplace in zone with Suburban Area Type	-	-0.292	-0.110	-	-0.220	-0.402
Workplace Off-peak Auto accessibility to Retail	-	0.015	0.053	0.027	0.107	0.068
Workplace Walk accessibility to Retail	-	0.060	-	0.040	-	0.060
Employment-status-independent calibration adjustment to ASCs						
Calibration adjustment to alternative-specific constant	-	**0.858**	**-0.537**	**-0.620**	**-2.134**	**-0.972**

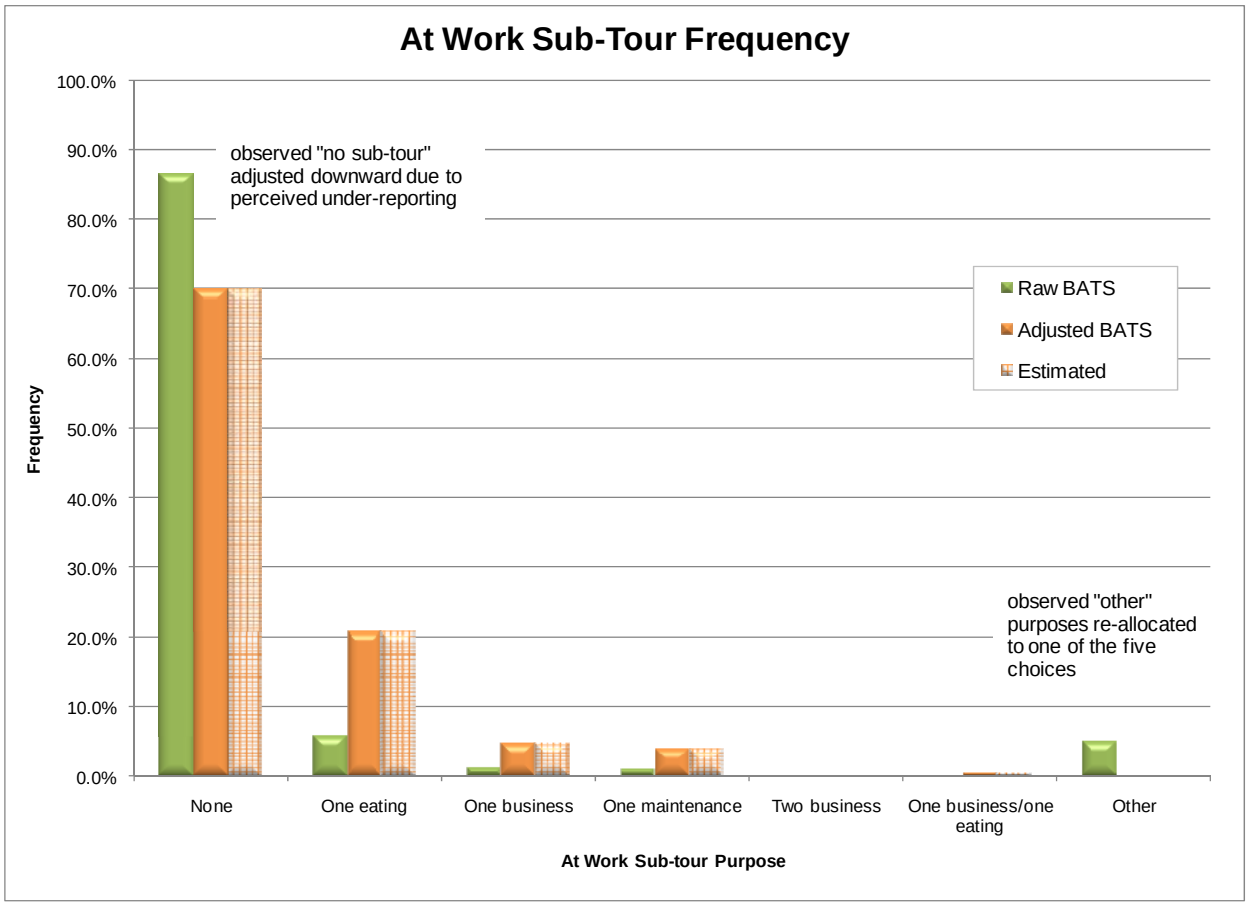


Figure 25: At-work Sub-tour Frequency

2.2.7 Joint, Individual Non-mandatory, and Work-Based Tour Primary Destination Choice

Number of Models: Eight (escort w/ kids, escort w/o kids, shopping, maintenance, social, discretionary, work-based)

Decision-Making Unit: Joint tours, individual non-mandatory tours, and work-based subtours

Model Form: Multinomial logit

Alternatives: 30 importance-sampled from 4352 = 1454 zones x 3 walk-transit proximity subzones

Source: Size terms estimated using BATS 2000, mode choice logsum parameter taken from SFCTA RPM-9 Model

The non-mandatory tour destination choice models operate similarly to the usual work and school location choice model, selecting the primary destination for travel tours. The only procedural difference between the models is that the usual work and school location choice model selects the usual location of an activity whether or not the activity is undertaken during the travel day, while the non-mandatory tour destination choice model selects the location for an activity which has already been generated. The result of the usual work and school location

choice model affects downstream model components such as auto ownership and the frequency of tours taken to the location. The result of the non-mandatory destination choice model result affects only the particular tour itself.

A note is warranted here regarding the meaning of a tour's "primary destination." The primary destination is the location of the activity that is assumed to provide the greatest impetus for engaging in the travel tour. In the household survey, the primary destination was not asked, but rather inferred from the pattern of stops in a closed loop in the respondents' travel diaries. The inference was made by weighing multiple criteria including a defined hierarchy of purposes, the duration of activities, and the distance from the tour origin. The model operates in the reverse direction, designating the primary purpose and destination and then adding intermediate stops based on spatial, temporal, and modal characteristics of the inbound and outbound journeys to the primary destination. The intermediate stop models are documented fully in Sections 2.3 and 2.4.

Calibration of the joint and individual non-mandatory tour destination choice models focused on matching the observed tour length frequency distributions from the household survey – achieving this match required adjustment of a piecewise linear distance term in the utility function, which appears in Table 39. The definitions of the size variables were not changed from the original specification and appear in Table 40. Comparisons between observed and modeled tour length frequency distributions are shown in Figure 26.

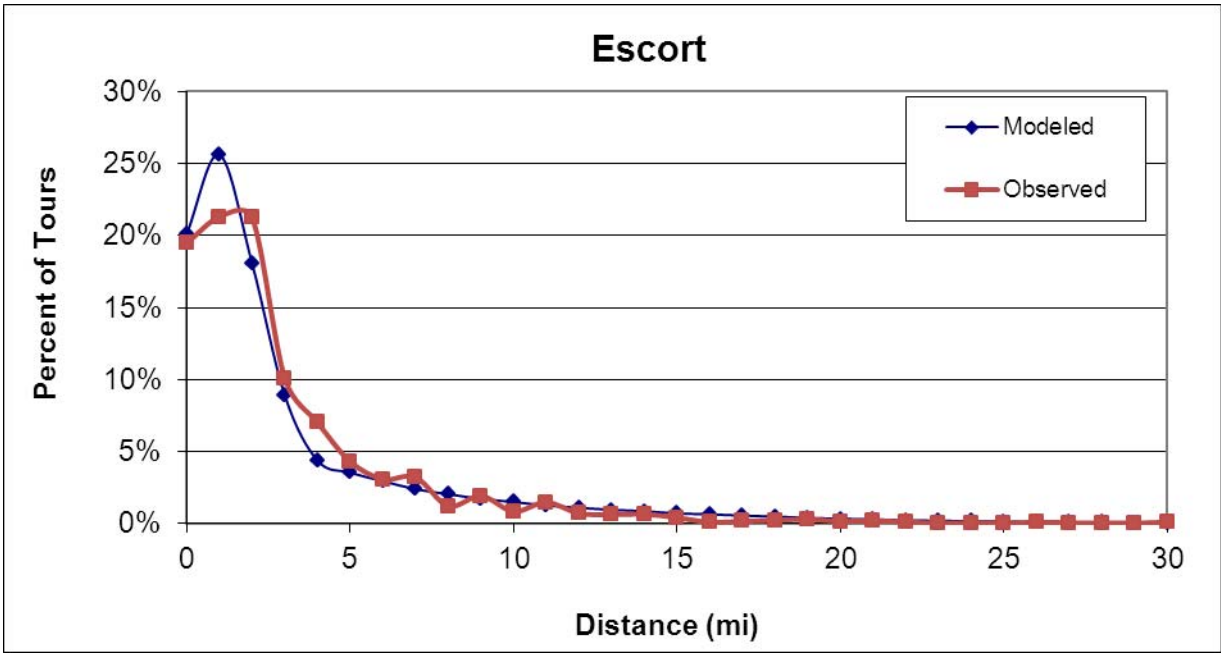
Table 39: Non-mandatory Tour Destination Choice Utility Function

Variable	Escort Coef.	Shop Coef.	Eat Out Coef.	Maint. Coef.	Social Coef.	Discr. Coef.	At work Coef.
Sample of alternatives correction factor	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Distance, piecewise linear from 0 to 1 miles	**-0.150**	**0.000**	**-0.561**	**0.000**	**-0.784**	**-0.168**	**-0.793**
Distance, piecewise linear from 1 to 2 miles	**-0.150**	**0.000**	**-0.561**	**0.000**	**-0.784**	**-0.168**	**-0.793**
Distance, piecewise linear from 2 to 5 miles	**-0.867**	**-0.566**	**-0.319**	**-0.605**	**-0.348**	**-0.495**	**-0.52**
Distance, piecewise linear from 5 to 15 miles	**-0.214**	**-0.183**	**-0.124**	**-0.109**	**-0.131**	**-0.119**	**-0.204**
Distance, piecewise linear for 15+ miles	**-0.214**	**-0.183**	**-0.124**	**-0.109**	**-0.131**	**-0.119**	**-0.204**
Mode choice logsum	0.676	0.676	0.676	0.676	0.676	0.676	0.514
Size variable	1.000	1.000	1.000	1.000	1.000	1.000	1.000

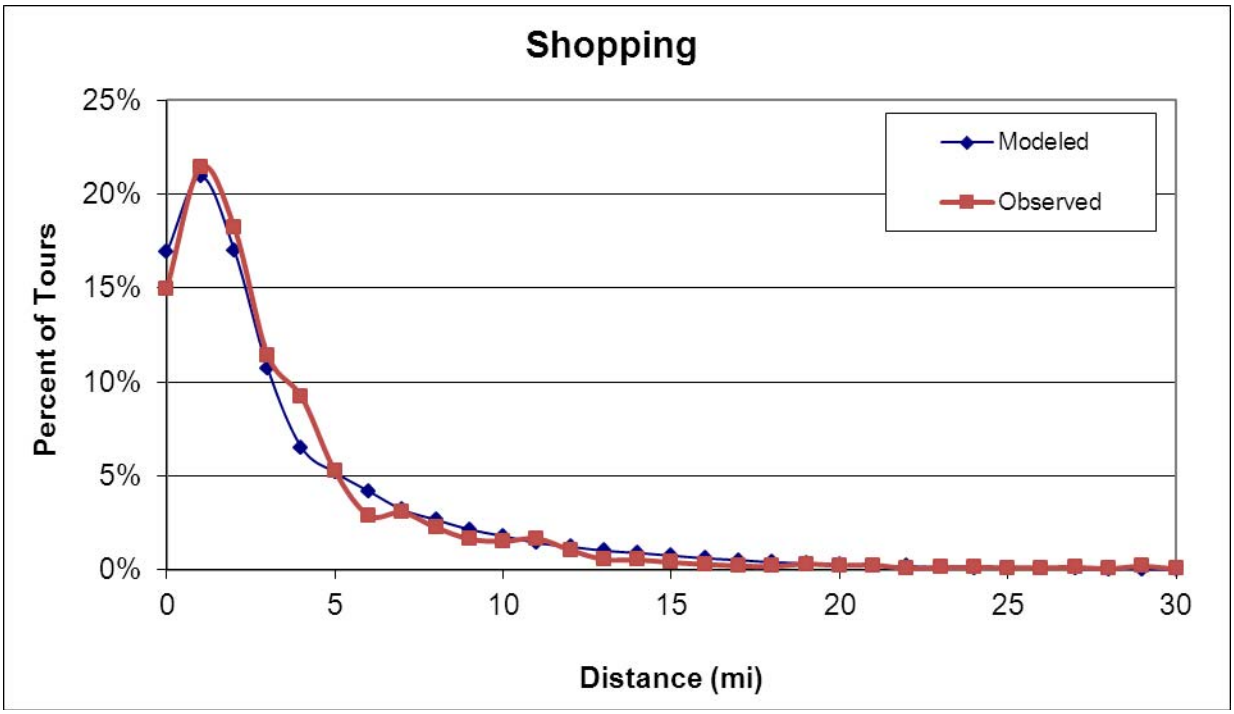
Table 40: Non-Mandatory and At-Work Destination Choice Size Coefficients

Variable	Escort	Shop	Eat Out	Maint.	Social	Discr.	At work
Total Households	-	-	-	-	-	0.252	-
Retail Employment	0.225	0.999	0.742	0.482	0.522	0.212	0.742
Financial & Prof. Service Employment	-	-	-	-	-	-	-
Health, Edu., and Rec. Service Employment	0.144	0.001	0.258	0.518	0.478	0.272	0.258
Other Employment	-	-	-	-	-	0.165	-
Agricultural & Nat. Res. Employment	-	-	-	-	-	-	-
Manufact., Trade & Transport. Employment	-	-	-	-	-	-	-
Residents Age 5-18	0.465	-	-	-	-	-	-
High School Enrollment	0.166	-	-	-	-	0.098	-

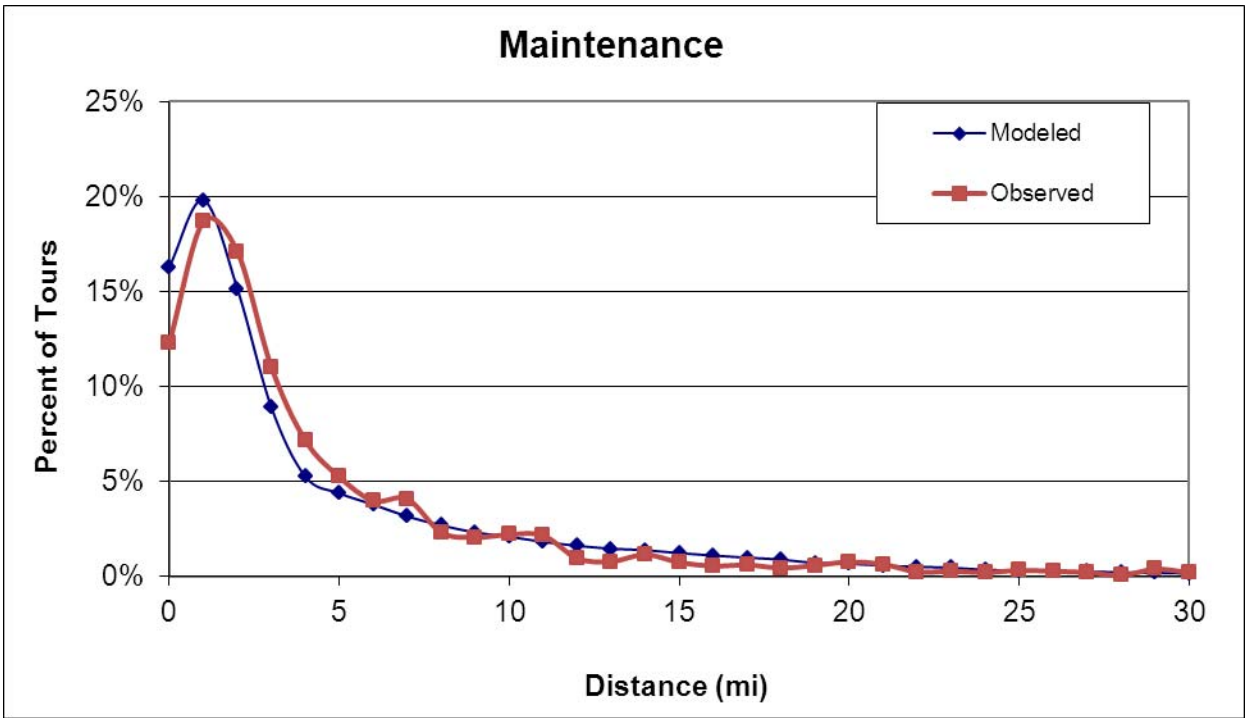
Figure 26: Non-mandatory Tour Length Frequency Distributions



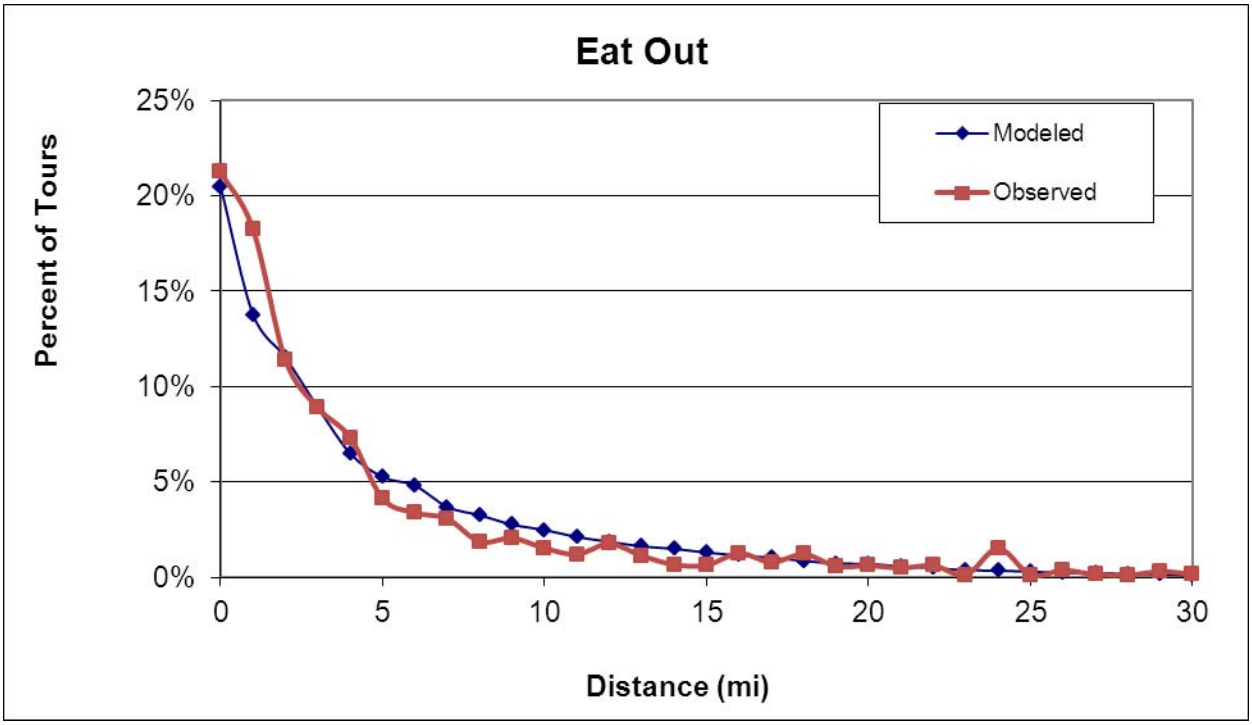
	Observed	Modeled	Diff.	% Diff.
Avg. Dist (mi.):	3.9	4.0	0.1	3%



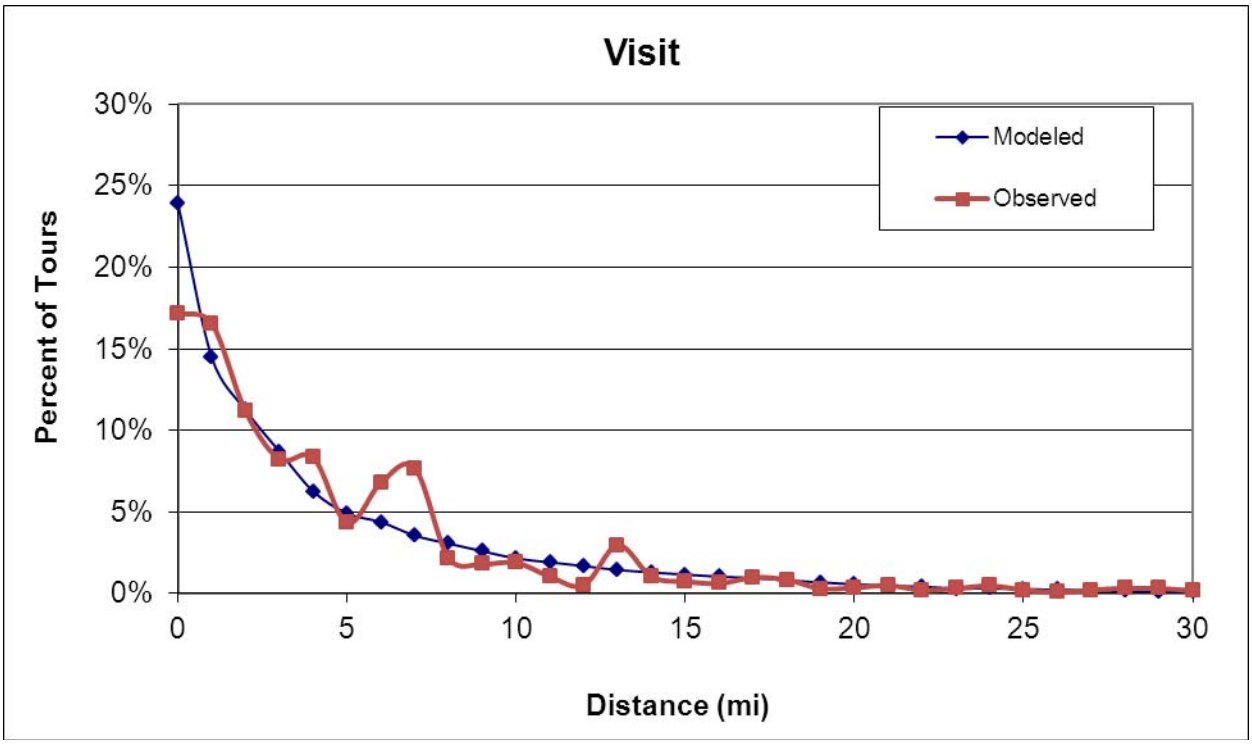
	Observed	Modeled	Diff.	% Diff.
Avg. Dist (mi.):	4.5	4.2	-0.3	-6%



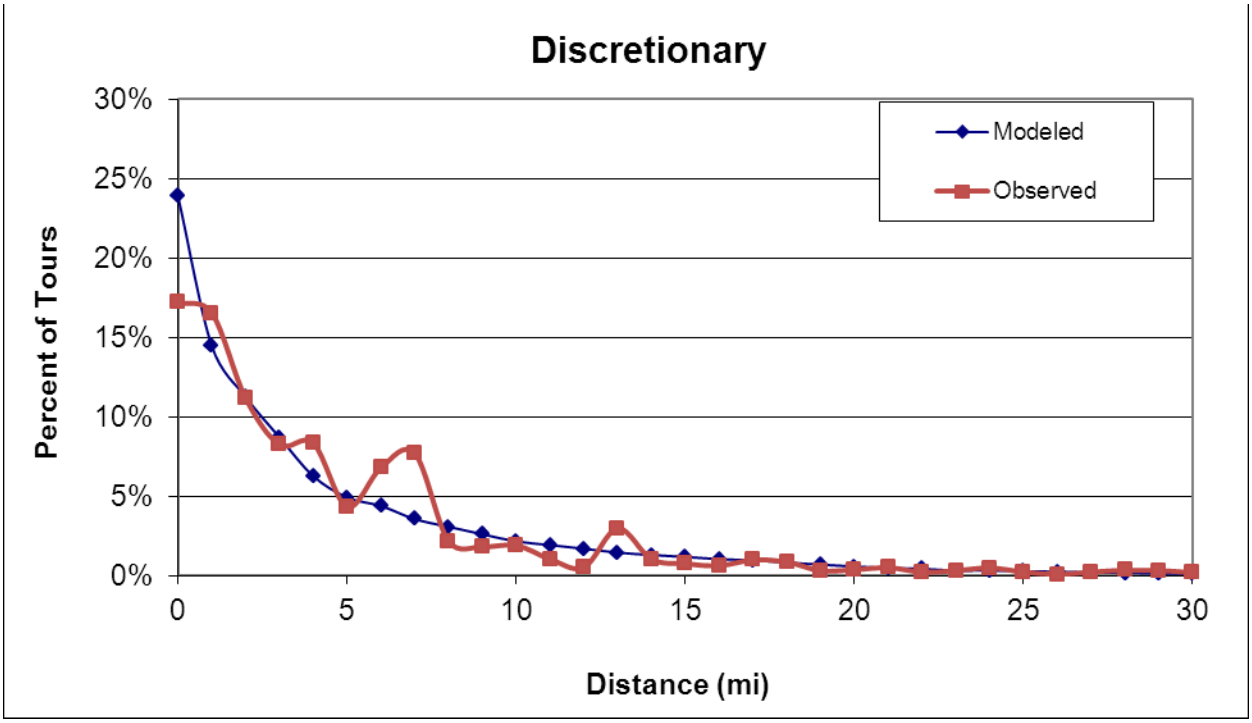
	Observed	Modeled	Diff.	% Diff.
Avg. Dist (mi.):	5.9	5.6	-0.3	-6%



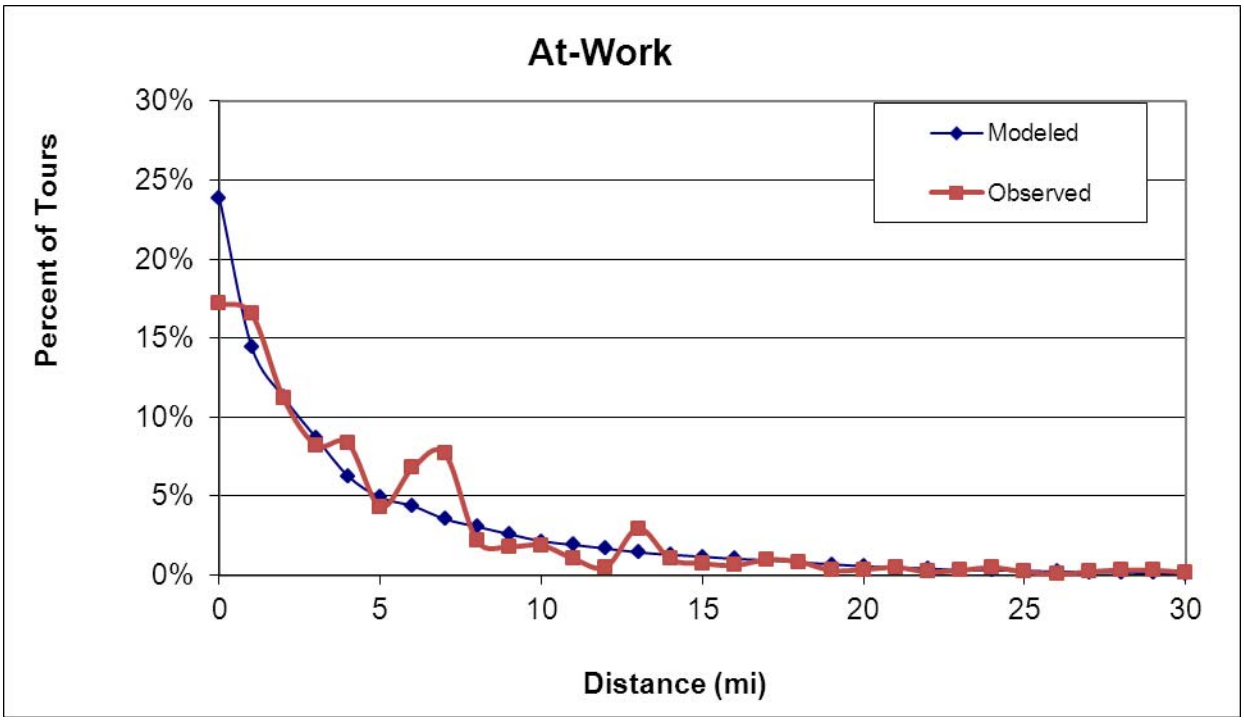
	Observed	Modeled	Diff.	% Diff.
Avg. Dist (mi.):	6.3	5.7	-0.5	-9%



	Observed	Modeled	Diff.	% Diff.
Avg. Dist (mi.):	5.9	5.3	-0.7	-11%



	Observed	Modeled	Diff.	% Diff.
Avg. Dist (mi.):	5.9	5.4	-0.6	-9%



	Observed	Modeled	Diff.	% Diff.
Avg. Dist (mi.):	3.8	3.1	-0.7	-19%

2.2.8 Joint, Individual Non-mandatory, and At-work Sub-tour Departure Time and Duration

Number of Models: Three (joint, individual non-mandatory, and at-work)

Decision-Making Unit: Joint tours, individual non-mandatory tours, and work-based subtours

Model Form: Multinomial logit

Alternatives: 190 (combinations of departure hour and arrival hour back at home)

Source: Transferred from ARC[16]

The tour departure time and duration models select the time of departure and arrival back at home for each tour. The primary drivers in the models are accessibility-based parameters such as the auto travel time for the departure/arrival hour combination, demographics, and time pattern characteristics such as the time windows available from previously scheduled tours.

Calibration of the models focused on matching the observed frequency distribution of times of departure, duration, and arrival back at home for each tour type, with Individual Non-mandatory Escort and Non-Escort tours calibrated separately. Accomplishing this required adjustment of constants for bands of the departure, duration and arrival times that define the alternative outcomes of the model. In general, the process taken was to first calibrate the departure and duration constants, and then to add arrival constants if necessary to match observed distributions

[16] See Progress Report for the Year 2003 Regional Transportation Plan Major Update Project for the Atlanta Regional Commission General Modeling: Task 2 – Activity / Tour-Based Models, by PB Consult with John Bowman and Mark Bradley.

for all dimensions. Care was taken to ensure that the model was not over-specified, by retaining one alternative as the base alternative for each dimension. The calibrated utility functions appear in Table 41 through Table 43.Comparisons between modeled and observed distributions of tour departure and arrival times for work and school appear in Figure 28 through Figure 34. The distributions are not as smooth for non-mandatory activities as they were for mandatory activities because non-mandatory activities are not as strictly scheduled. The times of joint tours are particularly jagged because the number of tours is small and the timing depends on the available time windows of multiple people in the household. Data for the distribution of duration times appear in Appendix A.

Table 41: Joint Tour Departure Time and Duration Utility Function Parameters

Variable	Coefficient
Travel time shift effects	
Free-flow round trip auto time (min) - duration (hrs)	0.005
Tour purpose shift effects	
Shopping -- departure hour	-0.060
Shopping -- duration	-0.121
Maintenance -- departure	-0.149
Maintenance -- duration	-0.149
Social -- departure	0.097
Social -- duration	0.164
Eat Out -- departure	0.075
Person type shift effects	
First person in household is Driving-age School Child -- departure	0.073
First person in household is Driving-age School Child -- duration	0.210
First person in household is Pre-driving-age School Child -- departure	0.047
First person in household is Pre-driving-age School Child -- duration	0.327
Other shift effects	
Destination in CBD - duration	0.107
Num. Mandatory tours of first person in household -- departure	0.047
Num. Joint tours of first person in household -- departure	0.052
First of 2+ joint tours for same purpose, 1st person -- departure	-0.236
Subsequent of 2+ joint tours for same purpose, 1st person -- duration	-0.173
Specific time period effects	
Maintenance tour -- depart before 07:00	-0.883
Shopping tour -- depart before 08:00	-1.037
Shopping tour -- arrive after 22:00	-0.603
First person in household is Pre-driving-age School Child -- arrive after 22:00	-1.180
First person in household is University Student -- arive after 22:00	0.547
Shopping tour -- duration < 2 hours	0.517
Discretionary tour -- duration < 2 hours	-0.697
First person in household is adult & household contains children -- arrive 19:00 to 21:00	0.336
Available time window effects	
First person in household has previously-scheduled tour ending in this departure hour	-0.456
First person in household has previously-scheduled tour beginning in this arrival hour	-0.399
Hours in first person's adjacent window before departure -- first tour	0.008
Hours in first person's adjacent window after arrival -- first tour	-0.026
Hours in first person's adjacent window before departure -- subsequent tour	-0.059
Hours in first person's adjacent window after arrival -- subsequent tour	-0.027
Departure constants	
00:00 to 05:00	**-14.477**

Variable	Coefficient
06:00	**-11.595**
07:00	**-9.005**
08:00	**-2.733**
09:00	**0.267**
10:00 to 12:00	**0.000**
13:00 to 15:00	**-1.603**
16:00 to 18:00	**-17.696**
19:00 to 21:00	**-18.987**
22:00 to 23:00	**-20.278**
Arrival constants	
00:00 to 06:00	**-8.729**
07:00 to 09:00	**-8.729**
10:00 to 12:00	**0.000**
13:00 to 14:00	**1.408**
15:00	**1.020**
16:00	**1.069**
17:00	**0.000**
18:00	**-0.596**
19:00 to 21:00	**-2.749**
22:00 to 23:00	**-4.243**
Duration constants	
0 to 1 hours	**-2.228**
2 to 3 hours	**0.000**
4 to 5 hours	**-0.562**
6 to 7 hours	**-0.655**
8 to 10 hours	**-0.741**
11 to 13 hours	**-0.815**
14 to 18 hours	**-2.738**

Table 42: Individual Non-mandatory Tour Departure Time and Duration Utility Function Parameters

Variable	Coefficient
Travel time shift effects	
Free-flow round trip auto time (min) - duration (hrs)	0.005
Tour purpose shift effects	
Shopping -- departure hour	-0.060
Shopping -- duration	-0.121
Maintenance -- departure	-0.149
Maintenance -- duration	-0.149
Social -- departure	0.097
Social -- duration	0.097
Eat Out -- departure	0.075
Person type shift effects	
Driving-age School Child -- departure	0.073
Driving-age School Child -- duration	0.210
Pre-driving-age School Child -- departure	0.047
Pre-driving-age School Child -- duration	0.327
Other shift effects	
Destination in CBD - duration	0.107
Num. Mandatory tours -- departure	0.047

Variable	Coefficient
Num. Joint tours -- departure	0.052
Num. Escort tours -- departure	0.020
Num. Indiv. Non-mandatory tours (excl. escort) -- departure	0.039
First of 2+ indiv. tours for same purpose -- departure	-0.236
Subsequent of 2+ indiv. tours for same purpose -- duration	-0.173
Specific time period effects	
Maintenance tour -- depart before 07:00	-0.883
Shopping tour -- depart before 08:00	-1.037
Shopping tour -- arrive after 22:00	-0.603
Pre-driving-age School Child -- arrive after 22:00	-1.180
University Student -- arive after 22:00	0.547
Shopping tour -- duration < 2 hours	0.517
Discretionary tour -- duration < 2 hours	-0.697
Person is adult & household contains children -- arrive 19:00 to 21:00	0.336
Available time window effects	
Person has previously-scheduled tour ending in this departure hour	-0.456
Person has previously-scheduled tour beginning in this arrival hour	-0.399
Hours in adjacent window before departure -- first tour	0.008
Hours in adjacent window after arrival -- first tour	-0.026
Hours in adjacent window before departure -- subsequent tour	-0.059
Hours in adjacent window after arrival -- subsequent tour	-0.027
Remaining indiv. Non-mandatory tours / number of remaining hours	-13.630
Departure constants, purpose is not Escort	
00:00 to 05:00	**-1.740**
06:00	**-0.654**
07:00	**0.554**
08:00	**1.051**
09:00	**0.972**
10:00 to 12:00	**0.882**
13:00 to 15:00	**0.411**
16:00 to 18:00	**0.000**
19:00 to 21:00	**-1.856**
22:00 to 23:00	**-8.229**
Arrival constants, purpose is not Escort	
00:00 to 06:00	**-0.052**
07:00 to 09:00	**-1.815**
10:00 to 12:00	**0.000**
13:00 to 14:00	**0.532**
15:00	**0.628**
16:00	**0.651**
17:00	**0.403**
18:00	**0.154**
19:00 to 21:00	**0.000**
22:00 to 23:00	**-0.867**
Duration constants, purpose is not Escort	
0 to 1 hours	**0.000**
2 to 3 hours	**0.051**
4 to 5 hours	**-0.594**
6 to 7 hours	**-0.951**
8 to 10 hours	**-0.828**
11 to 13 hours	**-0.956**
14 to 18 hours	**-1.043**

Variable	Coefficient
Departure constants, purpose is Escort	
00:00 to 05:00	**-1.740**
06:00	**-1.112**
07:00	**0.699**
08:00	**1.196**
09:00	**-0.225**
10:00 to 12:00	**0.029**
13:00 to 15:00	**0.000**
16:00 to 18:00	**-1.180**
19:00 to 21:00	**-3.949**
22:00 to 23:00	**-8.229**
Arrival constants, purpose is Escort	
00:00 to 06:00	**0.000**
07:00 to 09:00	**0.000**
10:00 to 12:00	**0.000**
13:00 to 14:00	**0.000**
15:00	**0.000**
16:00	**0.000**
17:00	**0.000**
18:00	**0.000**
19:00 to 21:00	**-0.537**
22:00 to 23:00	**-1.008**
Duration constants, purpose is Escort	
0 to 1 hours	**0.000**
2 to 3 hours	**-2.042**
4 to 5 hours	**-2.880**
6 to 7 hours	**-2.974**
8 to 10 hours	**-3.020**
11 to 13 hours	**-2.974**
14 to 18 hours	**-2.507**

Table 43: At-work Sub-tour Departure Time and Duration Utility Function Parameters

Variable	Coefficient
Travel time shift effects	
Outbound midday travel time -- departure hour	0.001
Inbound midday travel time -- departure	0.001
Outbound midday travel time -- duration (hours)	0.010
Inbound midday travel time -- duration	0.010
Tour purpose shift effects	
Business -- departure	-0.111
Business -- duration	0.265
Other tour shift effects	
First sub-tour to be scheduled for this work tour -- departure	-0.543

Variable	Coefficient
First sub-tour to be scheduled for this work tour -- duration	-0.399
Second to be scheduled of two sub-tours for same work tour -- departure	-0.184
Second to be scheduled of two sub-tours for same work tour -- duration	-0.249
Number of Mandatory tours -- departure	-0.019
Number of Mandatory tours -- duration	-0.770
Number of Joint tours -- departure	-0.021
Number of Joint tours -- duration	-0.250
Number of Indiv. Non-Mandatory tours -- departure	-0.013
Number of Indiv. Non-Mandatory tours -- duration	-0.042
Specific time period effects	
Purpose is Business, duration is 0 to 1 hour	-1.543
Purpose is Eating Out, duration is 1 hour	0.400
Purpose is Eating Out, departure at 11:00	1.511
Purpose is Eating Out, departure at 12:00	2.721
Purpose is Eating Out, departure at 13:00	2.122
Departure constants	
00:00 to 05:00	**-7.766**
06:00	**-6.157**
07:00	**-4.062**
08:00	**-2.331**
09:00	**-1.882**
10:00 to 12:00	**0.000**
12:00 to 15:00	**-0.775**
16:00 to 18:00	**-0.228**
19:00 to 12:00	**-1.015**
22:00 to 23:00	**-0.738**
Arrival constants	
00:00 to 06:00	**-2.928**
07:00 to 09:00	**-2.928**
10:00 to 12:00	**-2.297**
13:00 to 14:00	**0.000**
15:00	**-0.578**
16:00	**-1.094**
17:00	**-1.166**
18:00	**-1.496**
19:00 to 21:00	**-2.320**
22:00 to 23:00	**-2.320**
Duration constants	
0 hours	**-0.907**
1 hour	**0.000**
2 to 3 hours	**-1.362**
4 to 5 hours	**-0.820**
6 to 7 hours	**1.088**
8 to 10 hours	**1.734**
11 to 13 hours	**0.300**
14 to 18 hours	**0.000**

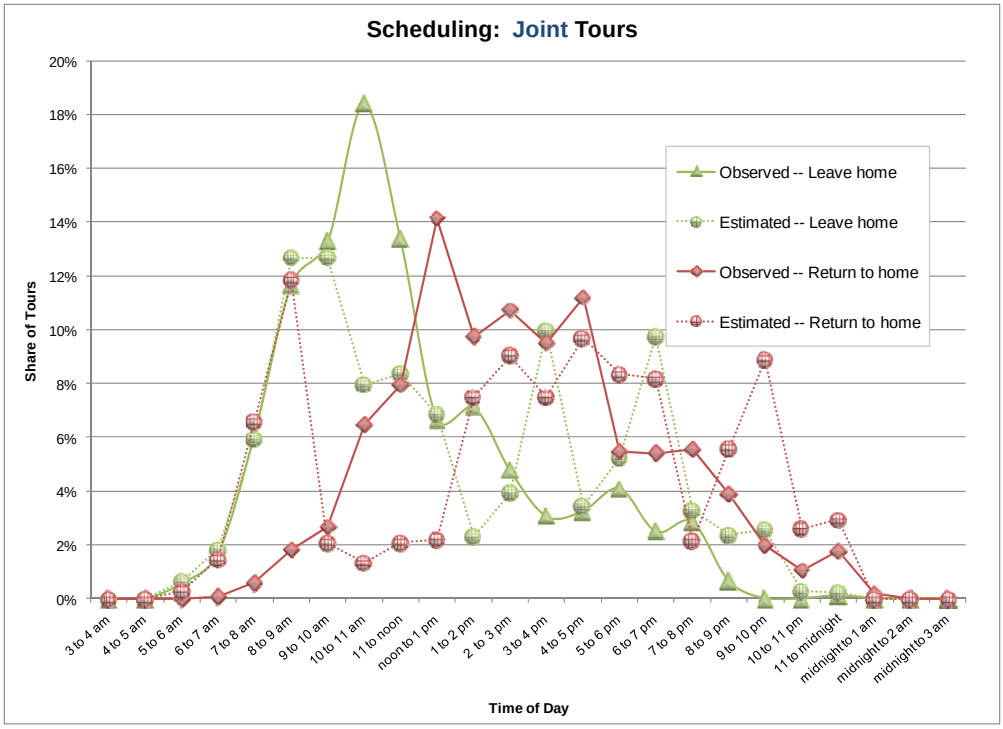


Figure 27: Joint Tour Departure and Arrival Times

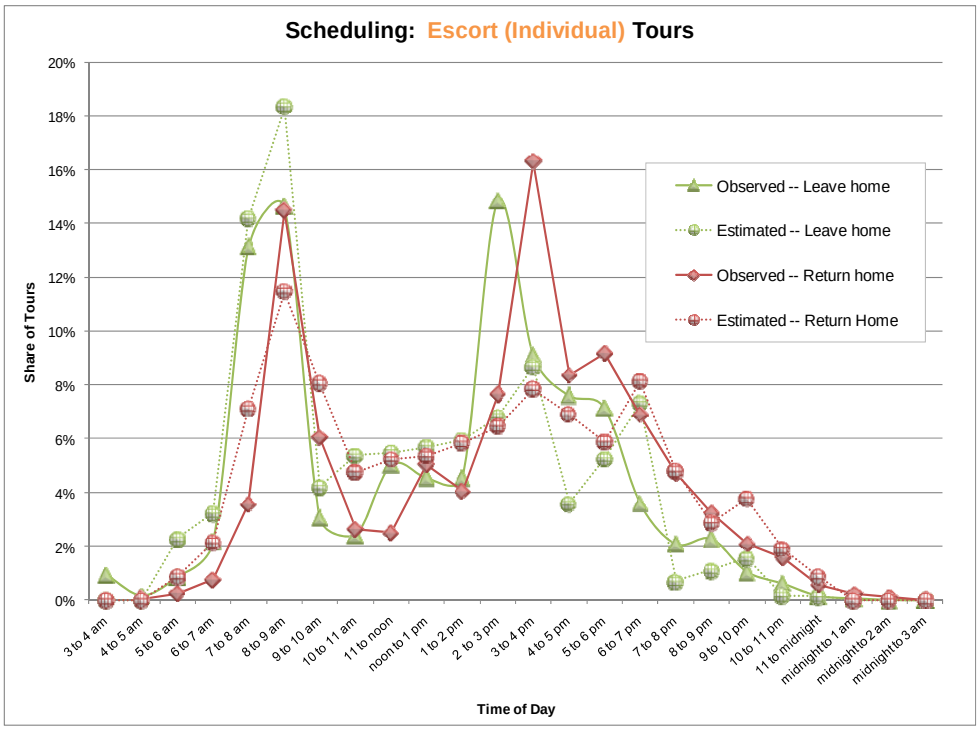


Figure 28: Individual Escort Tour Departure and Arrival Times

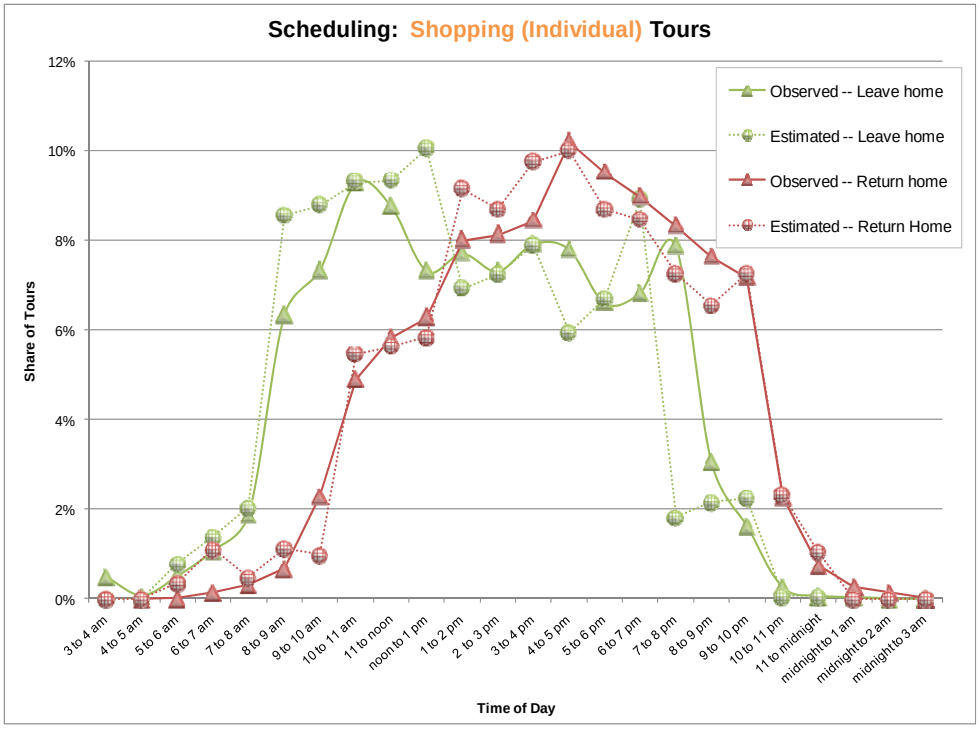


Figure 29: Individual Shopping Tour Departure and Arrival Times

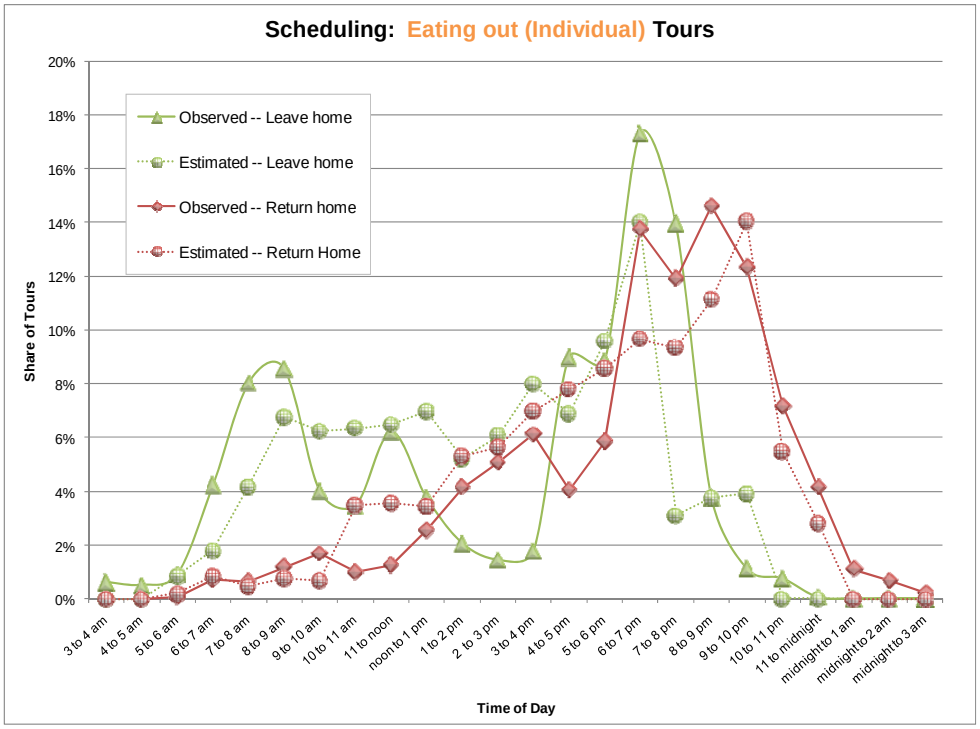


Figure 30: Individual Eating Out Tour Departure and Arrival Times

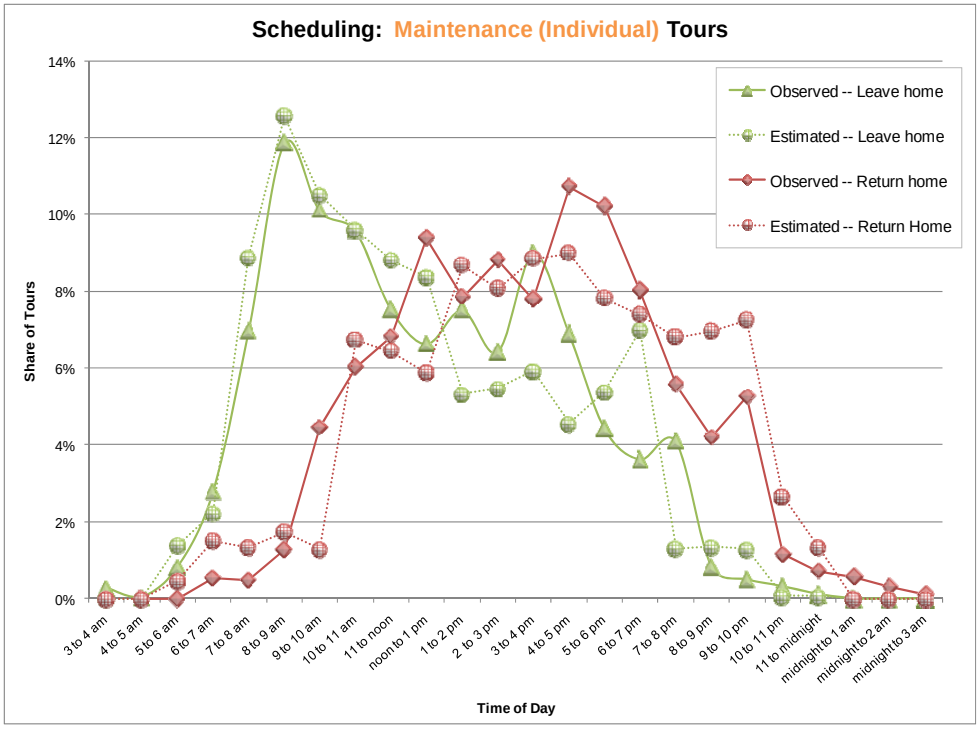


Figure 31: Individual Maintenance Tour Departure and Arrival Times

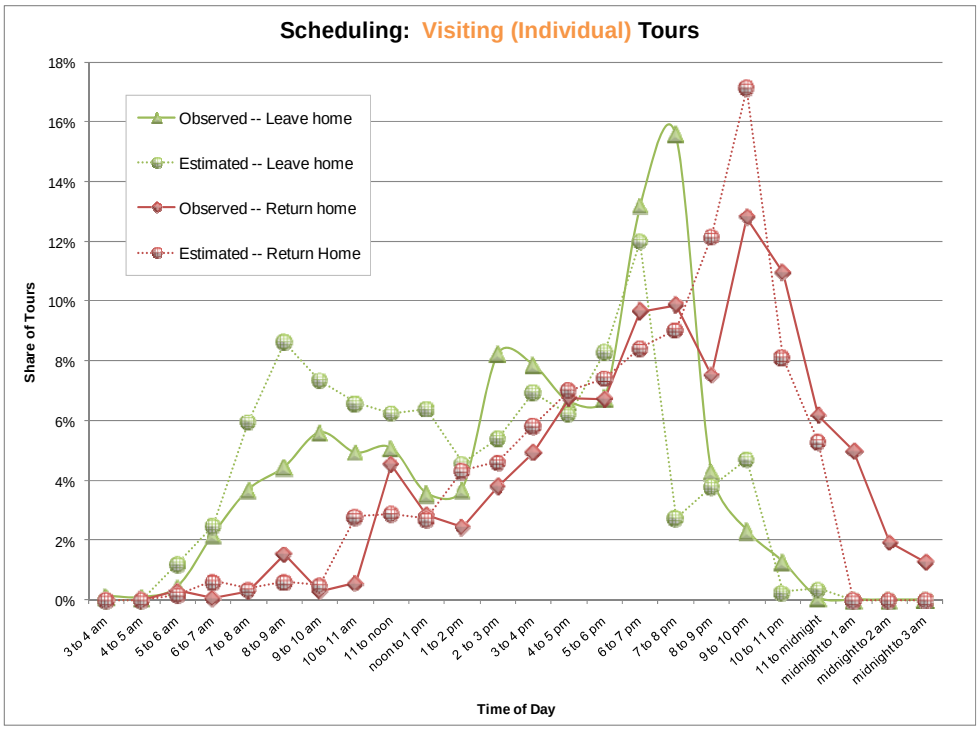


Figure 32: Individual Visiting Tour Departure and Arrival Times

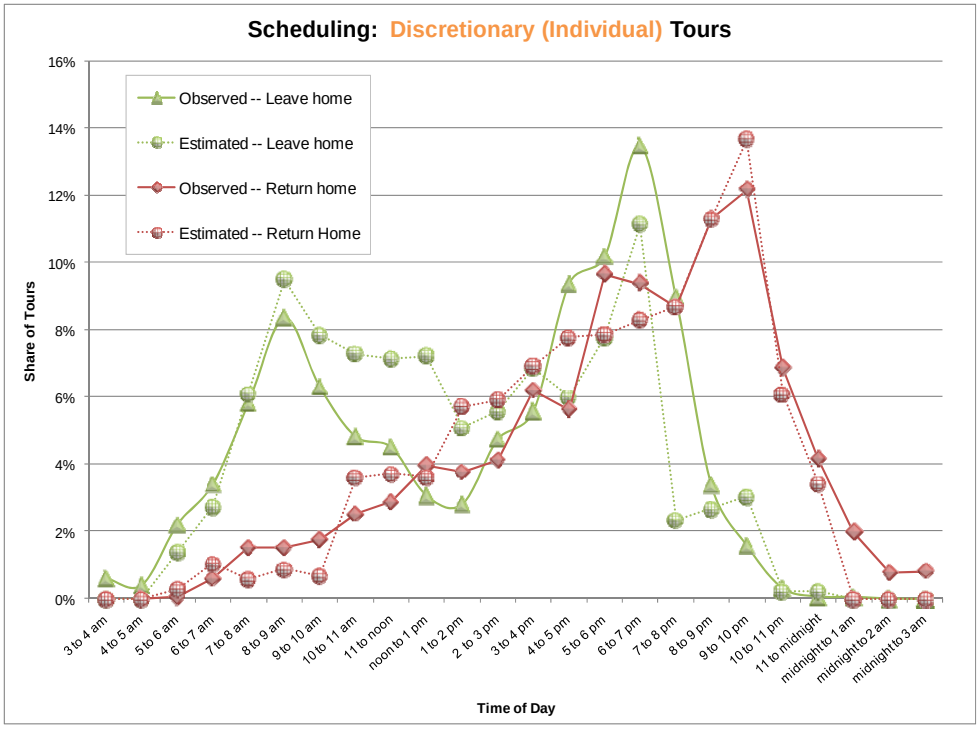


Figure 33: Individual Discretionary Tour Departure and Arrival Times

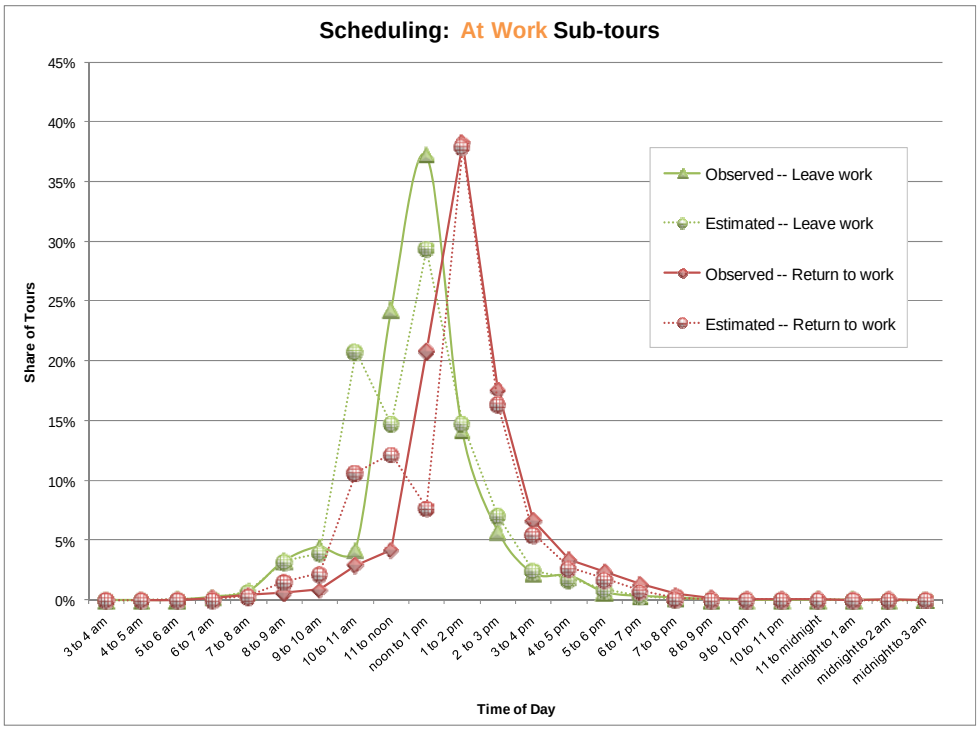


Figure 34: Individual At-work Sub-tour Departure and Arrival Times

2.3 Tour Level Models

This section describes the calibration of the short-term tour level models, which simulate a person or joint travel party's decisions about what travel modes it will consider and how many stops it will make during a specific travel tour. Again, it should be noted that the descriptions of some of the short-term models are combined into one section for the sake of parsimony, and therefore the order in which the calibration of the models are presented here deviates slightly from the order in which they run in the model system, as shown in section 1.1.8.

2.3.1 Tour Mode Choice

Number of Models:	Ten (one for each purpose)
Decision-Making Unit:	Tours
Model Form:	Nested logit
Alternatives:	18
Source:	Transferred from SFCTA (estimated using BATS 1990)

The tour mode choice model assigns to each tour the "primary" mode that is used to get from the origin to the primary destination. The tour-based modeling approach requires a reconsideration of the conventional mode choice structure. Instead of a single mode choice model used in a four-step structure, there are two different levels where the mode choice decision is modeled: (a) the tour mode level (upper-level choice); and, (b) the trip mode level (lower-level choice conditional upon the upper-level choice).

The tour mode level represents the decisions that apply to the entire tour, and that will affect the alternatives available for each individual trip. These decisions include the choice to use a private car versus using public transit, walking, or biking; whether carpooling will be considered; and whether transit will be accessed by car or by foot. Trip-level decisions correspond to details of the exact mode used for each trip, which may or may not change over the trips in the tour.

The tour mode choice structure is a nested logit model which separates similar modes into different nests to more accurately model the cross-elasticities between the alternatives. The eighteen modes are incorporated into the nesting structure with logsum coefficients as shown in Figure 35. The first level of nesting represents the decision to use a private car, non-motorized means, or transit. In the second level of nesting, the auto nest is divided into vehicle occupancy categories, and transit is divided into walk access and drive access nests. The final level splits the auto nests into free or pay alternatives and the transit nests into the specific line-haul modes. The logsum coefficients are 0.72 for the first nest, and 0.35 for the second nest.

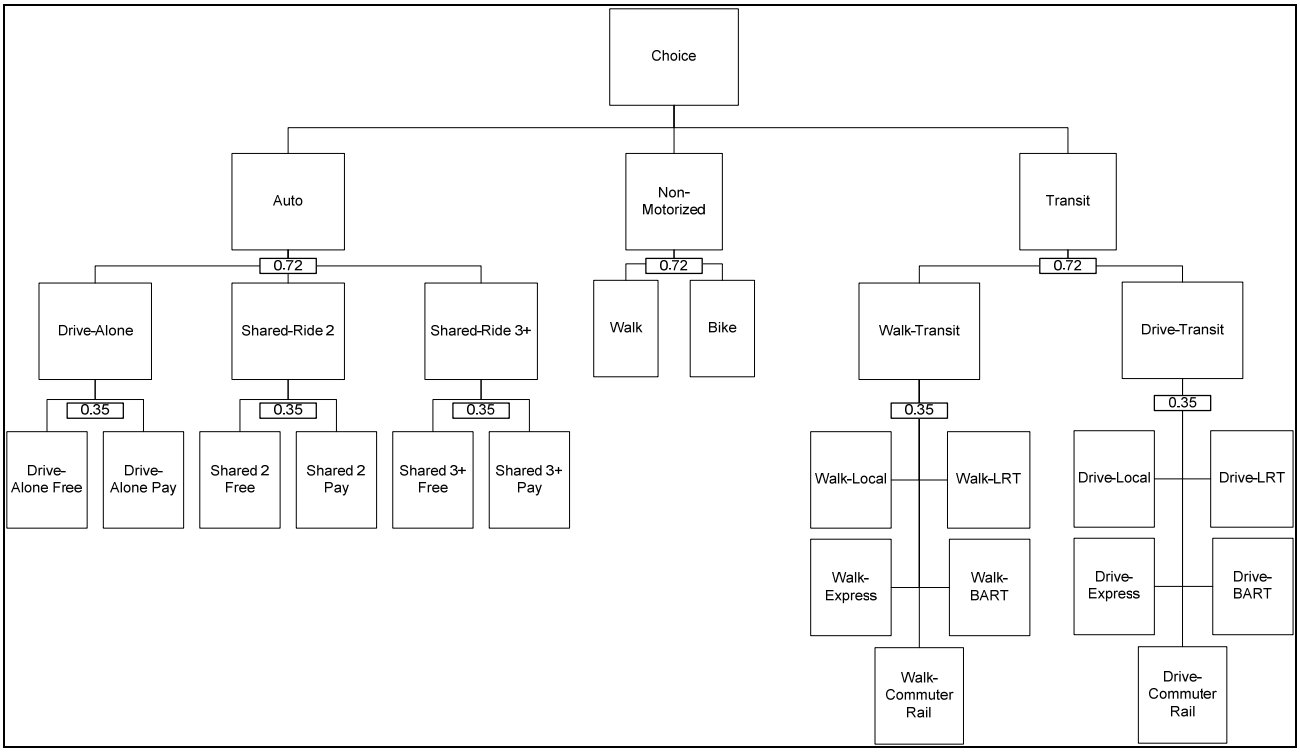


Figure 35: Tour Mode Choice Alternatives and Nests

The utility function parameters for the tour mode choice models appear in Table 44. The primary variables are in-vehicle time, other travel times, cost (the influence of which is derived from the auto in-vehicle time coefficient and the persons' modeled value of time), characteristics of the destination zone, demographics, and the household's level of auto ownership. The zonal network topography index is a rating of the intensity of topographical barriers in a zone from 1 (little barriers) to 3 (great barriers), and the zonal density index is a measure of both residential density, non-residential density, and the mixture of uses defined by:

$$\text{Density Index} = \frac{\text{Households} \big/ \text{Dev. Residential Acres} \times \text{Employment} \big/ \text{Dev. Commercial Acres}}{\text{Households} \big/ \text{Dev. Residential Acres} + \text{Employment} \big/ \text{Dev. Commercial Acres}}$$

Calibration of the tour mode choice model involved matching targets on several dimensions. Most importantly, it focused on matching the observed frequency of tours for each purpose in each aggregate alternative for the intermediate level of nesting – drive alone, shared ride 2, shared ride 3+, walk, bike, walk-transit, and drive-transit – for three categories of household auto sufficiency (see Table 45). Achieving this required adjustment of alternative-specific constants for these alternatives, segmented by auto sufficiency. The constants appear at the bottom of the table for each purpose, and graphically for work in Figure 36. The constants for walk and walk to transit are very large for zero-auto and auto-deficient households because they are in reference to the shared ride 2 alternative, which occurs infrequently and, when not on joint tours, for reasons the model does not understand very well.

When creating the targets for calibration, the transit counts were taken from operator data because of the unreliability of the small sample of transit tours in the household survey. Any excess or deficit of remaining tours in the targets obtained from the household survey was distributed proportionally into the other modes. In the case of individual non-mandatory tours, where the tour frequency was increased compared to the raw household survey (which appears as the "Unscaled Total" in Table 45), all excess tours were placed in the drive alone mode after observing low highway volumes in assignment, since it is possible that shared ride tours were more likely to be recalled than drive alone tours.

Another dimension that was controlled was the number of transfers on transit modes, segmented by walk and drive access. Achieving a reasonable match to observed data required the introduction of transfer penalties and segmentation of the initial wait time coefficients for short and long initial wait times. The number of transfers cannot be compared to observed data until trip mode choice runs, so tour mode choice and trip mode choice were calibrated in tandem. The validation results for the transfers are presented later in the section on trip mode choice.

After calibrating the transfer penalties, we introduced a penalty on drive-transit for short distances to reflect the hypothesis that people are unlikely to park and ride for short journeys. This penalty improved the match between the modeled and observed origin-destination distance distributions for Drive-Transit tours, as shown in Figure 37.

Next, we worked on bringing the number of transit trips to the CBDs in line with the survey by increasing the influence of the destination density index and introducing a CBD dummy. The CBD dummy was limited to the equivalent of 60 minutes of auto in-vehicle time. These factors reduced the over-estimation of auto work tours to the San Francisco CBD from above 60,000 to slightly above 20,000, which was deemed acceptable given that a higher CBD dummy would be difficult to justify.

After calibrating all factors generic to the transit line-haul modes in both tour mode choice and trip mode choice, we introduced alternative-specific constants for the transit line-haul modes. The transit line-haul mode constants were kept consistent between tour and trip mode choice with the tour mode choice equivalent in-vehicle time equal to twice the corresponding equivalent in-vehicle time trip mode choice (Table 47).

The ferry constant was capped at 120 minutes tour time and 60 minutes tour time across the board. Despite the fact that the wait time is segmented into short (less than 10 minutes) and long (greater than 10 minutes) wait, with a relatively smaller coefficient on long wait time to reflect convenience of service, the disutility of ferry due to infrequent service must be compensated for by the large constant in order to match ridership (note that transfers to ferry from feeder services would see the wait time as transfer wait, which is also penalized at twice the in-vehicle time coefficient). Factors influencing the large constant on ferry also include the unobserved attributes of discretionary and recreational riders. Care must be taken if modeling headway improvements on ferry service with these models as a result.

The number of tours in each submode does not match the survey exactly, (see Table 48) because these models were calibrated in tandem, combining feedback from not only the tour mode choice validation and trip mode choice validation against the household survey, but also the trip assignment validation against observed system boardings, discussed in Section 3.

Table 44: Tour Mode Choice Utility Function Parameters

	Tour Purpose									
Variable	**Work**	**College**	**School**	**Escort**	**Shop**	**Eat Out**	**Maint.**	**Social**	**Discr.**	**At-Work**
In-vehicle time (min.)										
Auto & local bus	-0.013	-0.022	-0.022	-0.018	-0.018	-0.018	-0.018	-0.018	-0.018	-0.019
Light rail	-0.012	-0.020	-0.020	-0.016	-0.016	-0.016	-0.016	-0.016	-0.016	-0.017
Ferry	-0.011	-0.018	-0.018	-0.014	-0.014	-0.014	-0.014	-0.014	-0.014	-0.015
Express bus	-0.013	-0.022	-0.022	-0.018	-0.018	-0.018	-0.018	-0.018	-0.018	-0.019
Heavy & commuter rail	-0.011	-0.018	-0.018	-0.014	-0.014	-0.014	-0.014	-0.014	-0.014	-0.015
Other travel times (min.)										
Initial wait time up to 10 minutes	-0.027	-0.045	-0.045	-0.035	-0.035	-0.035	-0.035	-0.035	-0.035	-0.038
Initial wait after 10 minutes	**-0.013**	**-0.022**	**-0.022**	**-0.018**	**-0.018**	**-0.018**	**-0.018**	**-0.018**	**-0.018**	**-0.019**
Drive access/egress time	-0.027	-0.045	-0.045	-0.035	-0.035	-0.035	-0.035	-0.035	-0.035	-0.038
Transfer wait time	-0.027	-0.045	-0.045	-0.035	-0.035	-0.035	-0.035	-0.035	-0.035	-0.038
Origin is within short walk to transit, walk-transit	-0.179	-0.299	-0.299	-0.233	-0.233	-0.233	-0.233	-0.233	-0.233	-0.251
Origin is within long walk to transit, walk-transit	-0.536	-0.896	-0.896	-0.700	-0.700	-0.700	-0.700	-0.700	-0.700	-0.752
Destination is within short walk to transit, transit	-0.179	-0.299	-0.299	-0.233	-0.233	-0.233	-0.233	-0.233	-0.233	-0.251
Destination is within long walk to transit, transit	-0.536	-0.896	-0.896	-0.700	-0.700	-0.700	-0.700	-0.700	-0.700	-0.752
Number of transfers										
Walk-transit	**-0.134**	**-0.224**	**-0.224**	**-0.175**	**-0.175**	**-0.175**	**-0.175**	**-0.175**	**-0.175**	**-0.188**
Drive-transit	**-0.268**	**-0.448**	**-0.448**	**-0.350**	**-0.350**	**-0.350**	**-0.350**	**-0.350**	**-0.350**	**-0.376**
Non-motorized impedance										
Distance (mi) up to 1.5 mi., walk	-0.536	-0.896	-0.896	-0.700	-0.700	-0.700	-0.700	-0.700	-0.700	-0.752
Distance (mi) above 1.5 mi., walk	-2.680	-4.480	-4.480	-3.500	-3.500	-3.500	-3.500	-3.500	-3.500	-3.760
Distance (mi) up to 6 mi., bike	-0.268	-0.448	-0.448	-0.350	-0.350	-0.350	-0.350	-0.350	-0.350	-0.376
Distance (mi) above 6 mi., bike	-1.340	-2.240	-2.240	-1.750	-1.750	-1.750	-1.750	-1.750	-1.750	-1.880
Cost										
Derived from person's value of time	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
Zonal topography index at destination										
Walk	-0.201	-0.336	-0.336	-0.263	-0.263	-0.263	-0.263	-0.263	-0.263	-0.141

Variable	Tour Purpose									
	Work	**College**	**School**	**Escort**	**Shop**	**Eat Out**	**Maint.**	**Social**	**Discr.**	**At-Work**
Bike	-0.268	-0.448	-0.448	-0.350	-0.350	-0.350	-0.350	-0.350	-0.350	-0.188
Transit	-0.029	-0.049	-0.049	-0.039	-0.039	-0.039	-0.039	-0.039	-0.039	-0.038
Zonal density index										
At destination--walk, bike, transit	**0.003**	**0.004**	**0.004**	**0.004**	**0.004**	**0.004**	**0.004**	**0.004**	**0.004**	**0.004**
At origin (max. 150)--walk, bike, walk-transit	**-**	**-**	**-**	**0.002**	**0.011**	**0.002**	**0.002**	**0.002**	**0.002**	**0.002**
Demographic variables										
Age 16-19, Drive Alone	-	-1.381	-1.381	-	-	-	-	-	-	-0.172
Age 0-10, Transit	-	-1.555	-1.555	-	-	-	-	-	-	-0.038
Age 16+, Shared Ride	-	-	-	-1.366	-1.366	-1.366	-1.366	-1.366	-1.366	-
Household size 1, Shared Ride	-0.735	-	-	-	-	-	-	-	-	-
Household size 2, Shared Ride	-	-0.636	-0.636	-	-	-	-	-	-	-
Other transit effects										
Destination is in CBD (Area Types 0&1), transit	**0.804**	**0.672**	**0.672**	**0.525**	**0.525**	**0.525**	**0.525**	**0.525**	**0.525**	**0.564**
Number of miles less than 15, drive-transit	**-0.241**	**-0.241**	**-0.241**	**-0.241**	**-0.241**	**-0.241**	**-0.241**	**-0.241**	**-0.241**	**-0.241**
Individual tour constants, zero autos										
Drive Alone	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Walk	**5.652**	**6.407**	**18.421**	**3.093**	**3.183**	**5.187**	**1.624**	**1.996**	**3.452**	**7.187**
Bike	**3.500**	**4.271**	**12.075**	**-0.321**	**2.150**	**1.614**	**2.132**	**0.516**	**0.094**	**-0.404**
Shared ride 2	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Shared ride 3+	**-0.040**	**-6.056**	**-6.024**	**-0.991**	**0.776**	**0.706**	**-0.309**	**-0.481**	**1.029**	**1.236**
Walk to Transit	**5.074**	**8.604**	**21.377**	**-1.894**	**2.995**	**3.038**	**2.770**	**1.307**	**2.278**	**3.062**
Drive to Transit	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Individual tour constants, fewer cars than workers										
Drive Alone	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Walk	**2.486**	**5.037**	**3.847**	**-0.725**	**2.526**	**3.498**	**1.653**	**3.245**	**2.632**	**1.018**
Bike	**0.392**	**-0.419**	**0.001**	**-4.848**	**-0.749**	**-1.464**	**-1.526**	**1.071**	**0.251**	**-0.756**
Shared ride 2	**-0.210**	**-1.321**	**0.272**	**-**	**0.384**	**0.786**	**0.492**	**2.138**	**0.844**	**-2.214**
Shared ride 3+	**-0.340**	**-0.993**	**1.322**	**-0.263**	**0.429**	**0.542**	**-0.636**	**2.155**	**1.556**	**-2.290**
Walk to Transit	**0.893**	**3.520**	**4.601**	**-3.638**	**-0.766**	**0.056**	**-2.303**	**1.397**	**1.041**	**-3.113**

	Tour Purpose									
Variable	**Work**	**College**	**School**	**Escort**	**Shop**	**Eat Out**	**Maint.**	**Social**	**Discr.**	**At-Work**
Drive to Transit	**-0.254**	**1.801**	**5.554**	**-2.160**	**-1.657**	**0.026**	**-1.049**	**1.343**	**-0.381**	**N/A**
Individual tour constants, as many cars as workers										
Drive Alone	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Walk	**0.263**	**1.384**	**0.915**	**-0.604**	**0.965**	**1.700**	**0.945**	**1.851**	**1.433**	**0.824**
Bike	**-1.821**	**-1.833**	**-2.217**	**-5.637**	**-2.928**	**-1.432**	**-3.263**	**-1.431**	**-1.314**	**15.604**
Shared ride 2	**-1.011**	**-1.692**	**-1.612**	**-**	**0.327**	**0.954**	**0.402**	**0.688**	**0.609**	**-1.306**
Shared ride 3+	**-1.124**	**-1.456**	**-0.805**	**0.059**	**0.217**	**1.072**	**0.178**	**0.858**	**0.828**	**-1.274**
Walk to Transit	**-0.574**	**0.608**	**0.911**	**-4.603**	**-2.151**	**-1.016**	**-1.610**	**-0.267**	**-0.770**	**-3.448**
Drive to Transit	**-1.356**	**1.152**	**0.942**	**-6.818**	**-3.854**	**-2.202**	**-4.362**	**-1.408**	**-1.217**	**N/A**
Joint tour constants, zero autos										
Drive Alone					**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	
Walk					**-3.337**	**-3.337**	**-3.337**	**-3.337**	**-3.337**	
Bike					**-6.520**	**-6.520**	**-6.520**	**-6.520**	**-6.520**	
Shared ride 2					**-**	**-**	**-**	**-**	**-**	
Shared ride 3+					**-2.191**	**-2.191**	**-2.191**	**-2.191**	**-2.191**	
Walk to Transit					**-1.485**	**-1.485**	**-1.485**	**-1.485**	**-1.485**	
Drive to Transit					**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	
Joint tour constants, fewer cars than workers										
Drive Alone					**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	
Walk					**-2.826**	**-2.826**	**-2.826**	**-2.826**	**-2.826**	
Bike					**-7.629**	**-7.629**	**-7.629**	**-7.629**	**-7.629**	
Shared ride 2					**-**	**-**	**-**	**-**	**-**	
Shared ride 3+					**-3.104**	**-3.104**	**-3.104**	**-3.104**	**-3.104**	
Walk to Transit					**-6.538**	**-6.538**	**-6.538**	**-6.538**	**-6.538**	
Drive to Transit					**-9.048**	**-9.048**	**-9.048**	**-9.048**	**-9.048**	
Joint tour constants, as many cars as workers										
Drive Alone					**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	
Walk					**-3.961**	**-3.961**	**-3.961**	**-3.961**	**-3.961**	
Bike					**-8.820**	**-8.820**	**-8.820**	**-8.820**	**-8.820**	

	Tour Purpose									
Variable	**Work**	**College**	**School**	**Escort**	**Shop**	**Eat Out**	**Maint.**	**Social**	**Discr.**	**At-Work**
Shared ride 2					-	-	-	-	-	
Shared ride 3+					**-3.732**	**-3.732**	**-3.732**	**-3.732**	**-3.732**	
Walk to Transit					**-18.115**	**-18.115**	**-18.115**	**-18.115**	**-18.115**	
Drive to Transit					**-10.252**	**-10.252**	**-10.252**	**-10.252**	**-10.252**	
Transit line-haul mode constants										
Bus	-	-	-	-	-	-	-	-	-	-
Light rail / Ferry if path does not contain ferry	**0.760**	**1.320**	**1.320**	**0.380**	**0.380**	**0.380**	**0.380**	**0.380**	**0.380**	**0.380**
Light rail / Ferry if path does contain ferry	**1.608**	**2.688**	**2.688**	**2.100**	**2.100**	**2.100**	**2.100**	**2.100**	**2.100**	**2.100**
Express bus	**-0.107**	**-0.179**	**-0.179**	**-0.140**	**-0.140**	**-0.140**	**-0.140**	**-0.140**	**-0.140**	**-0.140**
Heavy rail	**0.692**	**1.068**	**1.068**	**0.352**	**0.352**	**0.352**	**0.352**	**0.352**	**0.352**	**0.352**
Commuter rail	**0.658**	**0.894**	**0.894**	**0.337**	**0.337**	**0.337**	**0.337**	**0.337**	**0.337**	**0.337**

Table 45: Number of Tours by Aggregate Tour Mode and Purpose

Work

Tour Mode Choice Scaled Targets - Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	20,300	26,380	25,453	72,133
Bike	6,756	17,514	20,891	45,161
Drive Alone	0	179,281	1,378,554	1,557,835
Shared Ride 2	9,215	122,199	300,550	431,964
Shared Ride 3+	4,372	62,647	191,258	258,277
Walk-Transit	89,610	77,862	98,117	265,589
Drive-Transit	0	26,568	94,110	120,678
Total	130,253	512,451	2,108,933	2,751,637
Unscaled Total	138,872	345,740	2,163,320	2,647,932

Tour Mode Choice Model Results - Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	20,694	26,075	25,108	71,877
Bike	6,639	18,036	20,783	45,458
Drive Alone	0	180,836	1,378,175	1,559,011
Shared Ride 2	9,098	122,290	300,499	431,887
Shared Ride 3+	4,566	62,903	191,651	259,120
Walk-Transit	89,256	76,512	98,271	264,039
Drive-Transit	0	25,799	94,446	120,245
Total	130,253	512,451	2,108,933	2,751,637

Difference: Estimated – Observed

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	394	-305	-345	-256
Bike	-117	522	-108	297
Drive Alone	0	1,555	-379	1,176
Shared Ride 2	-117	91	-51	-77
Shared Ride 3+	194	256	393	843
Walk-Transit	-354	-1,350	154	-1,550
Drive-Transit	0	-769	336	-433
Total	0	0	0	0

ASC Equiv. Minutes of In-Vehicle Time

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers
Walk	422	185	20
Bike	261	29	-136
Drive Alone	0	0	0
Shared Ride 2	0	-16	-75
Shared Ride 3+	-3	-25	-84
Walk-Transit	379	67	-43
Drive-Transit	0	-19	-101

School

Tour Mode Choice Scaled Targets - Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	8,124	19,740	109,507	137,372
Bike	1,147	795	13,454	15,396
Drive Alone	0	650	36,725	37,375
Shared Ride 2	0	19,888	206,171	226,059
Shared Ride 3+	329	45,673	465,411	511,414
Walk-Transit	25,457	22,610	45,891	93,958
Drive-Transit	0	1,408	1,451	2,859
Total	35,057	110,764	878,611	1,024,432
Unscaled Total	41,775	84,800	749,635	876,210

Tour Mode Choice Model Results - Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	7,862	19,322	109,696	136,880
Bike	1,015	864	13,602	15,481
Drive Alone	0	598	36,699	37,297
Shared Ride 2	735	19,896	204,863	225,494
Shared Ride 3+	0	46,014	465,834	511,848
Walk-Transit	25,445	22,371	46,126	93,942
Drive-Transit	0	1,699	1,791	3,490
Total	35,057	110,764	878,611	1,024,432

Difference: Estimated - Observed

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	-262	-418	189	-492
Bike	-132	69	148	85
Drive Alone	0	-52	-26	-78
Shared Ride 2	735	8	-1,308	-565
Shared Ride 3+	-329	341	423	434
Walk-Transit	-12	-239	235	-16
Drive-Transit	0	291	340	631
Total	0	0	0	0

ASC Equiv. Minutes of In-Vehicle Time

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers
Walk	822	172	41
Bike	539	0	-99
Drive Alone	0	0	0
Shared Ride 2	0	12	-72
Shared Ride 3+	-269	59	-36
Walk-Transit	954	205	41
Drive-Transit	0	248	42

College

Tour Mode Choice Scaled Targets - Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	3,181	2,697	9,519	15,397
Bike	754	232	1,558	2,545
Drive Alone	0	4,107	64,453	68,560
Shared Ride 2	0	2,600	30,158	32,757
Shared Ride 3+	564	2,638	28,670	31,873
Walk-Transit	16,789	9,928	18,289	45,006
Drive-Transit	0	557	6,943	7,500
Total	21,288	22,759	159,591	203,638
Unscaled Total	22,705	32,664	217,928	273,297

Tour Mode Choice Model Results - Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	3,264	2,722	9,811	15,797
Bike	784	241	1,566	2,591
Drive Alone	0	4,152	64,166	68,318
Shared Ride 2	1,372	2,675	30,586	34,633
Shared Ride 3+	0	2,542	29,117	31,659
Walk-Transit	15,868	9,888	17,443	43,199
Drive-Transit	0	539	6,902	7,441
Total	21,288	22,759	159,591	203,638

Difference: Estimated – Observed

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	83	25	292	400
Bike	30	9	8	46
Drive Alone	0	45	-287	-242
Shared Ride 2	1,372	75	428	1,876
Shared Ride 3+	-564	-96	447	-214
Walk-Transit	-921	-40	-846	-1,807
Drive-Transit	0	-18	-41	-59
Total	0	0	0	0

ASC Equiv. Minutes of In-Vehicle Time

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers
Walk	286	225	62
Bike	191	-19	-82
Drive Alone	0	0	0
Shared Ride 2	0	-59	-76
Shared Ride 3+	-270	-44	-65
Walk-Transit	384	157	27
Drive-Transit	0	80	51

All Joint Tours

Tour Mode Choice Scaled Targets – Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	366	2,158	11,115	13,638
Bike	53	314	1,617	1,984
Drive Alone	0	0	0	-
Shared Ride 2	723	2,546	50,543	53,811
Shared Ride 3+	1,263	10,860	99,956	112,079
Walk-Transit	1,781	1,148	520	3,450
Drive-Transit	0	66	66	133
Total	4,186	17,092	163,817	185,095
Unscaled Total	5,663	8,809	157,177	171,649

Tour Mode Choice Model Results – Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	40	844	3,205	4,089
Bike	3	38	235	276
Drive Alone	0	0	0	-
Shared Ride 2	3,114	9,903	103,266	116,283
Shared Ride 3+	498	6,219	57,109	63,826
Walk-Transit	531	85	0	616
Drive-Transit	0	3	2	5
Total	4,186	17,092	163,817	185,095

Difference: Estimated - Observed

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	-326	-1,314	-7,910	-9,549
Bike	-50	-276	-1,382	-1,708
Drive Alone	0	0	0	0
Shared Ride 2	2,391	7,357	52,723	62,472
Shared Ride 3+	-765	-4,641	-42,847	-48,253
Walk-Transit	-1,250	-1,063	-520	-2,834
Drive-Transit	0	-63	-64	-128
Total	0	0	0	0

ASC Equiv. Minutes of In-Vehicle Time

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers
Walk	45	74	8
Bike	-286	-98	-205
Drive Alone	0	0	0
Shared Ride 2	0	0	0
Shared Ride 3+	65	42	-8
Walk-Transit	123	-48	-844
Drive-Transit	0	-142	-274

Escorting

Tour Mode Choice Scaled Targets - Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	1,411	4,818	41,814	48,043
Bike	328	478	2,818	3,624
Drive Alone	0	0	0	-
Shared Ride 2	1,757	48,480	351,220	401,457
Shared Ride 3+	467	30,433	380,440	411,341
Walk-Transit	293	295	2,752	3,340
Drive-Transit	0	1,118	488	1,606
Total	4,255	85,622	779,533	869,410
Unscaled Total	4,274	65,040	576,448	645,762

Tour Mode Choice Model Results - Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	1,373	4,560	36,631	42,564
Bike	309	390	1,810	2,509
Drive Alone	0	0	0	-
Shared Ride 2	2,154	50,044	372,395	424,593
Shared Ride 3+	325	29,702	367,223	397,250
Walk-Transit	93	117	1,247	1,457
Drive-Transit	0	810	227	1,037
Total	4,254	85,623	779,533	869,410

Difference: Estimated – Observed

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	-38	-258	-5,183	-5,479
Bike	-19	-88	-1,008	-1,115
Drive Alone	0	0	0	0
Shared Ride 2	397	1,564	21,175	23,136
Shared Ride 3+	-142	-731	-13,217	-14,091
Walk-Transit	-200	-178	-1,505	-1,883
Drive-Transit	0	-308	-261	-569
Total	-1	1	0	0

ASC Equiv. Minutes of In-Vehicle Time

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers
Walk	177	-41	-35
Bike	-18	-277	-322
Drive Alone	0	0	0
Shared Ride 2	0	0	0
Shared Ride 3+	-57	-15	3
Walk-Transit	-108	-208	-263
Drive-Transit	0	-123	-390

Shopping

Tour Mode Choice Scaled Targets – Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	24,131	15,408	53,682	93,220
Bike	4,064	3,002	6,136	13,202
Drive Alone	0	48,943	537,251	586,193
Shared Ride 2	5,242	14,075	166,060	185,376
Shared Ride 3+	6,765	10,252	123,442	140,458
Walk-Transit	23,495	4,787	9,634	37,916
Drive-Transit	0	663	1,745	2,409
Total	63,696	97,129	897,950	1,058,775
Unscaled Total	60,343	52,019	613,716	726,078

Tour Mode Choice Model Results – Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	25,202	16,608	50,283	92,093
Bike	4,801	3,037	5,601	13,439
Drive Alone	0	50,166	566,857	617,023
Shared Ride 2	8,009	13,650	153,470	175,129
Shared Ride 3+	7,493	9,644	113,960	131,097
Walk-Transit	18,191	3,575	6,632	28,398
Drive-Transit	0	449	1,147	1,596
Total	63,696	97,129	897,950	1,058,775

Difference: Estimated - Observed

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	1,071	1,200	-3,399	-1,127
Bike	737	35	-535	237
Drive Alone	0	1,223	29,606	30,830
Shared Ride 2	2,767	-425	-12,590	-10,247
Shared Ride 3+	728	-608	-9,482	-9,361
Walk-Transit	-5,304	-1,212	-3,002	-9,518
Drive-Transit	0	-214	-598	-813
Total	0	0	0	0

ASC Equiv. Minutes of In-Vehicle Time

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers
Walk	182	144	55
Bike	123	-43	-167
Drive Alone	0	0	0
Shared Ride 2	0	22	19
Shared Ride 3+	44	25	12
Walk-Transit	171	-44	-123
Drive-Transit	0	-95	-220

Other Maintenance

Tour Mode Choice Scaled Targets - Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	8,329	4,829	26,011	39,168
Bike	3,945	979	1,956	6,880
Drive Alone	0	29,186	304,868	334,053
Shared Ride 2	6,857	9,896	84,451	101,205
Shared Ride 3+	1,970	1,164	60,872	64,007
Walk-Transit	15,526	288	8,225	24,039
Drive-Transit	0	804	804	1,609
Total	36,627	47,147	487,187	570,961
Unscaled Total	28,131	22,143	345,912	396,186

Tour Mode Choice Model Results - Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	8,097	5,017	26,350	39,464
Bike	4,705	1,001	2,000	7,706
Drive Alone	0	29,943	307,016	336,959
Shared Ride 2	8,990	9,427	89,296	107,713
Shared Ride 3+	1,234	1,078	55,738	58,050
Walk-Transit	13,601	130	6,257	19,988
Drive-Transit	0	551	530	1,081
Total	36,627	47,147	487,187	570,961

Difference: Estimated – Observed

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	-232	188	339	296
Bike	760	22	44	826
Drive Alone	0	757	2,148	2,906
Shared Ride 2	2,133	-469	4,845	6,508
Shared Ride 3+	-736	-86	-5,134	-5,957
Walk-Transit	-1,925	-158	-1,968	-4,051
Drive-Transit	0	-253	-274	-528
Total	0	0	0	0

ASC Equiv. Minutes of In-Vehicle Time

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers
Walk	93	94	54
Bike	122	-87	-186
Drive Alone	0	0	0
Shared Ride 2	0	28	23
Shared Ride 3+	-18	-36	10
Walk-Transit	158	-132	-92
Drive-Transit	0	-60	-249

Eat Out

Tour Mode Choice Scaled Targets – Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	18,161	10,951	23,741	52,853
Bike	433	304	3,341	4,079
Drive Alone	0	13,521	118,673	132,193
Shared Ride 2	1,315	7,770	79,881	88,965
Shared Ride 3+	2,187	4,165	85,199	91,552
Walk-Transit	5,953	2,479	4,311	12,743
Drive-Transit	0	916	1,484	2,400
Total	28,050	40,106	316,629	384,785
Unscaled Total	37,666	27,481	265,106	330,253

Tour Mode Choice Model Results – Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	17,453	11,777	24,403	53,633
Bike	539	310	3,924	4,773
Drive Alone	0	14,014	115,615	129,629
Shared Ride 2	1,674	7,794	83,293	92,761
Shared Ride 3+	1,980	3,911	84,648	90,539
Walk-Transit	4,599	1,752	3,732	10,083
Drive-Transit	0	548	1,014	1,562
Total	26,245	40,106	316,629	382,980

Difference: Estimated - Observed

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	-708	826	662	780
Bike	106	6	583	694
Drive Alone	0	493	-3,058	-2,564
Shared Ride 2	359	24	3,412	3,796
Shared Ride 3+	-207	-254	-551	-1,013
Walk-Transit	-1,354	-727	-579	-2,660
Drive-Transit	0	-368	-470	-838
Total	-1,805	0	0	-1,805

ASC Equiv. Minutes of In-Vehicle Time

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers
Walk	296	200	97
Bike	92	-84	-82
Drive Alone	0	0	0
Shared Ride 2	0	45	55
Shared Ride 3+	40	31	61
Walk-Transit	174	3	-58
Drive-Transit	0	1	-126

Visiting

Tour Mode Choice Scaled Targets - Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	9,037	3,671	23,397	36,105
Bike	769	1,038	2,480	4,287
Drive Alone	0	2,620	97,917	100,536
Shared Ride 2	4,195	8,203	39,391	51,788
Shared Ride 3+	499	5,037	42,004	47,540
Walk-Transit	4,172	1,798	6,665	12,636
Drive-Transit	0	628	1,763	2,391
Total	18,672	22,994	213,617	255,283
Unscaled Total	10,434	26,713	151,817	188,964

Tour Mode Choice Model Results - Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	9,138	3,526	25,333	37,997
Bike	835	1,106	2,777	4,718
Drive Alone	0	2,926	93,585	96,511
Shared Ride 2	4,198	8,309	42,160	54,667
Shared Ride 3+	893	5,303	43,107	49,303
Walk-Transit	3,608	1,413	5,508	10,529
Drive-Transit	0	411	1,147	1,558
Total	18,672	22,994	213,617	255,283

Difference: Estimated – Observed

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	101	-145	1,936	1,892
Bike	66	68	297	431
Drive Alone	0	306	-4,332	-4,025
Shared Ride 2	3	106	2,769	2,879
Shared Ride 3+	394	266	1,103	1,763
Walk-Transit	-564	-385	-1,157	-2,107
Drive-Transit	0	-217	-616	-833
Total	0	0	0	0

ASC Equiv. Minutes of In-Vehicle Time

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers
Walk	114	185	106
Bike	30	61	-82
Drive Alone	0	0	0
Shared Ride 2	0	122	39
Shared Ride 3+	-27	123	49
Walk-Transit	75	80	-15
Drive-Transit	0	77	-80

Other Discretionary

Tour Mode Choice Scaled Targets – Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	23,835	9,320	46,390	79,544
Bike	679	3,011	12,571	16,261
Drive Alone	0	19,780	304,946	324,726
Shared Ride 2	7,397	11,793	147,366	166,556
Shared Ride 3+	6,583	21,674	173,867	202,124
Walk-Transit	12,613	9,081	12,877	34,570
Drive-Transit	0	652	5,511	6,163
Total	51,106	75,310	703,528	829,944
Unscaled Total	36,690	62,241	576,541	675,473

Tour Mode Choice Model Results – Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	24,042	9,976	47,432	81,450
Bike	706	3,274	13,883	17,863
Drive Alone	0	20,439	303,147	323,586
Shared Ride 2	5,421	11,841	151,783	169,045
Shared Ride 3+	9,752	22,396	172,439	204,587
Walk-Transit	11,185	6,954	11,034	29,173
Drive-Transit	0	430	3,810	4,240
Total	51,106	75,310	703,528	829,944

Difference: Estimated - Observed

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	207	656	1,042	1,906
Bike	27	263	1,312	1,602
Drive Alone	0	659	-1,799	-1,140
Shared Ride 2	-1,976	48	4,417	2,489
Shared Ride 3+	3,169	722	-1,428	2,463
Walk-Transit	-1,428	-2,127	-1,843	-5,397
Drive-Transit	0	-222	-1,701	-1,923
Total	0	0	0	0

ASC Equiv. Minutes of In-Vehicle Time

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers
Walk	197	150	82
Bike	5	14	-75
Drive Alone	0	0	0
Shared Ride 2	0	48	35
Shared Ride 3+	59	89	47
Walk-Transit	130	60	-44
Drive-Transit	0	-22	-70

At-Work Sub-Tours

Tour Mode Choice Scaled Targets - Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	17,319	47,045	124,905	189,269
Bike	0	0	5,898	5,898
Drive Alone	0	42,281	296,894	339,175
Shared Ride 2	635	23,065	104,871	128,571
Shared Ride 3+	1,435	13,603	78,692	93,730
Walk-Transit	1,594	1,995	2,632	6,222
Drive-Transit	0	0	0	-
Total	20,982	127,991	613,892	762,864
Unscaled Total	13,337	33,761	256,159	303,256

Tour Mode Choice Model Results - Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	17,453	48,477	131,043	196,973
Bike	4	749	3,957	4,710
Drive Alone	0	41,848	291,426	333,274
Shared Ride 2	662	22,476	105,178	128,316
Shared Ride 3+	1,365	12,988	80,141	94,494
Walk-Transit	1,498	1,643	2,381	5,522
Drive-Transit	0	0	0	-
Total	20,982	128,181	614,126	763,289

Difference: Estimated – Observed

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	134	1,432	6,138	7,704
Bike	4	749	-1,941	-1,188
Drive Alone	0	-433	-5,468	-5,901
Shared Ride 2	27	-589	307	-255
Shared Ride 3+	-70	-615	1,449	764
Walk-Transit	-96	-352	-251	-700
Drive-Transit	0	0	0	0
Total	0	190	234	425

ASC Equiv. Minutes of In-Vehicle Time

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers
Walk	382	54	44
Bike	-22	-40	830
Drive Alone	0	0	0
Shared Ride 2	0	-118	-69
Shared Ride 3+	66	-122	-68
Walk-Transit	163	-166	-183
Drive-Transit	N/A	N/A	N/A

Total

Tour Mode Choice Scaled Targets – Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	134,193	147,016	495,534	776,743
Bike	18,927	27,665	72,723	119,315
Drive Alone	0	340,367	3,140,279	3,480,646
Shared Ride 2	37,335	270,515	1,560,661	1,868,511
Shared Ride 3+	26,435	208,147	1,729,812	1,964,395
Walk-Transit	197,282	132,272	209,913	539,467
Drive-Transit	0	33,381	114,367	147,747
Total	414,172	1,159,364	7,323,288	8,896,824
Unscaled Total	362,224	733,930	5,808,652	6,904,807

Tour Mode Choice Model Results – Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	134,618	148,904	489,295	772,817
Bike	20,340	29,046	70,138	119,524
Drive Alone	0	344,922	3,156,686	3,501,608
Shared Ride 2	45,427	278,305	1,636,789	1,960,521
Shared Ride 3+	28,106	202,700	1,660,967	1,891,773
Walk-Transit	183,875	124,440	198,631	506,946
Drive-Transit	0	31,239	111,016	142,255
Total	412,366	1,159,556	7,323,522	8,895,444

Difference: Estimated - Observed

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Walk	425	1,888	-6,239	-3,926
Bike	1,413	1,381	-2,585	209
Drive Alone	0	4,555	16,407	20,962
Shared Ride 2	8,092	7,790	76,128	92,010
Shared Ride 3+	1,671	-5,447	-68,845	-72,622
Walk-Transit	-13,407	-7,832	-11,282	-32,521
Drive-Transit	0	-2,142	-3,351	-5,492
Total	-1,806	192	234	-1,380

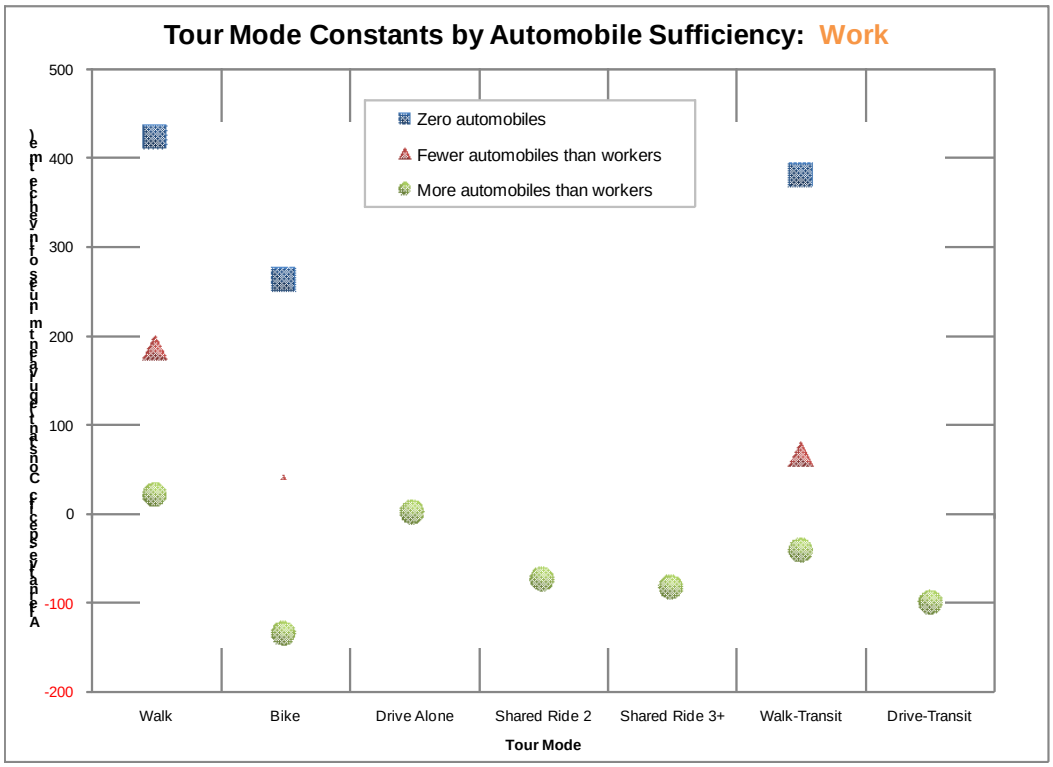
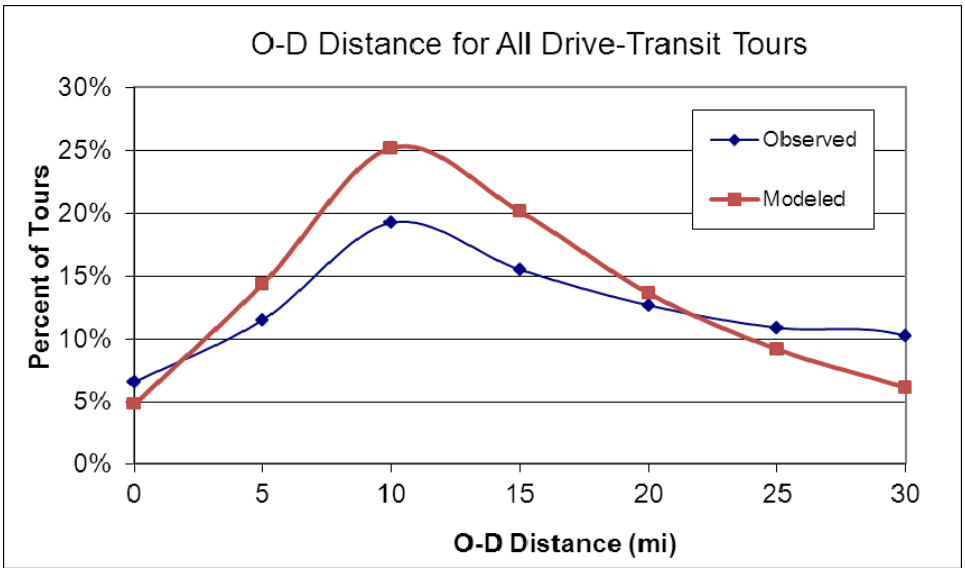


Figure 36: Tour Mode Constants by Automobile Sufficiency, Work



	Observed	Modeled	Diff.	% Diff
Avg. Dist (mi.):	21.2	17.8	-3.4	-16%

Figure 37: Origin-Destination Distance Frequency Distribution for Drive-Transit Tours

Table 46: Number of Tours to Central Business Districts by Mode

Work

Tour Mode Choice Scaled Targets - Absolute

	SF CBD	SJ CBD	Oak CBD	All CBDs
Walk	16,173	4,663	5,334	26,170
Bike	6,406	372	3,377	10,156
Auto	57,369	105,163	122,902	285,434
Walk-Transit	132,869	4,568	21,082	158,519
Drive-Transit	71,474	3,478	13,765	88,716
Total	284,292	118,243	166,460	568,995
Unscaled Total	318,938	97,119	175,506	591,564

Tour Mode Choice Model Results - Absolute

	SF CBD	SJ CBD	Oak CBD	All CBDs
Walk	19,369	2,586	4,107	26,062
Bike	5,453	1,911	2,548	9,912
Auto	79,963	100,164	127,287	307,414
Walk-Transit	128,359	9,100	20,154	157,613
Drive-Transit	51,148	4,482	12,364	67,994
Total	284,292	118,243	166,460	568,995

Difference: Estimated - Observed

	SF CBD	SJ CBD	Oak CBD	All CBDs
Walk	3,196	-2,077	-1,227	-108
Bike	-953	1,539	-829	-244
Auto	22,594	-4,999	4,385	21,980
Walk-Transit	-4,510	4,532	-928	-906
Drive-Transit	-20,326	1,004	-1,401	-20,722
Total	0	0	0	0

Non-Work

Tour Mode Choice Scaled Targets – Absolute

	SF CBD	SJ CBD	Oak CBD	All CBDs
Walk	118,060	34,687	44,563	197,310
Bike	3,165	1,438	4,946	9,549
Auto	123,331	267,605	290,339	681,275
Walk-Transit	39,604	14,141	50,981	104,725
Drive-Transit	7,762	1,738	2,723	12,223
Total	291,922	319,610	393,551	1,005,084
Unscaled Total	150,720	180,308	275,992	607,020

Tour Mode Choice Model Results – Absolute

	SF CBD	SJ CBD	Oak CBD	All CBDs
Walk	87,690	25,653	49,432	162,775
Bike	4,198	2,282	4,752	11,232
Auto	158,564	275,583	315,032	749,179
Walk-Transit	39,544	17,181	23,795	80,520
Drive-Transit	2,712	2,423	2,125	7,260
Total	292,708	323,122	395,136	1,010,966

Difference: Estimated - Observed

	SF CBD	SJ CBD	Oak CBD	All CBDs
Walk	-30,370	-9,034	4,869	-34,535
Bike	1,033	844	-194	1,683
Auto	35,233	7,978	24,693	67,904
Walk-Transit	-60	3,040	-27,186	-24,205
Drive-Transit	-5,050	685	-598	-4,963
Total	786	3,512	1,585	5,882

Total

Tour Mode Choice Scaled Targets - Absolute

	SF CBD	SJ CBD	Oak CBD	All CBDs
Walk	134,233	39,350	49,897	223,480
Bike	9,572	1,810	8,323	19,705
Auto	180,700	372,768	413,241	966,709
Walk-Transit	172,473	18,709	72,063	263,245
Drive-Transit	79,236	5,216	16,488	100,940
Total	576,214	437,853	560,011	1,574,079
Unscaled Total	469,659	277,427	451,499	1,198,584

Tour Mode Choice Model Results - Absolute

	SF CBD	SJ CBD	Oak CBD	All CBDs
Walk	107,059	28,239	53,539	188,837
Bike	9,651	4,193	7,300	21,144
Auto	238,527	375,747	442,319	1,056,593
Walk-Transit	167,903	26,281	43,949	238,133
Drive-Transit	53,860	6,905	14,489	75,254
Total	577,000	441,365	561,596	1,579,961

Difference: Estimated - Observed

	SF CBD	SJ CBD	Oak CBD	All CBDs
Walk	-27,174	-11,111	3,642	-34,643
Bike	79	2,383	-1,023	1,439
Auto	57,827	2,979	29,078	89,884
Walk-Transit	-4,570	7,572	-28,114	-25,112
Drive-Transit	-25,376	1,689	-1,999	-25,686
Total	786	3,512	1,585	5,882

Table 47: Transit Sub-mode ASC Equivalent Minutes of Bus In-Vehicle Time

	Work		School		Non-mandatory	
Mode	**Tour Equiv. Min.**	**Trip Equiv. Min.**	**Tour Equiv. Min.**	**Trip Equiv. Min.**	**Tour Equiv. Min.**	**Trip Equiv. Min.**
Light Rail	57	28	59	30	22	11
Ferry	120	60	120	60	120	60
Express Bus	-8	-4	-8	-4	-8	-4
Heavy Rail	52	26	48	24	20	10
Commuter Rail	49	25	40	20	19	10

Table 48: Number of Transit Tours by Line-haul Mode and Purpose

Work

Tour Mode Choice Scaled Targets - Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Local	50,034	41,541	57,566	149,141
LRT/Ferry	10,979	12,411	31,199	54,589
Express Bus	4,809	4,158	8,756	17,723
Heavy Rail	22,015	40,593	84,096	146,704
Commuter Rail	1,772	5,727	10,611	18,110
Total	89,610	104,430	192,227	386,267

Tour Mode Choice Model Results - Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Local	49,661	37,262	46,767	133,690
LRT/Ferry	11,204	18,536	30,015	59,755
Express Bus	3,830	3,197	10,255	17,282
Heavy Rail	21,149	36,332	89,328	146,809
Commuter Rail	3,412	6,984	16,352	26,748
Total	89,256	102,311	192,717	384,284

Difference: Estimated - Observed

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Local	-373	-4,279	-10,799	-15,451
LRT/Ferry	225	6,125	-1,184	5,166
Express Bus	-979	-961	1,499	-441
Heavy Rail	-866	-4,261	5,232	105
Commuter Rail	1,640	1,257	5,741	8,638
Total	-354	-2,119	490	-1,983

School

Tour Mode Choice Scaled Targets – Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Local	33,921	26,648	47,992	108,560
LRT/Ferry	4,365	709	13,795	18,870
Express Bus	0	2,561	2,566	5,127
Heavy Rail	3,596	4,080	7,761	15,436
Commuter Rail	364	506	460	1,330
Total	42,246	34,503	72,574	149,323

Tour Mode Choice Model Results - Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Local	32,926	25,644	51,174	109,744
LRT/Ferry	3,108	3,796	8,617	15,521
Express Bus	723	706	1,541	2,970
Heavy Rail	4,268	3,865	9,879	18,012
Commuter Rail	288	486	1,051	1,825
Total	41,313	34,497	72,262	148,072

Difference: Estimated - Observed

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Local	-995	-1,004	3,182	1,184
LRT/Ferry	-1,257	3,087	-5,178	-3,349
Express Bus	723	-1,855	-1,025	-2,157
Heavy Rail	672	-215	2,118	2,576
Commuter Rail	-76	-20	591	495
Total	-933	-6	-312	-1,251

Non-Mandatory

Tour Mode Choice Scaled Targets - Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Local	40,467	10,350	31,465	82,283
LRT/Ferry	9,306	4,540	7,637	21,483
Express Bus	7,534	41	1,873	9,448
Heavy Rail	5,554	11,568	17,247	34,369
Commuter Rail	759	413	1,491	2,662
Total	63,620	26,911	59,712	150,244

Tour Mode Choice Model Results - Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Local	38,082	11,455	27,866	77,403
LRT/Ferry	6,408	2,527	4,842	13,777
Express Bus	755	257	970	1,982
Heavy Rail	7,691	4,037	9,219	20,947
Commuter Rail	370	595	1,771	2,736
Total	53,306	18,871	44,668	116,845

Difference: Estimated - Observed

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Local	-2,385	1,105	-3,599	-4,880
LRT/Ferry	-2,898	-2,013	-2,795	-7,706
Express Bus	-6,779	216	-903	-7,466
Heavy Rail	2,137	-7,531	-8,028	-13,422
Commuter Rail	-389	182	280	74
Total	-10,314	-8,040	-15,044	-33,399

Total

Tour Mode Choice Scaled Targets - Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Local	124,422	78,539	137,022	339,984
LRT/Ferry	24,651	17,660	52,631	94,942
Express Bus	12,343	6,760	13,195	32,298
Heavy Rail	31,165	56,241	109,103	196,509
Commuter Rail	2,894	6,646	12,561	22,102
Total	195,476	165,845	324,514	685,834

Tour Mode Choice Model Results - Absolute

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Local	120,669	74,361	125,807	320,837
LRT/Ferry	20,720	24,859	43,474	89,053
Express Bus	5,308	4,160	12,766	22,234
Heavy Rail	33,108	44,234	108,426	185,768
Commuter Rail	4,070	8,065	19,174	31,309
Total	183,875	155,679	309,647	649,201

Difference: Estimated - Observed

Auto Sufficiency

	Autos==0	0 < Autos < Workers	Autos >= Workers	Total
Local	-3,753	-4,178	-11,215	-19,147
LRT/Ferry	-3,931	7,199	-9,157	-5,889
Express Bus	-7,035	-2,600	-429	-10,064
Heavy Rail	1,943	-12,007	-677	-10,741
Commuter Rail	1,176	1,419	6,613	9,207
Total	-11,601	-10,166	-14,867	-36,633

2.3.2 Stop Frequency

Number of Models:	Ten (one for each purpose)
Decision-Making Unit:	Tours
Model Form:	Multinomial logit
Alternatives:	16 (combinations of from zero to three outgoing and zero to three returning stops)
Source:	Transferred from ARC[17]

The stop frequency model assigns to each tour the number of intermediate destinations a person will travel to on each leg of the tour from the origin to tour primary destination and back. Calibration of the model focused on matching the observed distribution of stops on each leg by purpose. Achieving this required adjustment of coefficients for dummy variables indicating the number of outgoing stops, the number of returning stops, and the total number of stops. We also introduced a penalty on stops in walk-transit tours after finding that the number of trips on walk-transit tours exceeded the number of trips in the survey without the penalty, despite matching the number of walk-transit tours, as shown in section 2.3.1.

Intermediate stops are not modeled for drive-transit tours because doing so can have unintended consequences because of the difficulty of tracking the location of the vehicle. For example, consider someone who used a park and ride for work and then took transit to an intermediate shopping stop on the way home. Without knowing the vehicle location, it cannot be determined if it is reasonable to allow the person to drive home. Even if the tour were constrained to allow driving only on the first and final trip, the trip home from an intermediate stop may not use the same park and ride where the car was dropped off on the outbound leg, which is usually as close as possible to home because of the impracticality of coding drive access links from every park and ride lot to every zone.

The calibrated utility function parameters appear in Table 49. The coefficients listed apply to all alternatives with stops unless otherwise indicated. Comparisons between modeled and observed stop frequency distributions appear in Table 50. The match between the modeled and observed distributions worsened for a few non-mandatory purposes in the final stages of calibration. Calibration was performed without feedback iteration, and during the final runs, only mode choice parameters were adjusted. It appears that including feedback iterations in the demand models and achieving a match in the transit assignment have affected the stop frequency calibration. The overall effect is not particularly detrimental to the model because only non-mandatory tours are off. Non-mandatory tours, with the exception of at-work sub-tours, have similar diurnal distributions, and the errors between purposes will tend to cancel each other out. Nevertheless, revisiting the calibration of the stop frequency model is recommended for a future model version.

[17] See Activity-Based Travel Model Calibration Results: Coordinated Travel – Regional Activity Based Modeling Platform (CT-RAMP) for the Atlanta Region, Prepared for Atlanta Regional Commission, by Parsons Brinckerhoff and PBS&J, December 2009.

Table 49: Stop Frequency Utility Function Parameters

Variable	Work Coef.	College Coef.	School Coef.	Escort Coef.	Shop Coef.	Eat Out Coef.	Maint. Coef.	Social Coef.	Discr. Coef.	At-work Coef.
Household Income										
$30-60k	0.170	-	-	-	-	-	0.170	-	-	0.450
$60-100k	0.230	-	-	-	-	-	0.230	-	-	-
Greater than $100k	0.240	-	-	-	-	-	0.240	-	-	-
Household Composition										
Number of persons	-0.310	-0.283	-0.506	-0.240	-0.152	-	-0.310	-	-	-
Number of Full-time Workers	-	-	-	-	-	-	-	-	-	-
Number of Students	0.210	-	-	0.190	-	-	0.210	-	-	-
Presence of children Age 0-4	0.740	-	-	-	-	-	0.740	-	-	-
Number of children age 5-15	0.080	-	-	-	0.048	-	-	-	-	-
Presence of children age 5-15	0.260	0.682	0.330	-	-	-	-	-	-	-
Number of persons age 16+	0.030	-	-	-	-	-	-	-	-	-
Auto ownership										
At least as many autos as workers	0.160	-	0.533	-	-	-	-	-	-	-
Total number of vehicles	-	0.170	-	-	-	-0.190	-	-0.190	-	-
Tour mode										
Walk-transit	**-0.700**	**-0.700**	**-0.700**	**-0.700**	**-0.700**	**-0.700**	**-0.700**	**-0.700**	**-0.700**	**-**
Non-motorized	-1.540	-	-1.816	-1.910	-1.491	-1.730	-1.433	-1.730	-2.458	-
Person variables										
Female	0.220	0.735	0.410	-	0.172	-	0.301	-	-	-
Number of work tours	-0.150	-	-	-0.290	-0.548	-0.280	-0.364	-0.280	-0.615	-
Number of university tours	-0.480	-	-	-	-0.671	-	-0.625	-	-	-
Number of school tours	-1.550	-	-	-	-	-	-1.414	-	-0.818	-
Number of escort tours	0.200	0.902	1.237	-0.150	-	-	-	-	-	-
Number of shop tours	-	-	-	-	-	-0.240	-0.143	-0.240	-0.629	-
Number of maintenance tours	-	-	-	-	-0.198	-	-	-	-0.372	-
Number of eat out tours	-	-	-	-	-	-	-	-	-	-0.280

Variable	Work Coef.	College Coef.	School Coef.	Escort Coef.	Shop Coef.	Eat Out Coef.	Maint. Coef.	Social Coef.	Discr. Coef.	At-work Coef.
Number of shop tours taken by the household	-0.050	-	-	-	-0.073	-	-	-	-	-
Tour time of day										
Departure 06:00 to 07:00	-1.930	-	-	-	-	-	-	-	-	-
Departure at 11:00 or before	-	-	-	-	-	-	-	-	-	0.310
Return after 17:00	-	0.389	1.838	-	-	-0.450	-	-0.450	-0.638	-
Return after 19:00	0.310	-	-	-	-	-	-	-	-	-
Return at 14:00 or after	-	-	-	-	-	-	-	-	-	0.340
Duration at least 11 hours	0.600	-	-	-	-	-	-	-	-	-
Duration at least 9 hours	-	0.843	0.955	0.590	0.906	-	0.513	-	0.833	-
Duration at least 3 hours	-	-	-	-	-	1.310	-	1.310	-	-
Duration in hours	-	-	-	-	-	-	-	-	-	0.560
Retail accessibility										
At tour destination	-	-	-	-	-	-	-	-	-	-
Tour distance (one-way)										
Less than 20 miles	-0.220	-	-	-	0.377	-	-0.408	-	0.376	-
Less than 5 miles	-	-	-	0.320	-	-	-	-	-	-
Value in miles	0.010	-	0.044	0.010	0.029	-0.010	0.027	-0.010	-0.023	-
Other tour characteristics										
Number of subtours for work tours	0.190	-	-	-	-	-	-	-	-	-
Number of persons for joint tours, alts. w/ outgoing stops	-	-	-	-	-	-0.460	-	-0.460	-	-
Number of persons for joint tours, alts. w/ returning stops	-	-	-	-	-	-	0.490	-	-	-
Party composition all adults for joint tours	-	-	-	-	0.190	-	-	-	-	-
Origin is in Rural Area Type (6 or 7)	-	-	-	-	-	-	-	-	-	0.270
Alternative characteristic dummy variables, Indiv. Tour										
One outbound stop	**-0.833**	**-2.628**	**-2.123**	**-2.173**	**-1.339**	**-2.190**	**-2.451**	**-1.081**	**-1.581**	**-3.896**
Two outbound stops	**-2.613**	**-3.741**	**-3.798**	**-4.294**	**-3.110**	**-4.516**	**-4.351**	**-2.874**	**-3.323**	**-5.709**
Three outbound stops	**-3.934**	**-4.981**	**-5.850**	**-4.758**	**-4.487**	**-5.255**	**-6.116**	**-4.552**	**-4.623**	**-7.361**
One return stop	**-0.445**	**-2.003**	**-1.206**	**-0.968**	**-1.179**	**-1.761**	**-1.225**	**-1.120**	**-0.921**	**-3.671**
Two return stops	**-1.775**	**-3.510**	**-2.672**	**-2.410**	**-2.305**	**-3.697**	**-2.120**	**-2.764**	**-2.336**	**-5.388**

Variable	Work Coef.	College Coef.	School Coef.	Escort Coef.	Shop Coef.	Eat Out Coef.	Maint. Coef.	Social Coef.	Discr. Coef.	At-work Coef.
Three return stops	**-2.139**	**-3.677**	**-3.364**	**-3.024**	**-3.024**	**-4.717**	**-3.102**	**-3.451**	**-2.927**	**-6.210**
Presence of both outbound and return stops	-	-	-	-	-	-	**0.440**	-	-	-
Total number of stops is 4	-	**1.272**	**0.701**	-	**0.252**	**0.940**	**0.414**	**0.496**	**0.863**	**2.127**
Total number of stops is 5 or 6	**0.695**	**1.871**	**1.135**	**-1.807**	**0.514**	**2.026**	**0.488**	**0.882**	**0.939**	**2.127**
Alternative characteristic dummy variables, Joint Tour										
One outbound stop	-	-	-	-	**-1.783**	**-1.783**	**-2.473**	**-1.783**	**-1.783**	-
Two outbound stops	-	-	-	-	**-4.067**	**-4.067**	**-4.757**	**-4.067**	**-4.067**	-
Three outbound stops	-	-	-	-	**-4.998**	**-4.998**	**-5.688**	**-4.998**	**-4.998**	-
One return stop	-	-	-	-	**-1.329**	**-1.329**	**-1.969**	**-1.329**	**-1.329**	-
Two return stops	-	-	-	-	**-2.796**	**-2.796**	**-3.436**	**-2.796**	**-2.796**	-
Three return stops	-	-	-	-	**-3.379**	**-3.379**	**-4.019**	**-3.379**	**-3.379**	-
Presence of both outbound and return stops	-	-	-	-	-	-	**0.440**	-	-	-
Total number of stops is 4	-	-	-	-	**0.518**	**0.518**	**0.518**	**0.518**	**0.518**	-
Total number of stops is 5 or 6	-	-	-	-	**1.497**	**1.497**	**1.497**	**1.497**	**1.497**	-

Table 50: Distribution of Tours by Stop Frequency

OBSERVED

Outbound Stops	Inbound Stops	Purpose										
		Work	College	School	Joint	Escort	Shop	Eat Out	Maint.	Social	Discr.	At-work
Zero	Zero	57.9%	64.0%	70.2%	68.8%	70.0%	59.9%	80.7%	62.8%	73.4%	67.5%	82.6%
Zero	One	14.5%	14.8%	14.4%	14.7%	15.6%	13.4%	8.2%	17.5%	8.6%	13.4%	7.4%
Zero	Two	3.6%	3.3%	3.4%	3.5%	3.9%	4.2%	1.3%	6.2%	1.6%	3.0%	1.4%
Zero	Three	2.3%	2.2%	1.4%	1.9%	2.0%	2.0%	0.5%	2.4%	1.0%	1.4%	0.6%
One	Zero	9.1%	6.6%	4.6%	4.7%	4.8%	11.5%	5.0%	5.5%	8.4%	5.5%	5.6%
One	One	6.0%	3.0%	3.0%	3.7%	1.8%	3.5%	2.8%	2.3%	3.7%	4.5%	1.0%
One	Two	1.7%	0.6%	0.6%	0.8%	0.3%	1.2%	0.3%	1.2%	0.6%	1.2%	0.1%
One	Three	1.1%	0.7%	0.5%	0.4%	0.2%	0.6%	0.0%	0.4%	0.2%	0.9%	0.1%
Two	Zero	1.5%	2.5%	1.1%	0.6%	0.5%	1.6%	0.5%	0.5%	1.3%	1.0%	1.0%
Two	One	0.8%	0.8%	0.4%	0.3%	0.3%	0.7%	0.2%	0.2%	0.6%	0.7%	0.1%
Two	Two	0.3%	0.1%	0.1%	0.0%	0.0%	0.3%	0.0%	0.6%	0.2%	0.3%	0.0%
Two	Three	0.4%	0.3%	0.1%	0.1%	0.0%	0.2%	0.0%	0.1%	0.1%	0.1%	0.0%
Three	Zero	0.4%	0.5%	0.2%	0.1%	0.4%	0.4%	0.1%	0.2%	0.2%	0.4%	0.2%
Three	One	0.2%	0.2%	0.0%	0.2%	0.2%	0.2%	0.2%	0.0%	0.1%	0.1%	0.0%
Three	Two	0.1%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.1%	0.0%
Three	Three	0.1%	0.2%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

MODELED

Outbound Stops	Inbound Stops	Purpose										
		Work	College	School	Joint	Escort	Shop	Eat Out	Maint.	Social	Discr.	At-work
Zero	Zero	60.3%	67.6%	70.0%	66.4%	60.6%	78.4%	71.9%	64.2%	81.4%	82.7%	65.5%
Zero	One	13.6%	15.7%	15.8%	16.2%	14.5%	10.2%	9.7%	14.7%	8.2%	7.6%	13.5%
Zero	Two	3.5%	3.6%	3.7%	3.7%	5.2%	1.5%	1.9%	3.6%	1.5%	1.4%	3.5%
Zero	Three	2.4%	1.8%	2.0%	2.1%	2.3%	0.5%	0.9%	2.0%	0.6%	0.6%	1.9%
One	Zero	8.7%	6.3%	4.7%	6.5%	9.2%	6.6%	9.5%	7.6%	6.6%	6.0%	7.8%
One	One	5.1%	1.9%	1.8%	2.3%	3.3%	1.1%	2.5%	3.0%	0.2%	0.2%	3.3%
One	Two	1.3%	0.4%	0.4%	0.6%	1.1%	0.2%	0.5%	0.7%	0.0%	0.0%	0.9%
One	Three	1.0%	0.4%	0.2%	0.5%	0.7%	0.2%	0.4%	1.0%	0.1%	0.1%	0.7%
Two	Zero	1.6%	1.2%	0.6%	0.7%	1.5%	0.6%	1.6%	1.3%	1.0%	1.0%	1.3%
Two	One	0.9%	0.4%	0.2%	0.2%	0.5%	0.1%	0.4%	0.5%	0.0%	0.0%	0.5%
Two	Two	0.3%	0.2%	0.0%	0.1%	0.2%	0.0%	0.1%	0.3%	0.0%	0.0%	0.2%
Two	Three	0.3%	0.1%	0.0%	0.1%	0.1%	0.0%	0.1%	0.2%	0.0%	0.0%	0.2%
Three	Zero	0.4%	0.2%	0.3%	0.3%	0.4%	0.3%	0.3%	0.4%	0.2%	0.2%	0.3%
Three	One	0.3%	0.1%	0.1%	0.2%	0.2%	0.1%	0.1%	0.3%	0.0%	0.0%	0.2%
Three	Two	0.1%	0.0%	0.0%	0.1%	0.1%	0.1%	0.0%	0.1%	0.0%	0.0%	0.1%
Three	Three	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

DIFFERENCE (MODELED - OBSERVED)

Outbound Stops	Inbound Stops	Purpose										
		Work	**College**	**School**	**Joint**	**Escort**	**Shop**	**Eat Out**	**Maint.**	**Social**	**Discr.**	**At-work**
Zero	Zero	2.4%	3.6%	-0.1%	-2.4%	-9.4%	18.5%	-8.8%	1.4%	8.0%	15.2%	-17.1%
Zero	One	-0.9%	1.0%	1.3%	1.5%	-1.1%	-3.3%	1.5%	-2.8%	-0.3%	-5.7%	6.1%
Zero	Two	-0.1%	0.3%	0.4%	0.2%	1.3%	-2.7%	0.6%	-2.6%	-0.1%	-1.6%	2.1%
Zero	Three	0.1%	-0.4%	0.6%	0.2%	0.3%	-1.5%	0.4%	-0.4%	-0.4%	-0.8%	1.4%
One	Zero	-0.3%	-0.3%	0.1%	1.8%	4.4%	-4.8%	4.5%	2.1%	-1.9%	0.5%	2.2%
One	One	-0.9%	-1.1%	-1.2%	-1.4%	1.5%	-2.4%	-0.3%	0.8%	-3.5%	-4.3%	2.2%
One	Two	-0.4%	-0.2%	-0.2%	-0.2%	0.9%	-1.1%	0.2%	-0.4%	-0.6%	-1.1%	0.8%
One	Three	-0.1%	-0.3%	-0.3%	0.1%	0.5%	-0.4%	0.4%	0.5%	-0.1%	-0.8%	0.6%
Two	Zero	0.1%	-1.3%	-0.5%	0.1%	1.0%	-1.0%	1.1%	0.9%	-0.3%	0.1%	0.3%
Two	One	0.1%	-0.5%	-0.2%	-0.1%	0.2%	-0.6%	0.2%	0.3%	-0.5%	-0.7%	0.5%
Two	Two	-0.1%	0.1%	0.0%	0.1%	0.2%	-0.3%	0.1%	-0.3%	-0.1%	-0.2%	0.2%
Two	Three	-0.1%	-0.2%	-0.1%	0.0%	0.1%	-0.1%	0.1%	0.1%	0.0%	-0.1%	0.2%
Three	Zero	0.0%	-0.3%	0.2%	0.2%	0.0%	-0.1%	0.1%	0.2%	0.0%	-0.2%	0.2%
Three	One	0.0%	-0.1%	0.1%	-0.1%	0.0%	-0.1%	-0.1%	0.3%	-0.1%	-0.1%	0.2%
Three	Two	0.0%	-0.1%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	-0.1%	-0.1%	0.1%
Three	Three	0.0%	-0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%
Total		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

2.4 Trip Level Models

After stops are generated along the travel tours, the times of day and purposes are drawn for the individual trips from cross-classification tables. The time of day of outgoing stops is based on the tour departure time and the amount of time between the tour departure time and the stop time. The time of returning stops is based on the time of returning to home and the amount of time between the return time and the stop time. The individual trips then proceed through the trip-level models, which are presented here through trip mode choice. For highway and transit assignment validation results, refer to Section 3.

2.4.1 Stop Location

Number of Models:	10, one for each tour purpose
Decision-Making Unit:	Trips
Model Form:	Multinomial logit
Alternatives:	30 importance-sampled from 4352 = 1454 zones x 3 walk-transit proximity subzones
Source:	Size terms estimated using BATS 2000, mode choice logsum parameter taken from SFCTA RPM-9 Model

The stop location model iterates through the stops along each travel tour, and determines the intermediate destination for each individual trip, in sequence. Calibration of the model focused on matching the trip frequency distribution of the additional distance incurred by adding the stop to the tour (the "out-of-direction" distance). In order to achieve this match, we adjusted coefficients on the stop's distance from the tour origin and the stop and the distance between the tour origin and the destination, and an additional constant on the sum of these distances.

The calibrated utility function parameters, which are segmented by the tour purpose, appear in Table 51. The definitions of the size variables, which are segmented by the stop purpose, are in Table 52. Comparisons between the observed and modeled frequency distribution of stops by out-of-direction distance for each tour purpose appear in Figure 38. For the work purpose, an additional match between the trip frequency distribution of the proportion of the tour distance which occurs between the tour origin and the stop divided by the distance between the tour origin and the tour primary destination was desired because of travelers' tendency to cluster after-work errands near these locations. The frequency distribution of stops by location along the tour for each tour purpose appears in Figure 39.

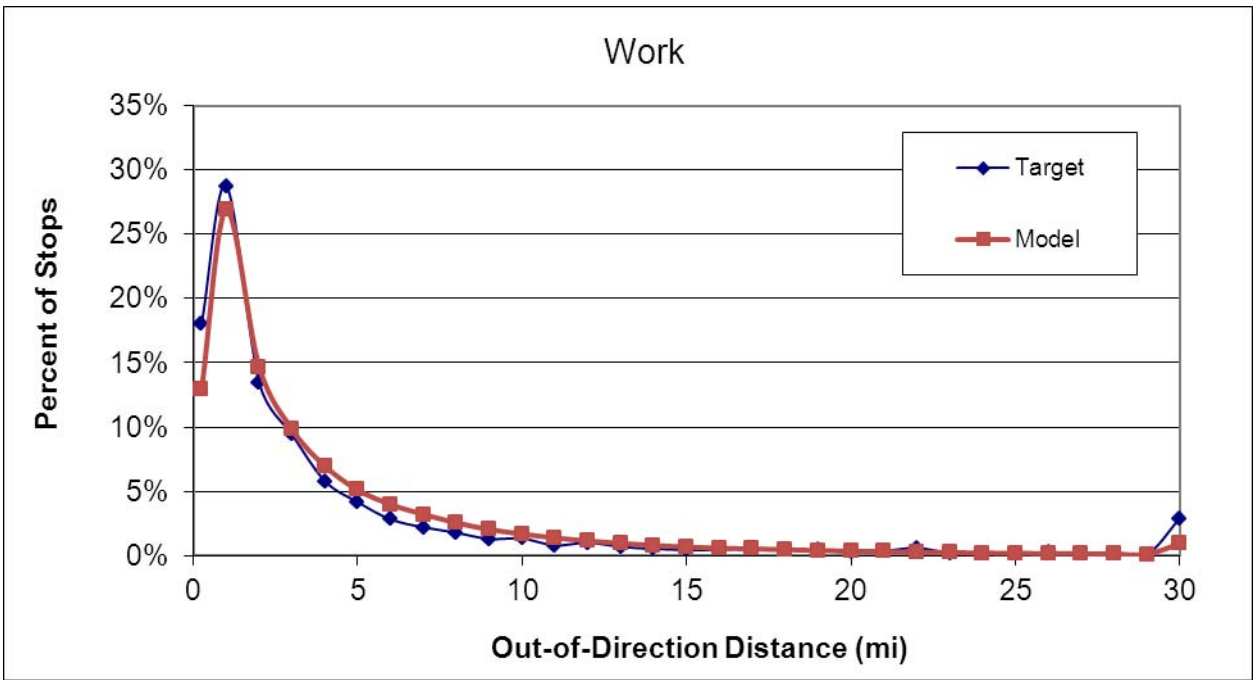
Table 51: Stop Location Utility Function Parameters, Segmented by Tour Purpose

Variable	Work Coef.	College Coef.	School Coef.	Escort Coef.	Shop Coef.	Eat Out Coef.	Maint. Coef.	Social Coef.	Discr. Coef.	At-work Coef.
Sample of alternatives correction factor	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Size Variable	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Trip Mode Choice logsum from origin to stop	1.821	1.821	1.821	1.821	1.821	1.821	1.821	1.821	1.821	1.821
Trip Mode Choice logsum from stop to destination	1.821	1.821	1.821	1.821	1.821	1.821	1.821	1.821	1.821	1.821
Stop distance from tour origin on outbound Indiv. Tours	**-0.232**	**-0.061**	**-0.106**	**-0.149**	**-0.119**	**-0.103**	**-0.096**	**-0.133**	**-0.126**	**-0.122**
Stop distance from tour dest. on outbound Indiv. Tours	**-0.112**	**-0.061**	**-0.106**	**-0.149**	**-0.119**	**-0.103**	**-0.096**	**-0.133**	**-0.126**	**-0.122**
Stop distance from tour origin on inbound Indiv. Tours	**-0.050**	**-0.061**	**-0.106**	**-0.149**	**-0.119**	**-0.103**	**-0.096**	**-0.133**	**-0.126**	**-0.122**
Stop distance from tour dest. on oinbound Indiv. Tours	**-0.200**	**-0.061**	**-0.106**	**-0.149**	**-0.119**	**-0.103**	**-0.096**	**-0.133**	**-0.126**	**-0.122**
Stop distance from tour origin on Joint Tours					**-0.124**	**-0.124**	**-0.124**	**-0.124**	**-0.124**	
Stop distance from tour dest. on Joint Tours					**-0.124**	**-0.124**	**-0.124**	**-0.124**	**-0.124**	

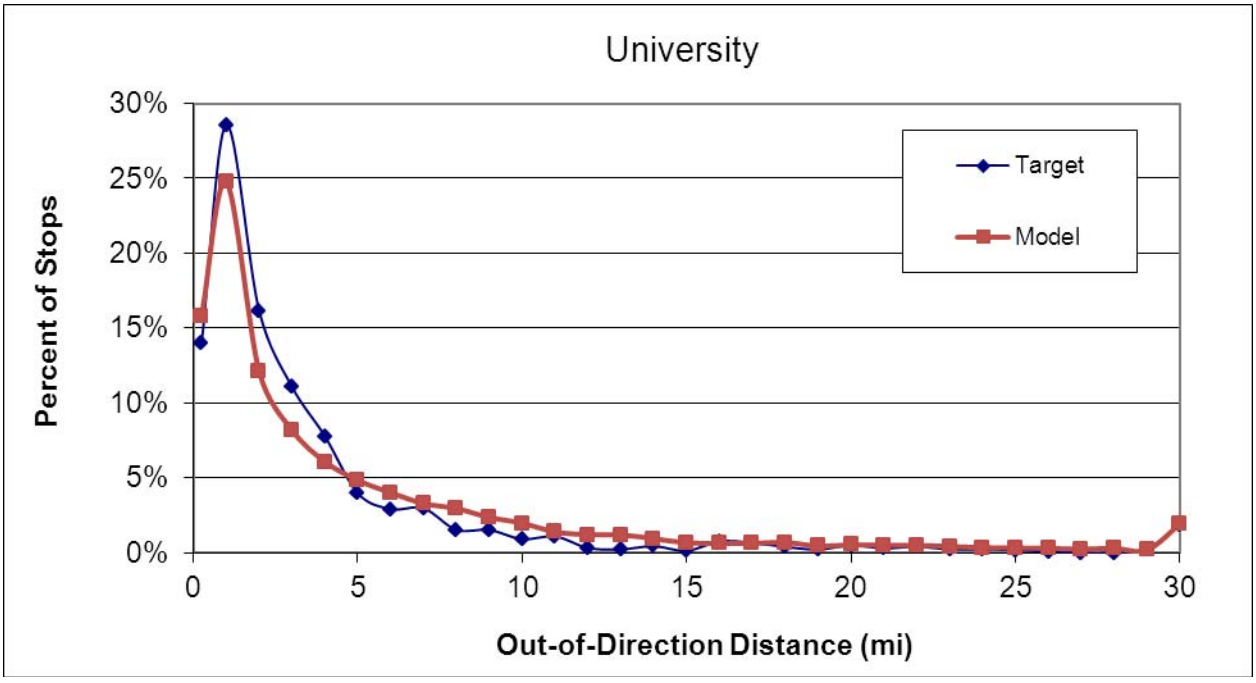
Table 52: Definitions of the Stop Destination Choice Size Coefficients, Segmented by Trip Purpose

Variable	Work	Escort	Shop	Eat Out	Maint.	Social	Discr.
Total Households	-	-	-	-	-	-	0.252
Retail Employment	1.000	0.225	1.000	0.742	0.482	0.522	0.212
Financial & Prof. Service Employment	1.000	-	-	-	-	-	-
Health, Edu., and Rec. Service Employment	1.000	0.144	-	0.258	0.518	0.478	0.272
Other Employment	1.000	-	-	-	-	-	0.165
Agricultural & Nat. Res. Employment	1.000	-	-	-	-	-	-
Manufacturing, Trade & Transport. Employment	1.000	-	-	-	-	-	-
Residents Age 5-18	-	0.465	-	-	-	-	-
High School Enrollment	-	0.166	-	-	-	-	-0.098

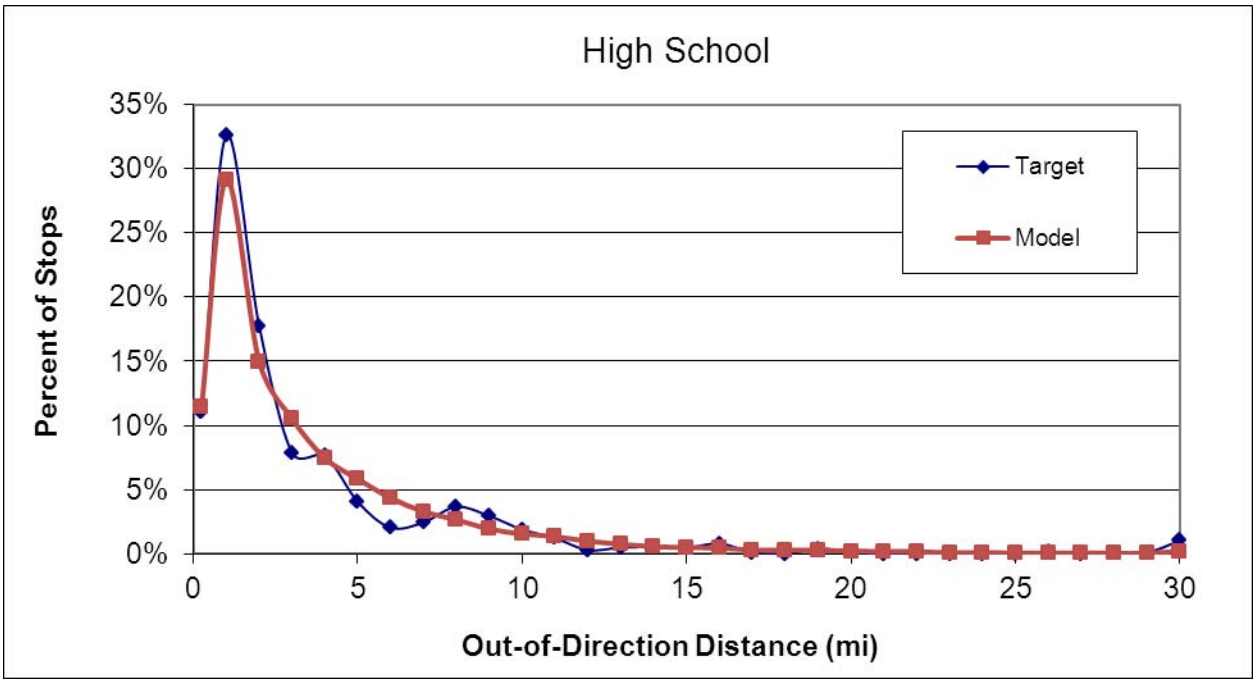
Figure 38: Frequency Distribution of Stops by Out-of-direction Distance and Tour Purpose



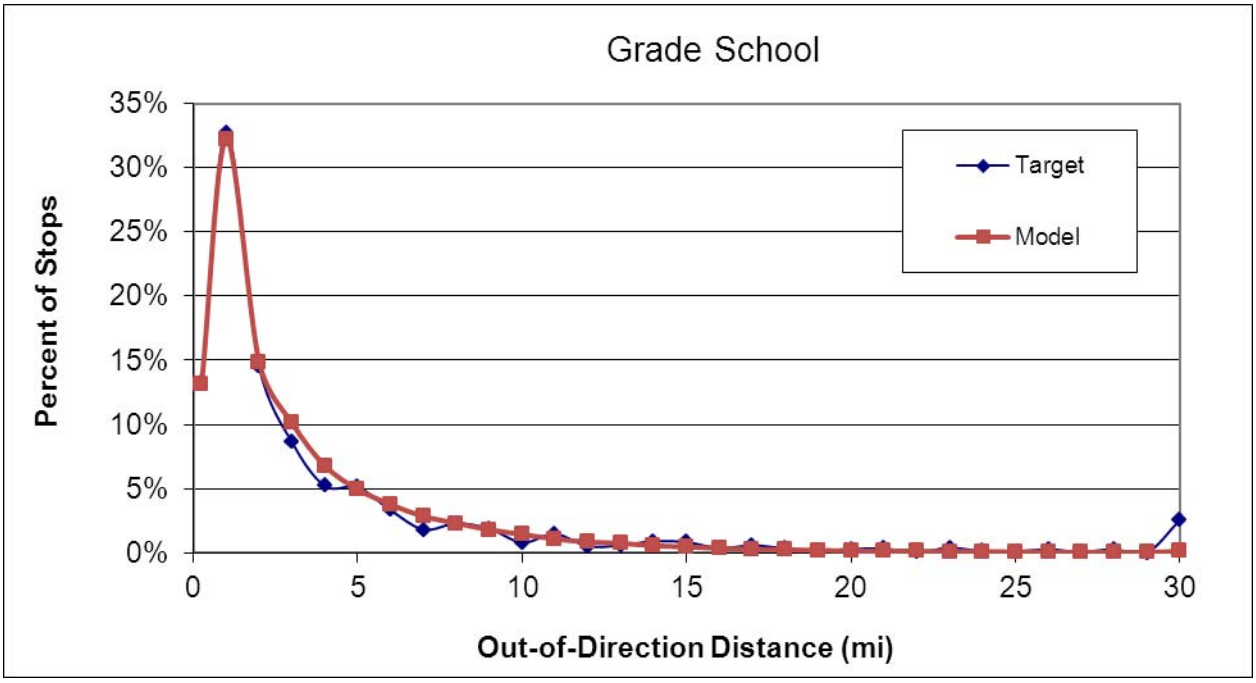
	Observed	Modeled	Diff.	% Diff
Avg. Dist (mi.):	4.30	4.16	-0.13	-3%



	Observed	Modeled	Diff.	% Diff
Avg. Dist (mi.):	3.94	4.15	0.22	6%

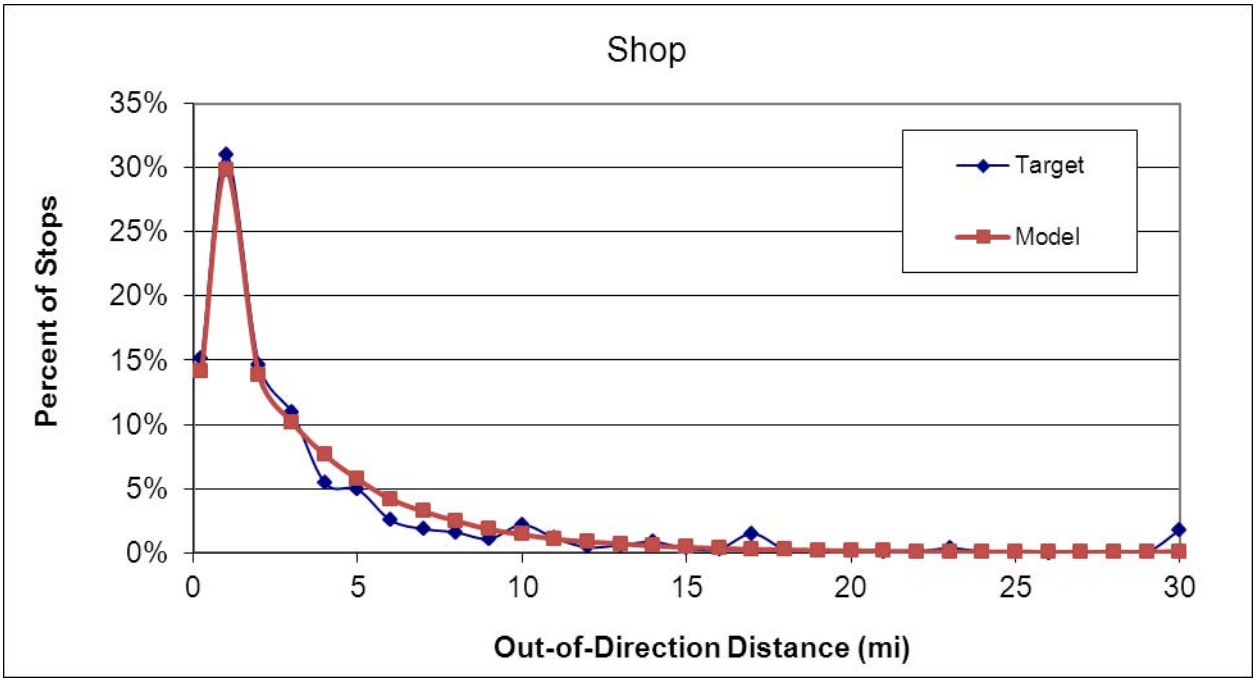


	Observed	Modeled	Diff.	% Diff
Avg. Dist (mi.):	3.55	3.51	-0.05	-1%

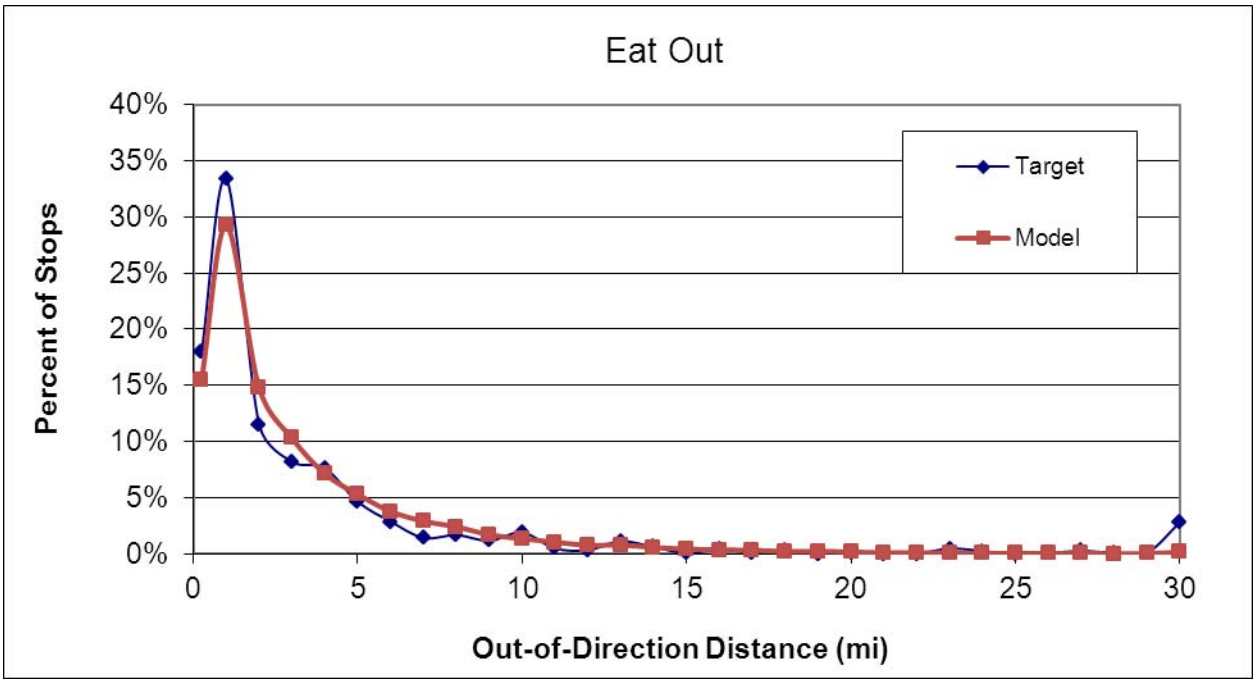


	Observed	Modeled	Diff.	% Diff
Avg. Dist (mi.):	4.18	3.22	-0.96	-23%

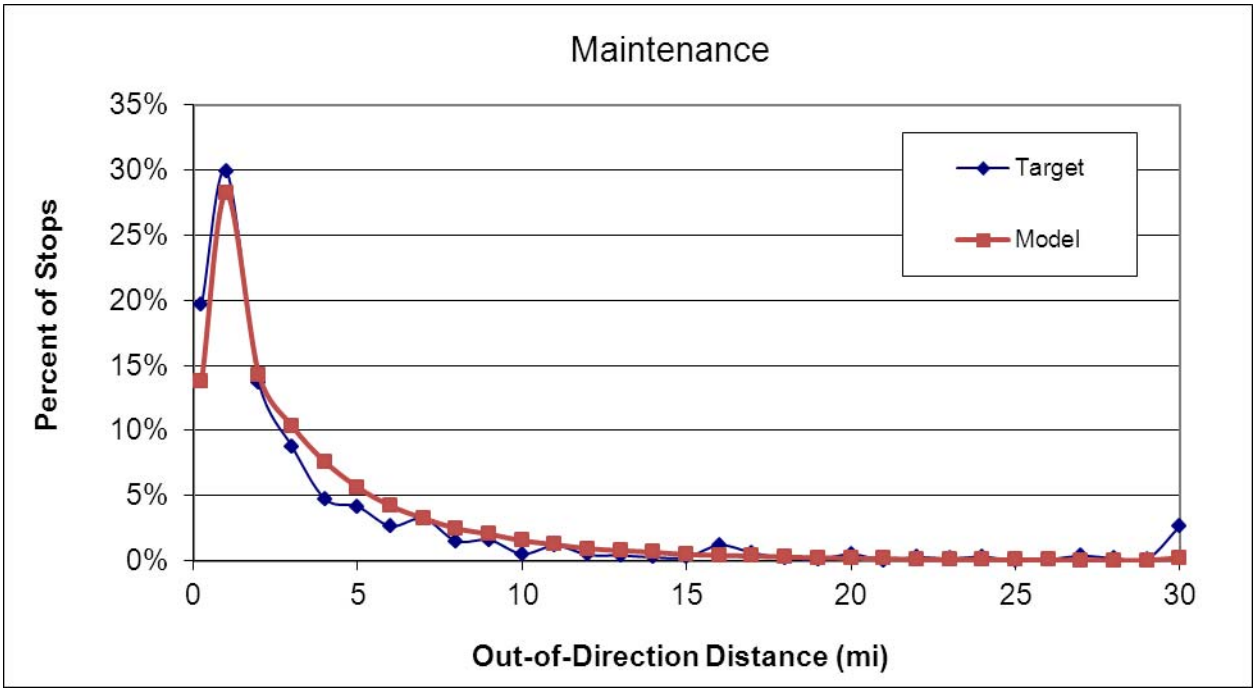
	Observed	Modeled	Diff.	% Diff
Avg. Dist (mi.):	3.89	3.33	-0.56	-14%



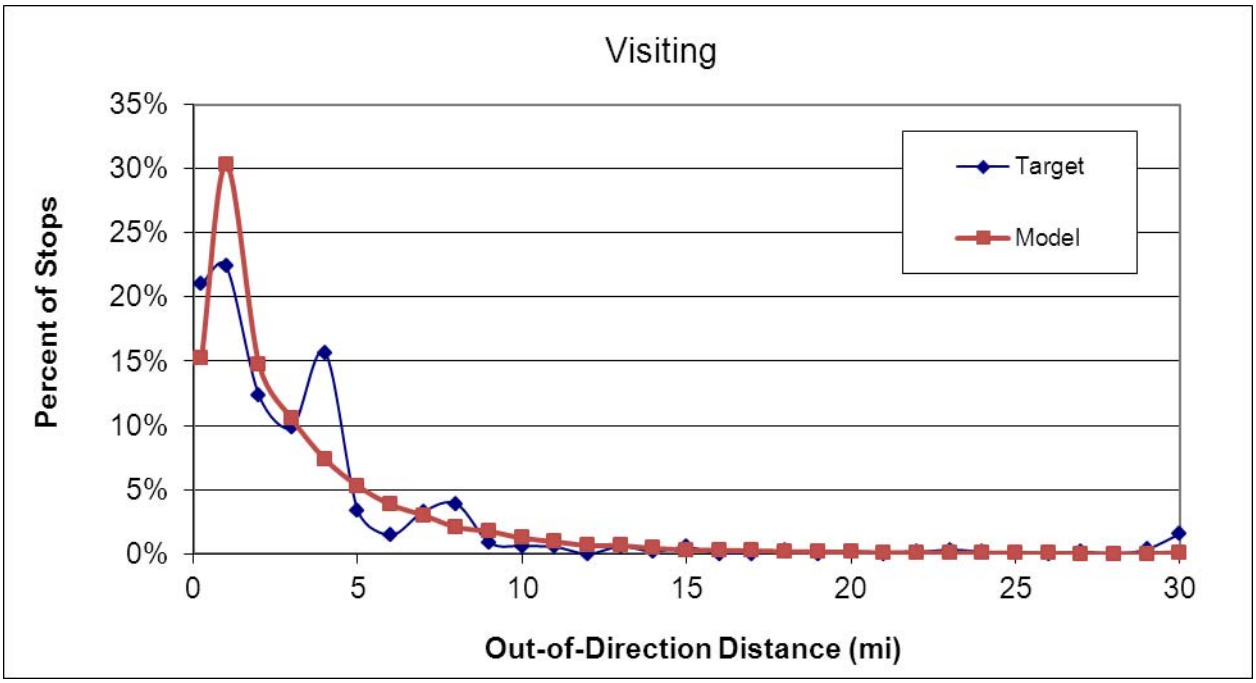
	Observed	Modeled	Diff.	% Diff
Avg. Dist (mi.):	3.77	3.32	-0.46	-12%



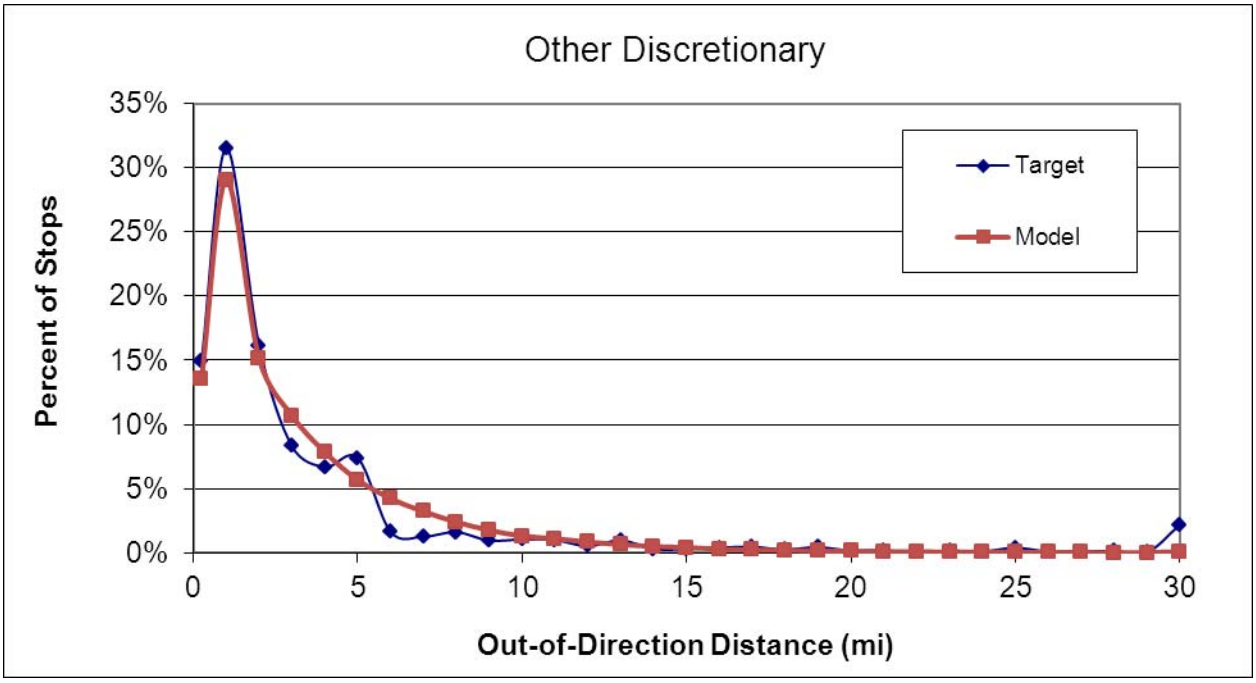
	Observed	Modeled	Diff.	% Diff
Avg. Dist (mi.):	3.75	3.28	-0.47	-12%



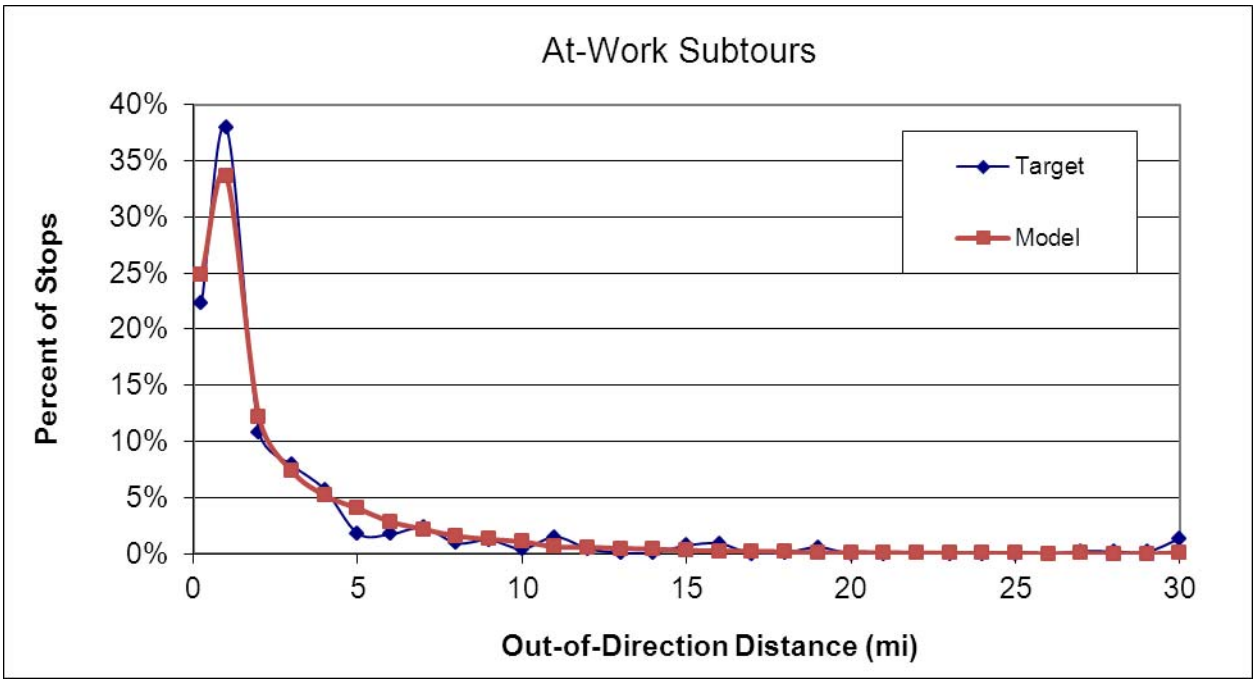
	Observed	Modeled	Diff.	% Diff
Avg. Dist (mi.):	3.97	3.53	-0.44	-11%



	Observed	Modeled	Diff.	% Diff
Avg. Dist (mi.):	3.51	3.01	-0.50	-14%

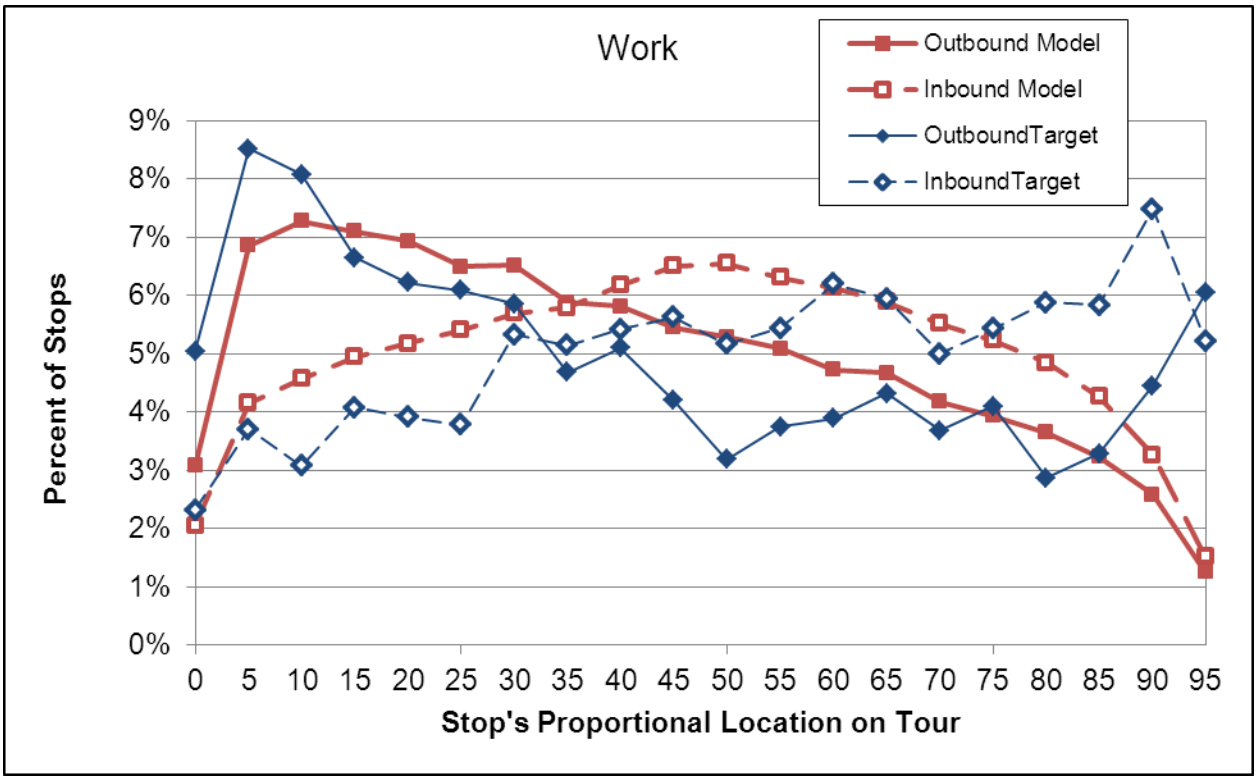


	Observed	Modeled	Diff.	% Diff
Avg. Dist (mi.):	3.76	3.26	-0.50	-13%



	Observed	Modeled	Diff.	% Diff
Avg. Dist (mi.):	2.96	2.62	-0.34	-11%

Figure 39: Frequency Distribution of Stops on Work Tours by the Proportional Proximity to Home



2.4.2 Trip Mode Choice

Number of Models:	Ten (one for each tour purpose)
Decision-Making Unit:	Trips
Model Form:	Nested logit
Alternatives:	18
Source:	Transferred from SFCTA (estimated using BATS 1990)

The trip mode choice model assigns a specific travel mode for each trip on a given tour. It operates similarly to the tour mode choice model, but only certain trip modes are available for each tour mode, as shown in Table 53. The correspondence rules are defined according to the following principles:

1) Pay trip modes are only available for pay tour modes (for example, drive-alone pay is only available at the trip mode level if drive-alone pay is selected as a tour mode).

2) The auto occupancy of the tour mode is determined by the maximum occupancy across all auto trips that make up the tour. Therefore, the auto occupancy for the tour mode is the maximum auto occupancy for any trip on the tour.

3) Transit tours can include auto shared-ride trips for particular legs. Therefore, 'casual carpool', wherein travelers share a ride to work and take transit back to the tour origin, is explicitly allowed in the tour/trip mode choice model structure.

4) The walk mode is allowed for any trip.

5) All transit line-haul submodes are allowed on transit tours. Free shared-ride modes are also available in walk-transit tours, albeit with a low probability. Paid shared-ride modes are not allowed on transit tours because no data is available on the sensitivity of transit riders to automobile value tolls (no value toll facilities existed in the Bay Area in 2000 or 2005), and no observed data is available to verify the number of people shifting into paid shared-ride trips on transit tours.

The trip mode choice utility function parameters appear in Table 54. The variables in the trip mode choice model are similar to those in the tour mode choice model. For definitions of specific variables, refer to section 2.3.1.

In most cases, the equivalent in-vehicle times for the coefficients in trip mode choice are consistent with the equivalent in-vehicle times for the coefficients in tour mode choice. For coefficients of dummy variables which apply in trip mode choice to multiple legs on a tour but apply only once in tour mode choice, the equivalent in-vehicle time in trip mode choice is half of the equivalent minutes of in-vehicle time in tour mode choice.

Calibration of the trip mode choice model focused on matching the observed distribution of trip modes for each tour mode. Achieving this required adjustment of alternative-specific constants for each trip mode, segmented by tour mode, except for the transit line-haul constants, which we kept consistent between Walk-Transit and Drive-Transit tour modes for individual tours. The alternative-specific constants for non-transit modes were allowed to differ from their equivalent

values in tour mode choice, but the transit line-haul constants were constrained to be consistent with those in tour mode choice for individual tours, as shown in the section on tour mode choice in Table 47.

Table 53: Trip Mode Availability by Tour Mode

	Trip Mode												
Tour Mode	Drive Alone (Free)	Drive Alone (Pay)	Shared Ride 2 (Free)	Shared Ride 2 (Pay)	Shared Ride 3+ (Free)	Shared Ride 3+ (Pay)	Walk	Bike	Local	Express	LRT/Ferry	Heavy	Commuter
Drive Alone (Free)	X						X						
Drive Alone (Pay)	X	X					X						
Shared Ride 2 (Free)	X		X				X						
Shared Ride 2 (Pay)	X	X	X	X			X						
Shared Ride 3+ (Free)	X		X		X		X						
Shared Ride 3+ (Pay)	X	X	X	X	X	X	X						
Walk							X						
Bike							X	X					
Walk-Transit			X		X		X		X	X	X	X	X
Drive-Transit									X	X	X	X	X

Table 54: Trip Mode Choice Utility Function Parameters

	Tour Purpose									
Variable	**Work**	**College**	**School**	**Escort**	**Shop**	**Eat Out**	**Maint.**	**Social**	**Discr.**	**At-Work**
In-vehicle time										
Auto & local bus	-0.022	-0.027	-0.027	-0.028	-0.028	-0.028	-0.028	-0.028	-0.028	-0.028
Light rail	-0.020	-0.024	-0.024	-0.025	-0.025	-0.025	-0.025	-0.025	-0.025	-0.025
Ferry	-0.018	-0.022	-0.022	-0.022	-0.022	-0.022	-0.022	-0.022	-0.022	-0.022
Express bus	-0.018	-0.018	-0.018	-0.018	-0.018	-0.018	-0.018	-0.018	-0.018	-0.018
Heavy & commuter rail	-0.018	-0.022	-0.022	-0.022	-0.022	-0.022	-0.022	-0.022	-0.022	-0.022
Other travel times										
Initial wait time up to 10 minutes	-0.044	-0.054	-0.054	-0.056	-0.056	-0.056	-0.056	-0.056	-0.056	-0.056
Initial wait after 10 minutes	**-0.022**	**-0.027**	**-0.027**	**-0.028**	**-0.028**	**-0.028**	**-0.028**	**-0.028**	**-0.028**	**-0.028**
Drive access/egress time	-0.044	-0.054	-0.054	-0.056	-0.056	-0.056	-0.056	-0.056	-0.056	-0.056
Transfer wait time	-0.044	-0.054	-0.054	-0.056	-0.056	-0.056	-0.056	-0.056	-0.056	-0.056
Origin is within short walk to transit, walk-transit	-0.293	-0.362	-0.362	-0.372	-0.372	-0.372	-0.372	-0.372	-0.372	-0.372
Origin is within long walk to transit, walk-transit	-0.880	-1.085	-1.085	-1.117	-1.117	-1.117	-1.117	-1.117	-1.117	-1.117
Destination is within short walk to transit, transit	-0.293	-0.362	-0.362	-0.372	-0.372	-0.372	-0.372	-0.372	-0.372	-0.372
Destination is within long walk to transit, transit	-0.880	-1.085	-1.085	-1.117	-1.117	-1.117	-1.117	-1.117	-1.117	-1.117
Number of transfers										
Walk-transit	**-0.110**	**-0.136**	**-0.136**	**-0.140**	**-0.140**	**-0.140**	**-0.140**	**-0.140**	**-0.140**	**-0.140**
Drive-transit	**-0.330**	**-0.407**	**-0.407**	**-0.419**	**-0.419**	**-0.419**	**-0.419**	**-0.419**	**-0.419**	**-0.419**
Non-motorized impedance										
Distance (mi) up to 1.5 mi., walk	-0.880	-1.084	-1.084	-1.116	-1.116	-1.116	-1.116	-1.116	-1.116	-1.116
Distance (mi) above 1.5 mi., walk	-4.400	-5.420	-5.420	-5.580	-5.580	-5.580	-5.580	-5.580	-5.580	-5.580
Distance (mi) up to 6 mi., bike	-0.440	-0.542	-0.542	-0.558	-0.558	-0.558	-0.558	-0.558	-0.558	-0.558
Distance (mi) above 6 mi., bike	-2.200	-2.710	-2.710	-2.790	-2.790	-2.790	-2.790	-2.790	-2.790	-2.790
Cost										
Derived from person's value of time	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
Zonal topography index at destination										
Walk	-0.330	-0.407	-0.407	-0.419	-0.419	-0.419	-0.419	-0.419	-0.419	-0.419
Bike	-0.440	-0.542	-0.542	-0.558	-0.558	-0.558	-0.558	-0.558	-0.558	-0.558

	Tour Purpose									
Variable	**Work**	**College**	**School**	**Escort**	**Shop**	**Eat Out**	**Maint.**	**Social**	**Discr.**	**At-Work**
Transit	-0.048	-0.060	-0.060	-0.061	-0.061	-0.061	-0.061	-0.061	-0.061	-0.061
Zonal density index										
At destination--walk, bike, transit	**0.004**	**0.005**	**0.005**	**0.006**	**0.006**	**0.006**	**0.006**	**0.006**	**0.006**	**0.006**
At origin (max. 150)--walk, bike, walk-transit	**0.013**	**0.016**	**0.016**	**0.017**	**0.017**	**0.017**	**0.017**	**0.017**	**0.017**	**0.017**
Demographic variables										
Household size 1, Shared Ride	-0.735	-0.735	-0.735	-0.735	-0.735	-0.735	-0.735	-0.735	-0.735	-0.735
Individual tour constants, Drive Alone tour mode										
Walk	-0.932	-1.428	-55.824	-	-1.617	-1.883	-1.394	-1.999	-1.664	-2.121
Individual tour constants, Shared Ride 2 tour mode										
Shared Ride 2	**0.022**	**0.499**	**-1.180**	**0.410**	**1.341**	**1.069**	**1.003**	**0.696**	**0.921**	**2.868**
Walk	**-0.028**	**-0.028**	**-0.028**	**-0.028**	**-0.028**	**-0.028**	**-0.028**	**-0.028**	**-0.028**	**-0.028**
Individual tour constants, Shared Ride 3+ tour mode										
Shared Ride 2	**-1.207**	**-0.280**	**-2.289**	**-0.308**	**-0.130**	**-0.272**	**-0.295**	**-0.113**	**-0.565**	**1.932**
Shared Ride 3+	**-0.154**	**0.702**	**-1.242**	**0.707**	**1.313**	**1.377**	**0.997**	**0.919**	**0.815**	**2.861**
Walk	**0.879**	**2.647**	**-0.409**	**-0.474**	**-0.264**	**0.468**	**0.311**	**0.272**	**-0.106**	**2.712**
Individual tour constants, Bike tour mode										
Walk	**-1.842**	**-0.468**	**-2.104**	**-13.520**	**-1.221**	**-2.593**	**-0.600**	**-13.238**	**-1.628**	**-1.842**
Individual tour constants, Transit tour modes										
Light rail	**0.624**	**0.799**	**0.799**	**0.303**	**0.303**	**0.303**	**0.303**	**0.303**	**0.303**	**0.303**
Ferry	**1.320**	**1.626**	**1.626**	**1.674**	**1.674**	**1.674**	**1.674**	**1.674**	**1.674**	**1.674**
Express Bus	**-0.088**	**-0.108**	**-0.108**	**-0.112**	**-0.112**	**-0.112**	**-0.112**	**-0.112**	**-0.112**	**-0.112**
Heavy Rail	**0.568**	**0.646**	**0.646**	**0.281**	**0.281**	**0.281**	**0.281**	**0.281**	**0.281**	**0.281**
Commuter Rail	**0.540**	**0.541**	**0.541**	**0.269**	**0.269**	**0.269**	**0.269**	**0.269**	**0.269**	**0.269**
Shared Ride 2	**-8.705**	**-13.395**	**-7.160**	**-4.365**	**-14.643**	**-4.859**	**-19.315**	**-11.309**	**-4.989**	**-22.659**
Shared Ride 3+	**-9.204**	**-14.420**	**-6.214**	**-3.267**	**-15.068**	**-4.084**	**-29.386**	**-21.631**	**-3.928**	**-18.928**
Walk	**-1.195**	**-4.917**	**-2.725**	**-1.489**	**-2.420**	**0.360**	**-0.538**	**-4.335**	**-2.247**	**-0.503**

Table 55: Distribution of Trip Modes by Tour Mode and Purpose

Work

Number of Trips - Target

	Trip Mode											
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**	*Unscaled Total:*
Drive Alone	4,309,466	-	-	55,764	-	-	-	-	-	-	4,365,230	*3,868,074*
Shared Ride 2	566,721	603,313	-	24,448	-	-	-	-	-	-	1,194,482	*1,351,729*
Shared Ride 3+	342,006	69,351	297,547	16,509	-	-	-	-	-	-	725,413	*966,444*
Walk	-	-	-	163,916	-	-	-	-	-	-	163,916	*147,510*
Bike	-	-	-	1,983	101,294	-	-	-	-	-	103,277	*89,357*
Walk-Transit	-	28,089	15,326	101,796	-	277,981	89,761	16,429	112,038	12,733	654,154	*669,521*
Drive-Transit	-	-	-	-	-	35,888	27,772	7,825	151,122	17,883	240,490	*241,356*
Total	5,218,193	700,754	312,873	364,417	101,294	313,869	117,533	24,254	263,160	30,616	7,446,962	*7,333,991*

Number of Trips - Model

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Drive Alone	4,309,896	-	-	55,334	-	-	-	-	-	-	4,365,230
Shared Ride 2	569,587	600,150	-	24,745	-	-	-	-	-	-	1,194,482
Shared Ride 3+	346,356	68,456	293,480	17,121	-	-	-	-	-	-	725,413
Walk	-	-	-	163,916	-	-	-	-	-	-	163,916
Bike	-	-	-	2,010	101,267	-	-	-	-	-	103,277
Walk-Transit	-	21,460	11,916	108,101	-	272,281	97,973	22,777	111,284	8,362	654,154
Drive-Transit	-	-	-	-	-	25,069	28,157	17,327	148,181	21,756	240,490
Total	5,225,839	690,066	305,396	371,227	101,267	297,350	126,130	40,104	259,465	30,118	7,446,962

Difference (Model - Target)

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Drive Alone	430	-	-	-430	-	-	-	-	-	-	-
Shared Ride 2	2,866	-3,163	-	297	-	-	-	-	-	-	-
Shared Ride 3+	4,350	-895	-4,067	612	-	-	-	-	-	-	-
Walk	-	-	-	-	-	-	-	-	-	-	-
Bike	-	-	-	27	-27	-	-	-	-	-	-
Walk-Transit	-	-6,629	-3,410	6,305	-	-5,700	8,212	6,348	-754	-4,371	-
Drive-Transit	-	-	-	-	-	-10,819	385	9,502	-2,941	3,873	-
Total	7,646	-10,688	-7,477	6,810	-27	-16,519	8,597	15,850	-3,695	-498	-

College

Number of Trips - Target

	Trip Mode											Unscaled
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**	*Total:*
Drive Alone	167,102	-	-	1,401	-	-	-	-	-	-	168,503	*249,338*
Shared Ride 2	28,864	53,072	-	3,120	-	-	-	-	-	-	85,056	*149,362*
Shared Ride 3+	19,436	11,738	43,640	3,256	-	-	-	-	-	-	78,070	*160,273*
Walk	-	-	-	46,364	-	-	-	-	-	-	46,364	*57,427*
Bike	-	-	-	740	6,533	-	-	-	-	-	7,273	*9,928*
Walk-Transit	-	7,393	1,902	8,934	-	69,251	12,159	2,096	9,482	1,188	112,405	*111,191*
Drive-Transit	-	-	-	-	-	502	1,884	-	11,469	1,027	14,882	*15,000*
Total	215,402	72,203	45,542	63,815	6,533	69,752	14,043	2,096	20,951	2,216	512,553	*752,520*

Number of Trips - Model

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Drive Alone	167,163	-	-	1,340	-	-	-	-	-	-	168,503
Shared Ride 2	28,663	53,054	-	3,339	-	-	-	-	-	-	85,056
Shared Ride 3+	19,231	11,668	43,572	3,599	-	-	-	-	-	-	78,070
Walk	-	-	-	46,364	-	-	-	-	-	-	46,364
Bike	-	-	-	663	6,610	-	-	-	-	-	7,273
Walk-Transit	-	10,783	2,807	12,537	-	67,905	10,040	915	7,172	246	112,405
Drive-Transit	-	-	-	-	-	2,815	3,751	767	6,979	570	14,882
Total	215,057	75,505	46,379	67,842	6,610	70,720	13,791	1,682	14,151	816	512,553

Difference (Model - Target)

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Drive Alone	61	-	-	-61	-	-	-	-	-	-	-
Shared Ride 2	-201	-18	-	219	-	-	-	-	-	-	-
Shared Ride 3+	-205	-70	-68	343	-	-	-	-	-	-	-
Walk	-	-	-	-	-	-	-	-	-	-	-
Bike	-	-	-	-77	77	-	-	-	-	-	-
Walk-Transit	-	3,390	905	3,603	-	-1,346	-2,119	-1,181	-2,310	-942	-
Drive-Transit	-	-	-	-	-	2,313	1,867	767	-4,490	-457	-
Total	-345	3,302	837	4,027	77	968	-252	-414	-6,800	-1,400	-

School

Number of Trips - Target

	Trip Mode											*Unscaled*
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**	*Total:*
Drive Alone	95,687	-	-	979	-	-	-	-	-	-	96,666	*83,807*
Shared Ride 2	18,104	513,688	-	40,347	-	-	-	-	-	-	572,139	*440,354*
Shared Ride 3+	117,703	223,251	886,023	81,595	-	-	-	-	-	-	1,308,572	*1,185,481*
Walk	-	-	-	296,873	-	-	-	-	-	-	296,873	*247,709*
Bike	-	-	-	632	33,325	-	-	-	-	-	33,957	*27,411*
Walk-Transit	-	8,515	14,539	16,426	-	153,867	19,520	4,421	4,939	-	222,227	*217,362*
Drive-Transit	-	-	-	-	-	1,247	1,577	135	4,021	-	6,980	*5,718*
Total	231,495	745,454	900,562	436,852	33,325	155,114	21,096	4,556	8,960	-	2,537,414	*2,207,841*

Number of Trips - Model

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Drive Alone	96,666	-	-	-	-	-	-	-	-	-	96,666
Shared Ride 2	61,550	449,700	-	60,889	-	-	-	-	-	-	572,139
Shared Ride 3+	135,964	220,782	858,847	92,979	-	-	-	-	-	-	1,308,572
Walk	-	-	-	296,873	-	-	-	-	-	-	296,873
Bike	-	-	-	714	33,243	-	-	-	-	-	33,957
Walk-Transit	-	8,520	13,712	18,415	-	150,992	13,958	2,831	12,887	912	222,227
Drive-Transit	-	-	-	-	-	2,315	470	444	3,192	559	6,980
Total	294,180	679,002	872,559	469,870	33,243	153,307	14,428	3,275	16,079	1,471	2,537,414

Difference (Model - Target)

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Drive Alone	979	-	-	-979	-	-	-	-	-	-	-
Shared Ride 2	43,446	-63,988	-	20,542	-	-	-	-	-	-	-
Shared Ride 3+	18,261	-2,469	-27,176	11,384	-	-	-	-	-	-	-
Walk	-	-	-	-	-	-	-	-	-	-	-
Bike	-	-	-	82	-82	-	-	-	-	-	-
Walk-Transit	-	5	-827	1,989	-	-2,875	-5,562	-1,590	7,948	912	-
Drive-Transit	-	-	-	-	-	1,068	-1,107	309	-829	559	-
Total	62,685	-66,452	-28,003	33,018	-82	-1,807	-6,668	-1,281	7,119	1,471	-

Escort

Number of Trips - Target

	Trip Mode											*Unscaled*
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**	*Total:*
Drive Alone	-	-	-	-	-	-	-	-	-	-	-	*173,586*
Shared Ride 2	342,877	692,193	-	4,875	-	-	-	-	-	-	1,039,945	*569,873*
Shared Ride 3+	206,999	150,132	609,286	8,704	-	-	-	-	-	-	975,121	*834,994*
Walk	-	-	-	89,271	-	-	-	-	-	-	89,271	*75,570*
Bike	-	-	-	-	5,224	-	-	-	-	-	5,224	*5,889*
Walk-Transit	-	396	173	232	-	1,945	450	41	-	71	3,309	*10,875*
Drive-Transit	-	-	-	-	-	42	-	-	1,826	206	2,074	*3,279*
Total	549,877	842,721	609,460	103,081	5,224	1,987	450	41	1,826	277	2,114,944	*1,674,066*

Number of Trips - Model

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Drive Alone	-	-	-	-	-	-	-	-	-	-	-
Shared Ride 2	343,778	688,572	-	7,595	-	-	-	-	-	-	1,039,945
Shared Ride 3+	207,911	149,686	603,582	13,942	-	-	-	-	-	-	975,121
Walk	-	-	-	89,271	-	-	-	-	-	-	89,271
Bike	-	-	-	-	5,224	-	-	-	-	-	5,224
Walk-Transit	-	311	165	296	-	2,066	233	29	204	5	3,309
Drive-Transit	-	-	-	-	-	1,466	85	44	401	78	2,074
Total	551,689	838,569	603,747	111,104	5,224	3,532	318	73	605	83	2,114,944

Difference (Model - Target)

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Drive Alone	-	-	-	-	-	-	-	-	-	-	-
Shared Ride 2	901	-3,621	-	2,720	-	-	-	-	-	-	-
Shared Ride 3+	912	-446	-5,704	5,238	-	-	-	-	-	-	-
Walk	-	-	-	-	-	-	-	-	-	-	-
Bike	-	-	-	-	-	-	-	-	-	-	-
Walk-Transit	-	-85	-8	64	-	121	-217	-12	204	-66	-
Drive-Transit	-	-	-	-	-	1,424	85	44	-1,425	-128	-
Total	1,812	-4,152	-5,713	8,023	-	1,545	-132	32	-1,221	-194	-

Shopping

Number of Trips - Target

	Trip Mode											Unscaled
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**	*Total:*
Drive Alone	1,636,410	-	-	23,114	-	-	-	-	-	-	1,659,524	*768,303*
Shared Ride 2	57,463	406,702	-	7,412	-	-	-	-	-	-	471,577	*530,047*
Shared Ride 3+	41,118	37,219	271,922	3,654	-	-	-	-	-	-	353,913	*431,618*
Walk	-	-	-	207,880	-	-	-	-	-	-	207,880	*153,020*
Bike	-	-	-	1,739	28,487	-	-	-	-	-	30,226	*24,589*
Walk-Transit	-	1,626	1,017	11,889	-	39,393	5,418	6,262	4,688	33	70,325	*108,976*
Drive-Transit	-	-	-	-	-	731	473	-	1,701	288	3,192	*4,818*
Total	1,734,992	445,547	272,938	255,688	28,487	40,124	5,890	6,262	6,389	321	2,796,637	*2,021,371*

Number of Trips - Model

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Drive Alone	1,634,635	-	-	24,889	-	-	-	-	-	-	1,659,524
Shared Ride 2	54,583	409,607	-	7,387	-	-	-	-	-	-	471,577
Shared Ride 3+	36,773	37,321	276,682	3,137	-	-	-	-	-	-	353,913
Walk	-	-	-	207,880	-	-	-	-	-	-	207,880
Bike	-	-	-	1,406	28,820	-	-	-	-	-	30,226
Walk-Transit	-	2,365	1,401	10,627	-	41,168	7,771	652	6,135	206	70,325
Drive-Transit	-	-	-	-	-	670	403	131	1,601	387	3,192
Total	1,725,991	449,293	278,083	255,326	28,820	41,838	8,174	783	7,736	593	2,796,637

Difference (Model - Target)

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Drive Alone	-1,775	-	-	1,775	-	-	-	-	-	-	-
Shared Ride 2	-2,880	2,905	-	-25	-	-	-	-	-	-	-
Shared Ride 3+	-4,345	102	4,760	-517	-	-	-	-	-	-	-
Walk	-	-	-	-	-	-	-	-	-	-	-
Bike	-	-	-	-333	333	-	-	-	-	-	-
Walk-Transit	-	739	384	-1,262	-	1,775	2,353	-5,610	1,447	173	-
Drive-Transit	-	-	-	-	-	-61	-70	131	-100	99	-
Total	-9,001	3,746	5,145	-362	333	1,714	2,284	-5,479	1,347	272	-

Eat Out

Number of Trips - Target

	Trip Mode											
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**	*Unscaled Total:*
Drive Alone	296,192	-	-	3,455	-	-	-	-	-	-	299,647	*183,540*
Shared Ride 2	32,116	180,232	-	4,203	-	-	-	-	-	-	216,551	*220,289*
Shared Ride 3+	20,971	17,273	170,849	2,534	-	-	-	-	-	-	211,627	*229,861*
Walk	-	-	-	112,240	-	-	-	-	-	-	112,240	*107,557*
Bike	-	-	-	68	9,866	-	-	-	-	-	9,934	*9,136*
Walk-Transit	-	1,263	461	4,772	-	8,198	4,717	452	2,487	65	22,416	*30,796*
Drive-Transit	-	-	-	-	-	429	434	-	1,715	547	3,124	*4,799*
Total	349,279	198,768	171,311	127,272	9,866	8,627	5,151	452	4,201	612	875,539	*785,979*

Number of Trips - Model

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Drive Alone	296,248	-	-	3,399	-	-	-	-	-	-	299,647
Shared Ride 2	32,305	179,467	-	4,779	-	-	-	-	-	-	216,551
Shared Ride 3+	20,266	17,489	171,447	2,425	-	-	-	-	-	-	211,627
Walk	-	-	-	112,240	-	-	-	-	-	-	112,240
Bike	-	-	-	86	9,848	-	-	-	-	-	9,934
Walk-Transit	-	913	276	4,554	-	10,709	2,849	240	2,755	120	22,416
Drive-Transit	-	-	-	-	-	504	333	138	1,823	326	3,124
Total	348,819	197,869	171,723	127,483	9,848	11,213	3,182	378	4,578	446	875,539

Difference (Model - Target)

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Drive Alone	56	-	-	-56	-	-	-	-	-	-	-
Shared Ride 2	189	-765	-	576	-	-	-	-	-	-	-
Shared Ride 3+	-705	216	598	-109	-	-	-	-	-	-	-
Walk	-	-	-	-	-	-	-	-	-	-	-
Bike	-	-	-	18	-18	-	-	-	-	-	-
Walk-Transit	-	-350	-185	-218	-	2,511	-1,868	-212	268	55	-
Drive-Transit	-	-	-	-	-	75	-101	138	108	-221	-
Total	-460	-899	412	211	-18	2,586	-1,969	-74	377	-166	-

Other Maintenance

Number of Trips - Target

	Trip Mode											*Unscaled*
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**	*Total:*
Drive Alone	868,590	-	-	13,941	-	-	-	-	-	-	882,531	*448,538*
Shared Ride 2	52,846	229,102	-	4,031	-	-	-	-	-	-	285,979	*266,641*
Shared Ride 3+	26,294	18,407	107,823	3,134	-	-	-	-	-	-	155,658	*190,922*
Walk	-	-	-	86,708	-	-	-	-	-	-	86,708	*54,627*
Bike	-	-	-	2,061	14,867	-	-	-	-	-	16,928	*10,423*
Walk-Transit	-	599	-	12,144	-	27,043	1,866	1,318	5,239	27	48,236	*68,076*
Drive-Transit	-	-	-	-	-	93	140	-	1,780	149	2,162	*3,217*
Total	947,729	248,108	107,823	122,020	14,867	27,136	2,006	1,318	7,019	176	1,478,202	*1,042,444*

Number of Trips - Model

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Drive Alone	867,070	-	-	15,461	-	-	-	-	-	-	882,531
Shared Ride 2	47,391	234,472	-	4,116	-	-	-	-	-	-	285,979
Shared Ride 3+	24,312	18,439	110,436	2,471	-	-	-	-	-	-	155,658
Walk	-	-	-	86,708	-	-	-	-	-	-	86,708
Bike	-	-	-	2,034	14,894	-	-	-	-	-	16,928
Walk-Transit	-	1,138	-	11,298	-	25,873	4,591	582	4,545	209	48,236
Drive-Transit	-	-	-	-	-	495	195	83	1,157	232	2,162
Total	938,773	254,049	110,436	122,088	14,894	26,368	4,786	665	5,702	441	1,478,202

Difference (Model - Target)

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Drive Alone	-1,520	-	-	1,520	-	-	-	-	-	-	-
Shared Ride 2	-5,455	5,370	-	85	-	-	-	-	-	-	-
Shared Ride 3+	-1,982	32	2,613	-663	-	-	-	-	-	-	-
Walk	-	-	-	-	-	-	-	-	-	-	-
Bike	-	-	-	-27	27	-	-	-	-	-	-
Walk-Transit	-	539	-	-846	-	-1,170	2,725	-736	-694	182	-
Drive-Transit	-	-	-	-	-	402	55	83	-623	83	-
Total	-8,956	5,941	2,613	68	27	-768	2,780	-653	-1,317	265	-

Social

Number of Trips - Target

	Trip Mode											*Unscaled*
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**	*Total:*
Drive Alone	235,034	-	-	2,405	-	-	-	-	-	-	237,439	*117,002*
Shared Ride 2	28,909	104,942	-	2,201	-	-	-	-	-	-	136,052	*128,597*
Shared Ride 3+	19,172	20,266	80,778	1,935	-	-	-	-	-	-	122,151	*131,748*
Walk	-	-	-	81,480	-	-	-	-	-	-	81,480	*49,926*
Bike	-	-	-	-	10,085	-	-	-	-	-	10,085	*8,686*
Walk-Transit	-	1,740	-	2,047	-	13,334	424	246	6,097	720	24,608	*26,572*
Drive-Transit	-	-	-	-	-	1,144	1,195	-	776	-	3,116	*4,782*
Total	283,116	126,947	80,778	90,067	10,085	14,478	1,619	246	6,873	720	614,931	*467,314*

Number of Trips - Model

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Drive Alone	234,691	-	-	2,748	-	-	-	-	-	-	237,439
Shared Ride 2	28,167	105,305	-	2,580	-	-	-	-	-	-	136,052
Shared Ride 3+	18,019	19,664	82,714	1,754	-	-	-	-	-	-	122,151
Walk	-	-	-	81,480	-	-	-	-	-	-	81,480
Bike	-	-	-	-	10,085	-	-	-	-	-	10,085
Walk-Transit	-	1,612	-	1,958	-	15,629	2,511	303	2,508	87	24,608
Drive-Transit	-	-	-	-	-	443	372	159	1,817	325	3,116
Total	280,877	126,581	82,714	90,520	10,085	16,072	2,883	462	4,325	412	614,931

Difference (Model - Target)

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Drive Alone	-343	-	-	343	-	-	-	-	-	-	-
Shared Ride 2	-742	363	-	379	-	-	-	-	-	-	-
Shared Ride 3+	-1,153	-602	1,936	-181	-	-	-	-	-	-	-
Walk	-	-	-	-	-	-	-	-	-	-	-
Bike	-	-	-	-	-	-	-	-	-	-	-
Walk-Transit	-	-128	-	-89	-	2,295	2,087	57	-3,589	-633	-
Drive-Transit	-	-	-	-	-	-701	-823	159	1,041	325	-
Total	-2,239	-366	1,936	453	-	1,594	1,264	216	-2,548	-308	-

Other Discretionary

Number of Trips - Target

	Trip Mode											*Unscaled*
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**	*Total:*
Drive Alone	838,754	-	-	11,833	-	-	-	-	-	-	850,587	*469,889*
Shared Ride 2	68,985	369,722	-	12,130	-	-	-	-	-	-	450,836	*420,525*
Shared Ride 3+	83,115	59,359	392,769	8,557	-	-	-	-	-	-	543,800	*566,860*
Walk	-	-	-	172,074	-	-	-	-	-	-	172,074	*123,562*
Bike	-	-	-	1,302	36,496	-	-	-	-	-	37,798	*33,117*
Walk-Transit	-	5,429	7,666	6,821	-	31,994	10,187	403	8,211	237	70,948	*79,507*
Drive-Transit	-	-	-	-	-	2,014	1,318	-	4,893	255	8,480	*12,327*
Total	990,853	434,510	400,435	212,717	36,496	34,008	11,505	403	13,104	492	2,134,523	*1,705,787*

Number of Trips - Model

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Drive Alone	837,810	-	-	12,777	-	-	-	-	-	-	850,587
Shared Ride 2	67,864	370,196	-	12,776	-	-	-	-	-	-	450,836
Shared Ride 3+	74,788	59,760	400,824	8,428	-	-	-	-	-	-	543,800
Walk	-	-	-	172,074	-	-	-	-	-	-	172,074
Bike	-	-	-	1,187	36,611	-	-	-	-	-	37,798
Walk-Transit	-	4,613	5,228	6,566	-	40,636	7,018	662	5,920	305	70,948
Drive-Transit	-	-	-	-	-	1,609	794	469	4,658	950	8,480
Total	980,462	434,569	406,052	213,808	36,611	42,245	7,812	1,131	10,578	1,255	2,134,523

Difference (Model - Target)

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Drive Alone	-944	-	-	944	-	-	-	-	-	-	-
Shared Ride 2	-1,121	474	-	646	-	-	-	-	-	-	-
Shared Ride 3+	-8,327	401	8,055	-129	-	-	-	-	-	-	-
Walk	-	-	-	-	-	-	-	-	-	-	-
Bike	-	-	-	-115	115	-	-	-	-	-	-
Walk-Transit	-	-816	-2,438	-255	-	8,642	-3,169	259	-2,291	68	-
Drive-Transit	-	-	-	-	-	-405	-524	469	-235	695	-
Total	-10,391	59	5,617	1,091	115	8,237	-3,693	728	-2,526	763	-

At-work

Number of Trips - Target

	Trip Mode											*Unscaled*
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**	*Total:*
Drive Alone	718,969	-	-	8,929	-	-	-	-	-	-	727,898	*381,135*
Shared Ride 2	35,594	239,762	-	5,425	-	-	-	-	-	-	280,781	*145,633*
Shared Ride 3+	18,319	5,003	184,084	490	-	-	-	-	-	-	207,897	*95,915*
Walk	-	-	-	465,335	-	-	-	-	-	-	465,335	*193,962*
Bike	-	-	-	-	11,052	-	-	-	-	-	11,052	*5,808*
Walk-Transit	-	-	101	2,719	-	4,861	1,648	-	3,800	-	13,129	*16,923*
Drive-Transit	-	-	-	-	-	-	-	-	-	-	-	*849*
Total	772,882	244,765	184,186	482,899	11,052	4,861	1,648	-	3,800	-	1,706,092	*840,225*

Number of Trips - Model

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Drive Alone	717,611	-	-	10,287	-	-	-	-	-	-	727,898
Shared Ride 2	-	271,478	-	9,303	-	-	-	-	-	-	280,781
Shared Ride 3+	-	44,916	158,892	4,089	-	-	-	-	-	-	207,897
Walk	-	-	-	465,335	-	-	-	-	-	-	465,335
Bike	-	-	-	414	10,638	-	-	-	-	-	11,052
Walk-Transit	-	1	245	2,961	-	6,977	1,603	160	1,117	65	13,129
Drive-Transit	-	-	-	-	-	-	-	-	-	-	-
Total	717,611	316,395	159,137	492,389	10,638	6,977	1,603	160	1,117	65	1,706,092

Difference (Model - Target)

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Drive Alone	-1,358	-	-	1,358	-	-	-	-	-	-	-
Shared Ride 2	-35,594	31,716	-	3,878	-	-	-	-	-	-	-
Shared Ride 3+	-18,319	39,913	-25,192	3,599	-	-	-	-	-	-	-
Walk	-	-	-	-	-	-	-	-	-	-	-
Bike	-	-	-	414	-414	-	-	-	-	-	-
Walk-Transit	-	1	144	242	-	2,116	-45	160	-2,683	65	-
Drive-Transit	-	-	-	-	-	-	-	-	-	-	-
Total	-55,271	71,630	-25,049	9,490	-414	2,116	-45	160	-2,683	65	-

All Individual Tours

Number of Trips - Target

	Trip Mode											
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**	*Unscaled Total:*
Drive Alone	9,166,202	-	-	121,823	-	-	-	-	-	-	9,288,025	*6,743,211*
Shared Ride 2	1,232,479	3,392,728	-	108,191	-	-	-	-	-	-	4,733,398	*4,223,049*
Shared Ride 3+	895,135	611,998	3,044,722	130,367	-	-	-	-	-	-	4,682,222	*4,794,117*
Walk	-	-	-	1,722,141	-	-	-	-	-	-	1,722,141	*1,210,871*
Bike	-	-	-	8,526	257,228	-	-	-	-	-	265,754	*224,344*
Walk-Transit	-	55,052	41,186	167,780	-	627,866	146,150	31,668	156,980	15,075	1,241,757	*1,339,800*
Drive-Transit	-	-	-	-	-	42,090	34,792	7,960	179,303	20,354	284,500	*296,145*
Total	11,293,817	4,059,778	3,085,908	2,258,828	257,228	669,956	180,942	39,628	336,284	35,429	22,217,797	*18,831,537*

Number of Trips - Model

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Drive Alone	9,161,790	-	-	126,235	-	-	-	-	-	-	9,288,025
Shared Ride 2	1,233,888	3,362,001	-	137,509	-	-	-	-	-	-	4,733,398
Shared Ride 3+	883,620	648,181	3,000,476	149,945	-	-	-	-	-	-	4,682,222
Walk	-	-	-	1,722,141	-	-	-	-	-	-	1,722,141
Bike	-	-	-	8,514	257,240	-	-	-	-	-	265,754
Walk-Transit	-	51,716	35,750	177,313	-	634,236	148,547	29,151	154,527	10,517	1,241,757
Drive-Transit	-	-	-	-	-	35,386	34,560	19,562	169,809	25,183	284,500
Total	11,279,298	4,061,898	3,036,226	2,321,657	257,240	669,622	183,107	48,713	324,336	35,700	22,217,797

Difference (Model - Target)

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Drive Alone	-4,412	-	-	4,412	-	-	-	-	-	-	-
Shared Ride 2	1,409	-30,727	-	29,318	-	-	-	-	-	-	-
Shared Ride 3+	-11,515	36,183	-44,246	19,578	-	-	-	-	-	-	-
Walk	-	-	-	-	-	-	-	-	-	-	-
Bike	-	-	-	-12	12	-	-	-	-	-	-
Walk-Transit	-	-3,336	-5,436	9,533	-	6,370	2,397	-2,517	-2,453	-4,558	-
Drive-Transit	-	-	-	-	-	-6,704	-232	11,602	-9,494	4,829	-
Total	-14,519	2,120	-49,682	62,829	12	-334	2,165	9,085	-11,948	271	-

All Joint Tours

Number of Trips - Target

	Trip Mode											
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**	*Unscaled Total:*
Auto	17,199	179,030	253,703	6,887	-	-	-	-	-	-	456,819	*420,287*
Walk	-	-	-	8,759	-	-	-	-	-	-	8,759	*27,361*
Bike	-	-	-	-	583	-	-	-	-	-	583	*3,102*
Walk-Transit	-	-	-	418	-	694	207	-	133	-	1,452	*8,419*
Drive-Transit	-	-	-	-	-	-	3	-	7	-	10	*266*
Total	17,199	179,030	253,703	16,064	583	694	209	-	140	-	467,623	*459,435*

Number of Trips - Model

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Auto	-	182,142	266,920	7,757	-	-	-	-	-	-	456,819
Walk	-	-	-	8,759	-	-	-	-	-	-	8,759
Bike	-	-	-	3	580	-	-	-	-	-	583
Walk-Transit	-	1	18	444	-	721	134	5	128	1	1,452
Drive-Transit	-	-	-	-	-	2	-	-	4	4	10
Total	-	182,143	266,938	16,963	580	723	134	5	132	5	467,623

Difference (Model - Target)

	Trip Mode										
Tour Mode	DA	SR 2	SR 3+	Walk	Bike	Local	LRF	Express	Heavy	Commuter	**Total**
Auto	-17,199	3,112	13,217	870	-	-	-	-	-	-	-
Walk	-	-	-	-	-	-	-	-	-	-	-
Bike	-	-	-	3	-3	-	-	-	-	-	-
Walk-Transit	-	1	18	26	-	27	-73	5	-5	1	-
Drive-Transit	-	-	-	-	-	2	-3	-	-3	4	-
Total	-17,199	3,113	13,235	899	-3	29	-75	5	-8	5	-

The tour mode choice and trip mode choice transfer penalty coefficients were also calibrated to match the average number of boardings per transit trip from the household travel survey. The distribution of trips by the number of boardings and access mode appears in Table 56.

Table 56: Number of Transit Trips by Tour Mode and Number of Boardings

Walk-Transit

Targets, Scaled to match Modeled Number of Trips by Mode

	Trip Mode					
Number of Boardings	Walk-Local	Walk-LRF	Walk-Express	Walk-BART	Walk-Commuter	Total
1	453,122	116,752	13,912	123,194	6,227	713,207
2	136,099	28,000	13,786	22,652	3,219	203,756
3	36,415	2,977	907	7,047	614	47,960
4+	7,898	731	-	1,105	243	9,976
Total	633,534	148,459	28,605	153,998	10,303	974,899
Boardings/Trip	1.37	1.24	1.55	1.26	1.51	1.34

Model Data

	Trip Mode					
Number of Boardings	Walk-Local	Walk-LRF	Walk-Express	Walk-BART	Walk-Commuter	Total
1	478,710	89,401	14,065	61,322	2,694	646,192
2	148,034	53,543	11,074	71,062	4,438	288,151
3	6,629	5,209	3,209	19,854	2,666	37,567
4+	161	306	257	1,760	521	3,005
Total	633,534	148,459	28,605	153,998	10,319	974,915
Boardings/Trip	1.26	1.44	1.64	1.76	2.11	1.38

Nominal Difference

	Trip Mode					
Number of Boardings	Walk-Local	Walk-LRF	Walk-Express	Walk-BART	Walk-Commuter	Total
1	25,588	-27,351	153	-61,872	-3,533	-67,015
2	11,935	25,543	-2,712	48,410	1,219	84,395
3	-29,786	2,232	2,302	12,807	2,052	-10,393
4+	-7,737	-425	257	655	278	-6,971
Total	-	-	-	-	16	16
Boardings/Trip	-0.11	0.19	0.09	0.49	0.60	0.04

Drive-Transit

Targets, Scaled to match Modeled Number of Trips by Mode

	Trip Mode					
Number of Boardings	Drive-Local	Drive-LRF	Drive-Express	Drive-BART	Drive-Commuter	Total
1	34,190	28,508	17,588	154,720	21,586	256,592
2	853	5,211	1,351	13,466	3,075	23,956
3	72	623	72	1,073	259	2,098
4+	-	-	-	-	-	-
Total	35,115	34,342	19,010	169,258	24,921	282,646
Boardings/Trip	1.03	1.19	1.08	1.09	1.14	1.10

Model Data

	Trip Mode					
Number of Boardings	Drive-Local	Drive-LRF	Drive-Express	Drive-BART	Drive-Commuter	Total
1	26,999	22,830	12,448	113,627	13,149	189,053
2	7,793	10,946	6,039	52,664	11,552	88,994
3	323	563	523	2,966	220	4,595
4+	-	3	-	1	-	4
Total	35,115	34,342	19,010	169,258	24,921	282,646
Boardings/Trip	1.24	1.35	1.37	1.35	1.48	1.35

Nominal Difference

	Trip Mode					
Number of Boardings	Drive-Local	Drive-LRF	Drive-Express	Drive-BART	Drive-Commuter	Total
1	-7,191	-5,678	-5,140	-41,093	-8,437	-67,539
2	6,940	5,735	4,688	39,198	8,477	65,038
3	251	-60	451	1,893	-39	2,497
4+	-	3	-	1	-	4
Total	-	-	-	-	-	0
Boardings/Trip	0.21	0.16	0.29	0.25	0.34	0.25

3 Model Year 2000 Validation

This section presents the highway and transit assignment results for the year 2000, with comparisons to observed data from the Caltrans highway traffic count database and reported transit operator system boardings.

3.1 Highway Assignment

After the demand models have run, the trip lists output from the model are converted to trip matrices, segmented by mode and time period, combined with commercial and internal-external trips, and assigned to the five period-specific highway networks. Each time period's assignment is a multi-class static user equilibrium assignment with ten user classes: Drive Alone (free), Drive Alone (pay), Shared Ride 2 (free), Shared Ride 2 (pay), Shared Ride 3+ (free), Shared Ride 3+ (pay), Small Trucks (free), Small Truck (pay), Large Trucks (free), and Large Trucks (pay). The links allowed to the different private vehicle classes are the same as in the skims, as shown in Section 1. Non-toll paying trucks are not permitted on HOV or toll facilities. Toll-paying trucks are allowed on selected toll facilities. All large trucks are excluded from additional selected non-commercial facilities. The solution to the traffic assignment problem is found using the Frank-Wolfe algorithm. The convergence criterion is a relative gap of 0.0005.

The highway assignment was validated against the Caltrans State Highway Traffic Count Database. The match between the modeled highway volumes and the observed traffic counts is detailed by Area Type and Facility Type in Table 57. The daily traffic volume on all matched facilities is within 3 percent of the observed value. The percent deviations by facility type, +2 percent for freeways, +9 percent for collectors, and -6 percent for arterials, are all within FHWA guidelines from the TMIP *Model Validation and Reasonableness Checking Manual*.

In an earlier version of the calibration, the highway volumes by time of day did not match the observations closely. Particularly problematic were the Midday volumes, which were 20% low on average. In previous model development for SFCTA, it was found that very small truck volumes, which peak during Midday, are underestimated in the MTC commercial vehicle models. The underestimation was attributed to excessive decay in the gravity model impedance function for the very small truck trip distribution model. Since the very small truck trips were very short, they did not get assigned to the higher-volume links on which the highway validation is based. Therefore, we imported that trip distribution impedance function into *Travel Model One*, decreased the number of very small truck trips by 40%, and adjusted the diurnal distribution of truck trips to increase the share of midday very small truck trips from 37% to 52%. This adjustment balanced the match between the highway volumes and traffic counts during the different time periods.

Daily percent root mean squared errors (%RMSE) are 29 percent overall, 21 percent on freeways, 68 percent on expressways, 132 percent on collectors, and 67 percent on arterials. Since the traffic counts are only on state highways, the number of counts on freeways and arterials greatly exceeds the number on collectors. Therefore, caution should be exercised when using the data to compare the results across facility types. Nonetheless, it does appear that volumes on expressways are over predicted. Revision of the volume delay function lookup table is recommended to bring the deviations in balance (see Section 5 for a summary of recommendations).

Differences between modeled and observed volumes are broken out by volume category in Table 58. The overall %RMSE and %RMSE on the highest volume category are within FHWA guidelines, but the deviations for lower volume facilities are not within the guidelines. It is possible that the variability in the observed count data is as large a source of this error as the error in the model because the Caltrans highway count database contains few observations for these lower volume facilities. Collecting a larger set of highway counts is recommended for future model validations.

A scatter plot of modeled versus observed highway volumes appears for daily traffic in Figure 40 and by time of day in Figure 41 to Figure 45. No systematic pattern of deviation from the 45-degree line or large outliers can be observed.

Traffic volumes at bridge crossings and county lines appear for daily traffic in Table 59 and for the AM and PM peaks in Table 60 and Table 61. The overall daily screen line total is slightly high, with a 6% excess. The excess is greater during the AM and PM peaks, which is consistent with the slight over-prediction of traffic in these time periods overall.

Table 57: Highway Counts by Period, Area Type, and Facility Type

Sum of Counts by Area Type and Facility Type
24-Hour Total

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core	Observed	-	-	-	-	-	-	48,635	48,635
0	Modeled	-	-	-	-	-	-	55,256	55,256
CBD	Observed	-	-	-	-	-	-	-	-
1	Modeled	-	-	-	-	-	-	-	-
UBD	Observed	67,570	1,918,594	49,607	-	-	-	170,229	2,206,000
2	Modeled	83,355	1,967,574	76,978	-	-	-	137,950	2,265,857
Urban	Observed	-	4,346,451	71,930	-	-	-	298,279	4,716,660
3	Modeled	-	4,348,268	63,508	-	-	-	196,244	4,608,020
Suburb.	Observed	71,471	3,690,270	339,012	19,497	15,787	-	176,534	4,312,571
4	Modeled	92,540	3,833,468	526,448	15,202	3,934	-	120,911	4,592,503
Rural	Observed	-	1,142,356	245,765	34,906	-	8,830	437,218	1,869,075
5	Modeled	-	1,150,717	259,048	44,114	-	9,299	547,305	2,010,483
Total	Observed	139,041	11,097,671	706,314	54,403	15,787	8,830	1,130,895	13,152,941
	Modeled	175,895	11,300,027	925,981	59,316	3,934	9,299	1,057,666	13,532,118

Difference in Sum of Counts by Area Type and Facility Type
24-Hour Total

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core	Diff	-	-	-	-	-	-	6,621	6,621
0	% Diff							14%	14%
CBD	Diff	-	-	-	-	-	-	-	-
1	% Diff								
UBD	Diff	15,785	48,980	27,371	-	-	-	-32,279	59,857
2	% Diff	23%	3%	55%				-19%	3%
Urban	Diff	-	1,817	-8,422	-	-	-	-102,035	-108,640
3	% Diff		0%	-12%				-34%	-2%
Suburb.	Diff	21,069	143,198	187,436	-4,295	-11,853	-	-55,623	279,932
4	% Diff	29%	4%	55%	-22%	-75%		-32%	6%
Rural	Diff	-	8,361	13,283	9,208	-	469	110,087	141,408
5	% Diff		1%	5%	26%		5%	25%	8%
Total	Diff	36,854	202,356	219,667	4,913	-11,853	469	-73,229	379,177
	% Diff	27%	2%	31%	9%	-75%	5%	-6%	3%
FHWA Target			*+/-7%*		*+/-25%*			*+/-10%*	

%RMSE in Counts by Area Type and Facility Type
24-Hour Total

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core	%RMSE							59%	
0	N	-	-	-	-	-	-	2	
CBD	%RMSE								
1	N	-	-	-	-	-	-	-	-
UBD	%RMSE	33%	21%	79%				44%	23%
2	N	2	28	2	-	-	-	7	39
Urban	%RMSE		20%	33%				54%	23%
3	N	-	68	2	-	-	-	17	87
Suburb.	%RMSE	68%	20%	96%	35%			71%	30%
4	N	3	77	20	3	1	-	15	119
Rural	%RMSE		24%	35%	188%		10%	86%	45%
5	N	-	29	14	22	-	2	62	129
Total	%RMSE	46%	21%	68%	132%		15%	67%	29%
	N	5	202	38	25	1	3	103	377

Sum of Counts by Area Type and Facility Type
Early AM (3 am to 6 am)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core 0	Observed	-	-	-	-	-	-	1,348	1,348
	Modeled	-	-	-	-	-	-	1,634	1,634
CBD 1	Observed	-	-	-	-	-	-	-	-
	Modeled	-	-	-	-	-	-	-	-
UBD 2	Observed	3,911	75,885	1,575	-	-	-	4,480	85,851
	Modeled	3,985	71,179	2,564	-	-	-	3,083	80,811
Urban 3	Observed	-	201,175	1,154	-	-	-	7,846	210,175
	Modeled	-	202,170	1,641	-	-	-	5,311	209,122
Suburb. 4	Observed	1,861	208,648	17,552	291	290	-	4,749	233,391
	Modeled	3,443	223,979	21,966	478	166	-	4,569	254,601
Rural 5	Observed	-	68,524	14,972	1,148	-	756	16,944	102,344
	Modeled	-	77,338	16,740	2,850	-	1,104	33,809	131,841
Total	Observed	5,772	554,232	35,253	1,439	290	756	35,367	633,109
	Modeled	7,428	574,666	42,911	3,328	166	1,104	48,406	678,009

Difference in Sum of Counts by Area Type and Facility Type
Early AM (3 am to 6 am)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core 0	Diff	-	-	-	-	-	-	286	286
	% Diff							21%	21%
CBD 1	Diff	-	-	-	-	-	-	-	-
	% Diff								
UBD 2	Diff	74	-4,706	989	-	-	-	-1,397	-5,040
	% Diff	2%	-6%	63%				-31%	-6%
Urban 3	Diff	-	995	487	-	-	-	-2,535	-1,053
	% Diff		0%	42%				-32%	-1%
Suburb. 4	Diff	1,582	15,331	4,414	187	-124	-	-180	21,210
	% Diff	85%	7%	25%	64%	-43%		-4%	9%
Rural 5	Diff	-	8,814	1,768	1,702	-	348	16,865	29,497
	% Diff		13%	12%	148%		46%	100%	29%
Total	Diff	1,656	20,434	7,658	1,889	-124	348	13,039	44,900
	% Diff	29%	4%	22%	131%	-43%	46%	37%	7%

%RMSE in Counts by Area Type and Facility Type
Early AM (3 am to 6 am)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core 0	%RMSE							0%	
	N	-	-	-	-	-	-	2	
CBD 1	%RMSE								
	N	-	-	-	-	-	-	-	-
UBD 2	%RMSE	0%	28%	0%				0%	29%
	N	2	28	2	-	-	-	7	39
Urban 3	%RMSE		33%	0%				0%	36%
	N	-	68	2	-	-	-	17	87
Suburb. 4	%RMSE	0%	52%	74%	62%			33%	60%
	N	3	77	20	3	1	-	15	119
Rural 5	%RMSE		19%	19%	186%		0%	141%	44%
	N	-	29	14	22	-	2	62	129
Total	%RMSE	0%	40%	52%	160%		0%	88%	49%
	N	5	202	38	25	1	3	103	377

Sum of Counts by Area Type and Facility Type
AM Peak (6 am to 10 am)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core 0	Observed	-	-	-	-	-	-	9,388	9,388
	Modeled	-	-	-	-	-	-	13,361	13,361
CBD 1	Observed	-	-	-	-	-	-	-	-
	Modeled	-	-	-	-	-	-	-	-
UBD 2	Observed	14,863	457,157	10,886	-	-	-	38,412	521,318
	Modeled	18,666	484,038	17,721	-	-	-	30,738	551,164
Urban 3	Observed	-	1,062,451	15,801	-	-	-	60,620	1,138,872
	Modeled	-	1,133,277	17,470	-	-	-	46,549	1,197,296
Suburb. 4	Observed	18,439	876,888	79,633	3,636	4,731	-	40,660	1,023,987
	Modeled	25,967	986,991	143,490	3,226	1,010	-	34,568	1,195,252
Rural 5	Observed	-	283,533	60,881	7,815	-	2,619	109,501	464,349
	Modeled	-	317,540	72,210	11,987	-	2,429	162,948	567,114
Total	Observed	33,302	2,680,029	167,201	11,451	4,731	2,619	258,581	3,157,914
	Modeled	44,633	2,921,846	250,891	15,213	1,010	2,429	288,165	3,524,187

Difference in Sum of Counts by Area Type and Facility Type
AM Peak (6 am to 10 am)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core 0	Diff	-	-	-	-	-	-	3,973	3,973
	% Diff							42%	42%
CBD 1	Diff	-	-	-	-	-	-	-	-
	% Diff								
UBD 2	Diff	3,803	26,881	6,835	-	-	-	-7,674	29,846
	% Diff	26%	6%	63%				-20%	6%
Urban 3	Diff	-	70,826	1,669	-	-	-	-14,071	58,424
	% Diff		7%	11%				-23%	5%
Suburb. 4	Diff	7,528	110,103	63,857	-410	-3,721	-	-6,092	171,265
	% Diff	41%	13%	80%	-11%	-79%		-15%	17%
Rural 5	Diff	-	34,007	11,329	4,172	-	-190	53,447	102,765
	% Diff		12%	19%	53%		-7%	49%	22%
Total	Diff	11,331	241,817	83,690	3,762	-3,721	-190	29,584	366,273
	% Diff	34%	9%	50%	33%	-79%	-7%	11%	12%

%RMSE in Counts by Area Type and Facility Type
AM Peak (6 am to 10 am)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core 0	%RMSE							102%	
	N	-	-	-	-	-	-	2	
CBD 1	%RMSE								
	N	-	-	-	-	-	-	-	-
UBD 2	%RMSE	41%	21%	89%				63%	25%
	N	2	28	2	-	-	-	7	39
Urban 3	%RMSE		25%	68%				55%	27%
	N	-	68	2	-	-	-	17	87
Suburb. 4	%RMSE	92%	30%	129%	37%			57%	41%
	N	3	77	20	3	1	-	15	119
Rural 5	%RMSE		40%	41%	227%		17%	116%	67%
	N	-	29	14	22	-	2	62	129
Total	%RMSE	64%	27%	91%	167%		21%	83%	38%
	N	5	202	38	25	1	3	103	377

Sum of Counts by Area Type and Facility Type
Midday (10 am to 3 pm)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core	Observed	-	-	-	-	-	-	13,692	13,692
0	Modeled	-	-	-	-	-	-	15,550	15,550
CBD	Observed	-	-	-	-	-	-	-	-
1	Modeled	-	-	-	-	-	-	-	-
UBD	Observed	19,170	501,815	15,505	-	-	-	47,057	583,547
2	Modeled	21,835	509,286	21,957	-	-	-	34,332	587,411
Urban	Observed	-	1,142,234	18,822	-	-	-	84,376	1,245,432
3	Modeled	-	1,071,478	15,132	-	-	-	50,734	1,137,344
Suburb.	Observed	16,833	967,875	100,218	5,294	4,992	-	49,950	1,145,162
4	Modeled	18,760	903,400	124,487	3,242	1,084	-	29,017	1,079,989
Rural	Observed	-	279,753	69,554	9,926	-	2,286	134,836	496,355
5	Modeled	-	254,415	56,105	11,041	-	2,268	112,220	436,048
Total	Observed	36,003	2,891,677	204,099	15,220	4,992	2,286	329,911	3,484,188
	Modeled	40,595	2,738,578	217,681	14,283	1,084	2,268	241,852	3,256,341

Difference in Sum of Counts by Area Type and Facility Type
Midday (10 am to 3 pm)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core	Diff	-	-	-	-	-	-	1,858	1,858
0	% Diff							14%	14%
CBD	Diff	-	-	-	-	-	-	-	-
1	% Diff								
UBD	Diff	2,665	7,471	6,452	-	-	-	-12,725	3,864
2	% Diff	14%	1%	42%				-27%	1%
Urban	Diff	-	-70,756	-3,690	-	-	-	-33,642	-108,088
3	% Diff		-6%	-20%				-40%	-9%
Suburb.	Diff	1,927	-64,475	24,269	-2,052	-3,908	-	-20,933	-65,173
4	% Diff	11%	-7%	24%	-39%	-78%		-42%	-6%
Rural	Diff	-	-25,338	-13,449	1,115	-	-18	-22,616	-60,307
5	% Diff		-9%	-19%	11%		-1%	-17%	-12%
Total	Diff	4,592	-153,099	13,582	-937	-3,908	-18	-88,059	-227,847
	% Diff	13%	-5%	7%	-6%	-78%	-1%	-27%	-7%

%RMSE in Counts by Area Type and Facility Type
Midday (10 am to 3 pm)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core	%RMSE							68%	
0	N	-	-	-	-	-	-	2	
CBD	%RMSE								
1	N	-	-	-	-	-	-	-	-
UBD	%RMSE	20%	22%	60%				48%	24%
2	N	2	28	2	-	-	-	7	39
Urban	%RMSE		20%	33%				57%	22%
3	N	-	68	2	-	-	-	17	87
Suburb.	%RMSE	57%	22%	68%	48%			67%	29%
4	N	3	77	20	3	1	-	15	119
Rural	%RMSE		26%	37%	179%		2%	65%	44%
5	N	-	29	14	22	-	2	62	129
Total	%RMSE	34%	22%	53%	130%		4%	62%	29%
	N	5	202	38	25	1	3	103	377

Sum of Counts by Area Type and Facility Type
PM Peak (3 pm to 7 pm)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core	Observed	-	-	-	-	-	-	12,833	12,833
0	Modeled	-	-	-	-	-	-	17,057	17,057
CBD	Observed	-	-	-	-	-	-	-	-
1	Modeled	-	-	-	-	-	-	-	-
UBD	Observed	16,651	493,445	12,479	-	-	-	48,186	570,761
2	Modeled	20,715	535,176	20,876	-	-	-	45,274	622,040
Urban	Observed	-	1,138,316	21,511	-	-	-	85,447	1,245,274
3	Modeled	-	1,188,793	19,409	-	-	-	61,590	1,269,791
Suburb.	Observed	22,778	1,005,189	96,244	6,903	3,788	-	54,113	1,189,015
4	Modeled	27,703	1,054,208	152,696	6,024	1,053	-	34,757	1,276,440
Rural	Observed	-	327,581	67,979	11,436	-	2,177	124,311	533,484
5	Modeled	-	329,180	70,908	11,822	-	2,275	148,184	562,370
Total	Observed	39,429	2,964,531	198,213	18,339	3,788	2,177	324,890	3,551,367
	Modeled	48,417	3,107,356	263,888	17,846	1,053	2,275	306,862	3,747,698

Difference in Sum of Counts by Area Type and Facility Type
PM Peak (3 pm to 7 pm)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core	Diff	-	-	-	-	-	-	4,224	4,224
0	% Diff							33%	33%
CBD	Diff	-	-	-	-	-	-	-	-
1	% Diff								
UBD	Diff	4,064	41,731	8,397	-	-	-	-2,912	51,279
2	% Diff	24%	8%	67%				-6%	9%
Urban	Diff	-	50,477	-2,102	-	-	-	-23,857	24,517
3	% Diff		4%	-10%				-28%	2%
Suburb.	Diff	4,925	49,019	56,452	-879	-2,735	-	-19,356	87,425
4	% Diff	22%	5%	59%	-13%	-72%		-36%	7%
Rural	Diff	-	1,599	2,929	386	-	98	23,873	28,886
5	% Diff		0%	4%	3%		5%	19%	5%
Total	Diff	8,988	142,825	65,675	-493	-2,735	98	-18,028	196,331
	% Diff	23%	5%	33%	-3%	-72%	5%	-6%	6%

%RMSE in Counts by Area Type and Facility Type
PM Peak (3 pm to 7 pm)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core	%RMSE							58%	
0	N	-	-	-	-	-	-	2	
CBD	%RMSE								
1	N	-	-	-	-	-	-	-	-
UBD	%RMSE	35%	27%	95%				41%	29%
2	N	2	28	2	-	-	-	7	39
Urban	%RMSE		24%	35%				50%	26%
3	N	-	68	2	-	-	-	17	87
Suburb.	%RMSE	49%	24%	95%	44%			82%	33%
4	N	3	77	20	3	1	-	15	119
Rural	%RMSE		26%	43%	162%		13%	81%	47%
5	N	-	29	14	22	-	2	62	129
Total	%RMSE	38%	25%	71%	114%		15%	66%	33%
	N	5	202	38	25	1	3	103	377

Sum of Counts by Area Type and Facility Type
Evening (7 pm to 3 am)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core 0	Observed	-	-	-	-	-	-	11,374	11,374
	Modeled	-	-	-	-	-	-	7,655	7,655
CBD 1	Observed	-	-	-	-	-	-	-	-
	Modeled	-	-	-	-	-	-	-	-
UBD 2	Observed	12,975	390,292	9,162	-	-	-	32,094	444,523
	Modeled	18,154	367,895	13,859	-	-	-	24,522	424,431
Urban 3	Observed	-	802,275	14,642	-	-	-	59,990	876,907
	Modeled	-	752,550	9,856	-	-	-	32,060	794,466
Suburb. 4	Observed	11,560	631,670	45,365	3,373	1,986	-	27,062	721,016
	Modeled	16,667	664,891	83,810	2,232	621	-	18,000	786,221
Rural 5	Observed	-	182,965	32,379	4,581	-	992	51,626	272,543
	Modeled	-	172,244	43,085	6,414	-	1,223	90,144	313,110
Total	Observed	24,535	2,007,202	101,548	7,954	1,986	992	182,146	2,326,363
	Modeled	34,821	1,957,580	150,610	8,646	621	1,223	172,381	2,325,882

Difference in Sum of Counts by Area Type and Facility Type
Evening (7 pm to 3 am)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core 0	Diff	-	-	-	-	-	-	-3,719	-3,719
	% Diff							-33%	-33%
CBD 1	Diff	-	-	-	-	-	-	-	-
	% Diff								
UBD 2	Diff	5,179	-22,397	4,697	-	-	-	-7,572	-20,092
	% Diff	40%	-6%	51%				-24%	-5%
Urban 3	Diff	-	-49,725	-4,786	-	-	-	-27,930	-82,441
	% Diff		-6%	-33%				-47%	-9%
Suburb. 4	Diff	5,107	33,221	38,445	-1,141	-1,365	-	-9,062	65,205
	% Diff	44%	5%	85%	-34%	-69%		-33%	9%
Rural 5	Diff	-	-10,721	10,706	1,833	-	231	38,518	40,567
	% Diff		-6%	33%	40%		23%	75%	15%
Total	Diff	10,286	-49,622	49,062	692	-1,365	231	-9,765	-481
	% Diff	42%	-2%	48%	9%	-69%	23%	-5%	-0%

%RMSE in Counts by Area Type and Facility Type
Evening (7 pm to 3 am)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core 0	%RMSE							63%	
	N	-	-	-	-	-	-	2	
CBD 1	%RMSE								
	N	-	-	-	-	-	-	-	-
UBD 2	%RMSE	57%	37%	74%				49%	40%
	N	2	28	2	-	-	-	7	39
Urban 3	%RMSE		41%	47%				67%	43%
	N	-	68	2	-	-	-	17	87
Suburb. 4	%RMSE	82%	35%	133%	46%			98%	45%
	N	3	77	20	3	1	-	15	119
Rural 5	%RMSE		34%	69%	246%		41%	142%	67%
	N	-	29	14	22	-	2	62	129
Total	%RMSE	59%	39%	93%	157%		48%	91%	50%
	N	5	202	38	25	1	3	103	377

Table 58: Modeled and Observed Volumes by Volume Category

Vol. Low	Vol. High	Obs. Vol.	Mod. Vol.	Diff.	% Diff.	N	%RMSE	FHWA Target
0	1,000	5,348	973	-4,375	-82%	52	206%	60%
1,000	2,500	29,901	63,159	33,258	111%	17	284%	47%
2,500	5,000	55,751	72,380	16,629	30%	15	112%	36%
5,000	10,000	305,497	358,040	52,543	17%	42	76%	29%
10,000	25,000	1,426,296	1,570,602	144,306	10%	88	63%	25%
25,000	50,000	1,555,881	1,598,622	42,741	3%	44	30%	22%
50,000	+	9,765,437	9,859,042	93,605	1%	116	17%	21%
Total		13,144,111	13,522,818	378,707	3%	374	29%	35%

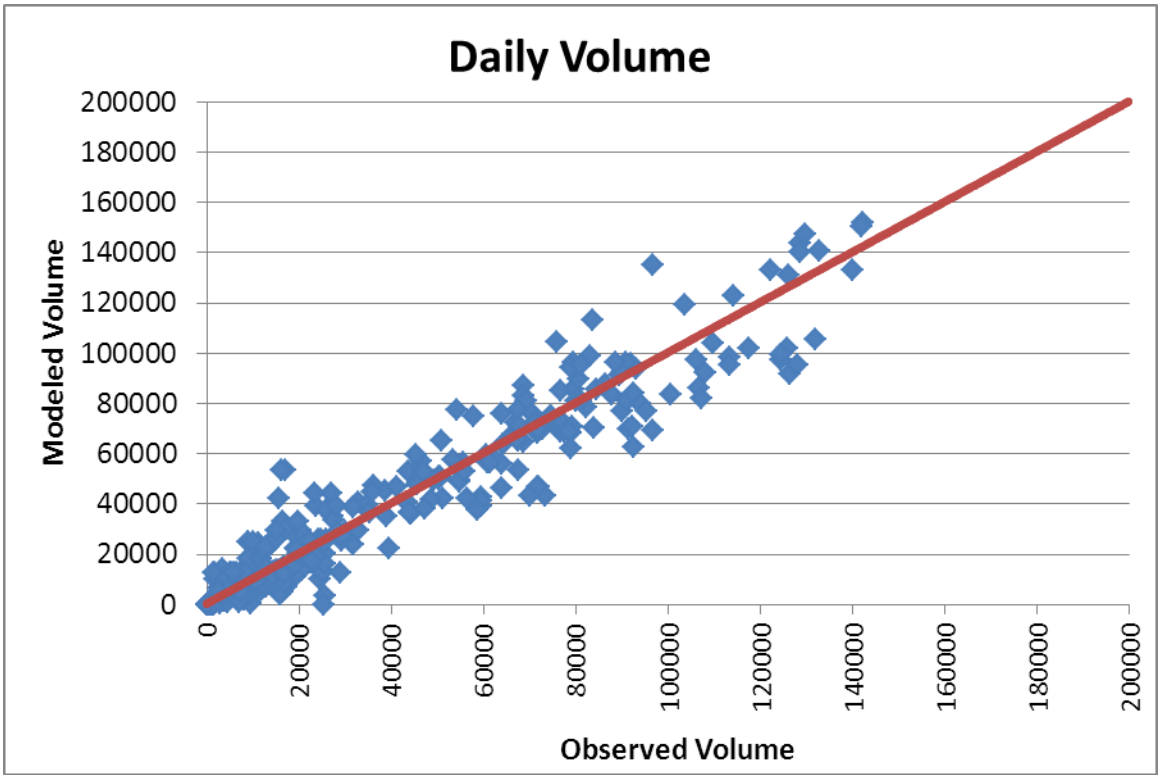


Figure 40: Scatter plot of Modeled versus Observed Daily Traffic Volume

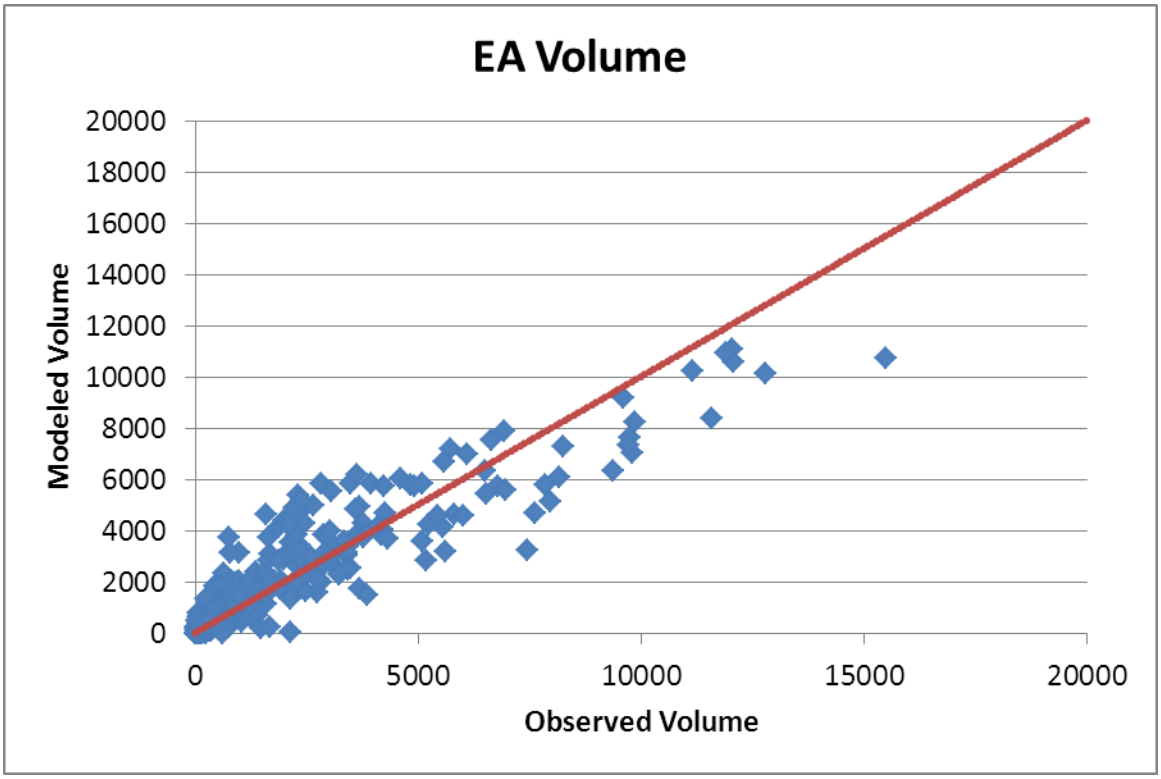


Figure 41: Scatter plot of Modeled versus Observed Early AM Traffic Volume

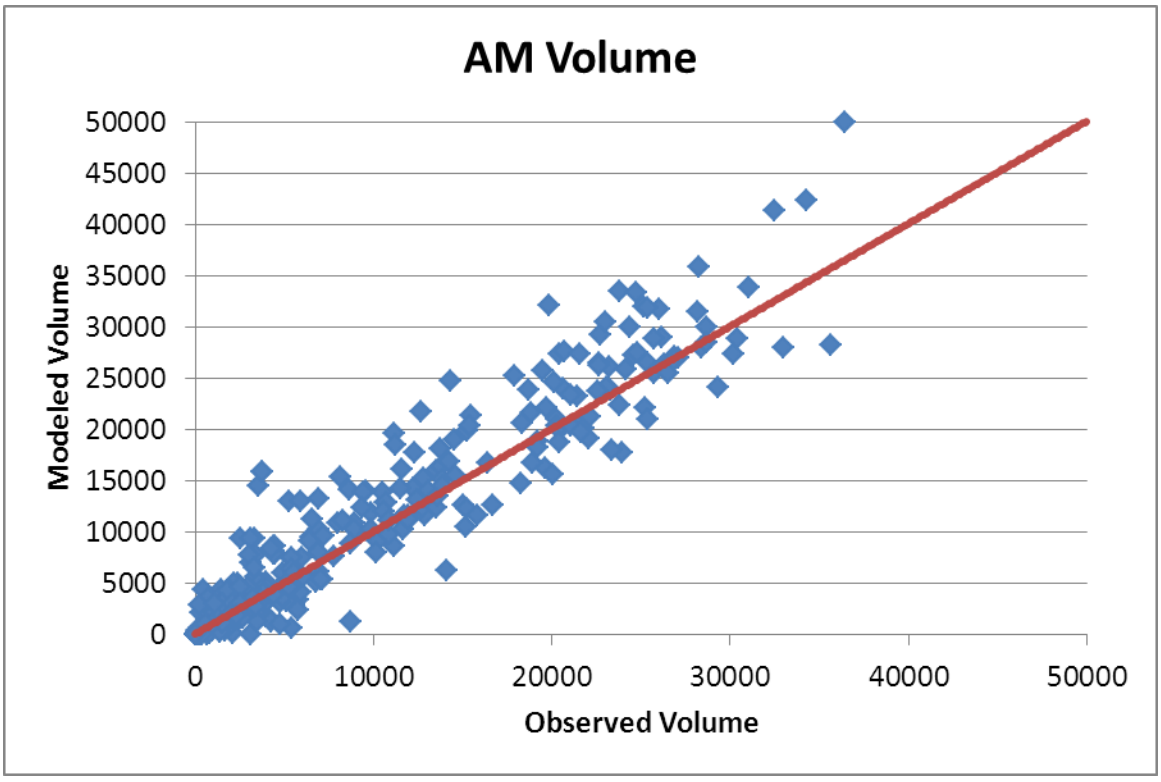


Figure 42: Scatter plot of Modeled versus Observed AM Peak Traffic Volume

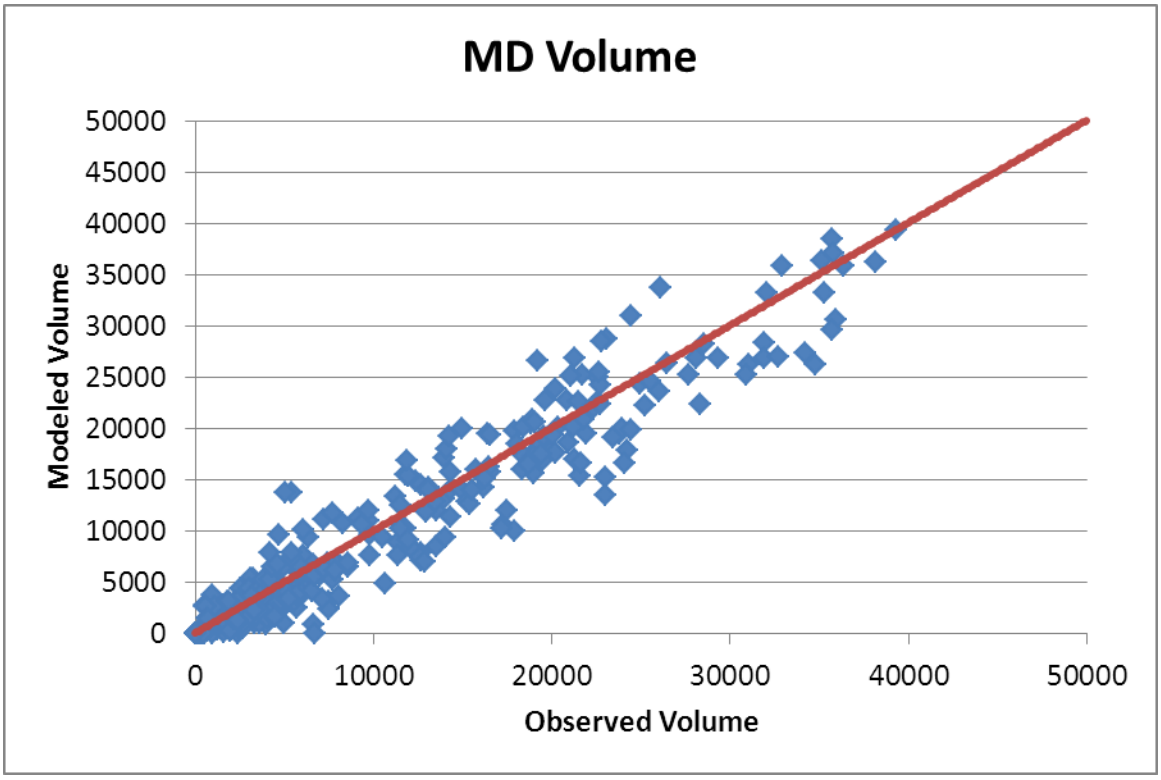


Figure 43: Scatter plot of Modeled versus Observed Midday Traffic Volume

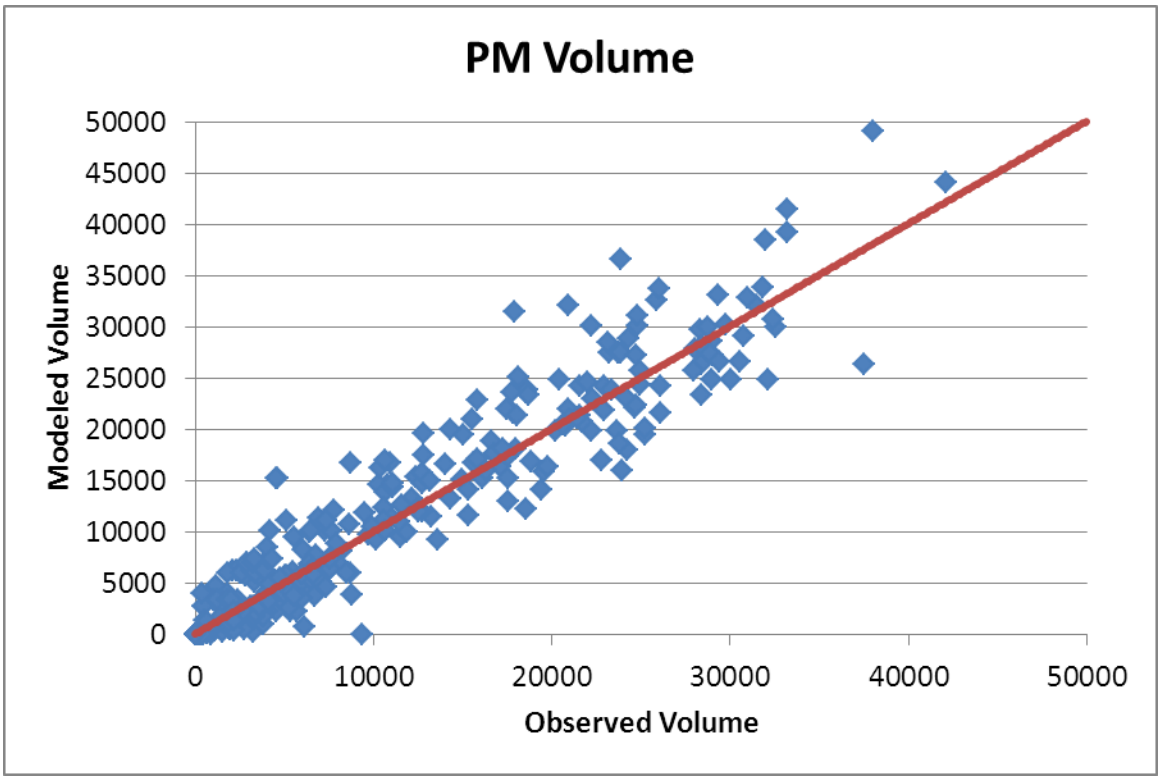


Figure 44: Scatter plot of Modeled versus Observed PM Peak Traffic Volume

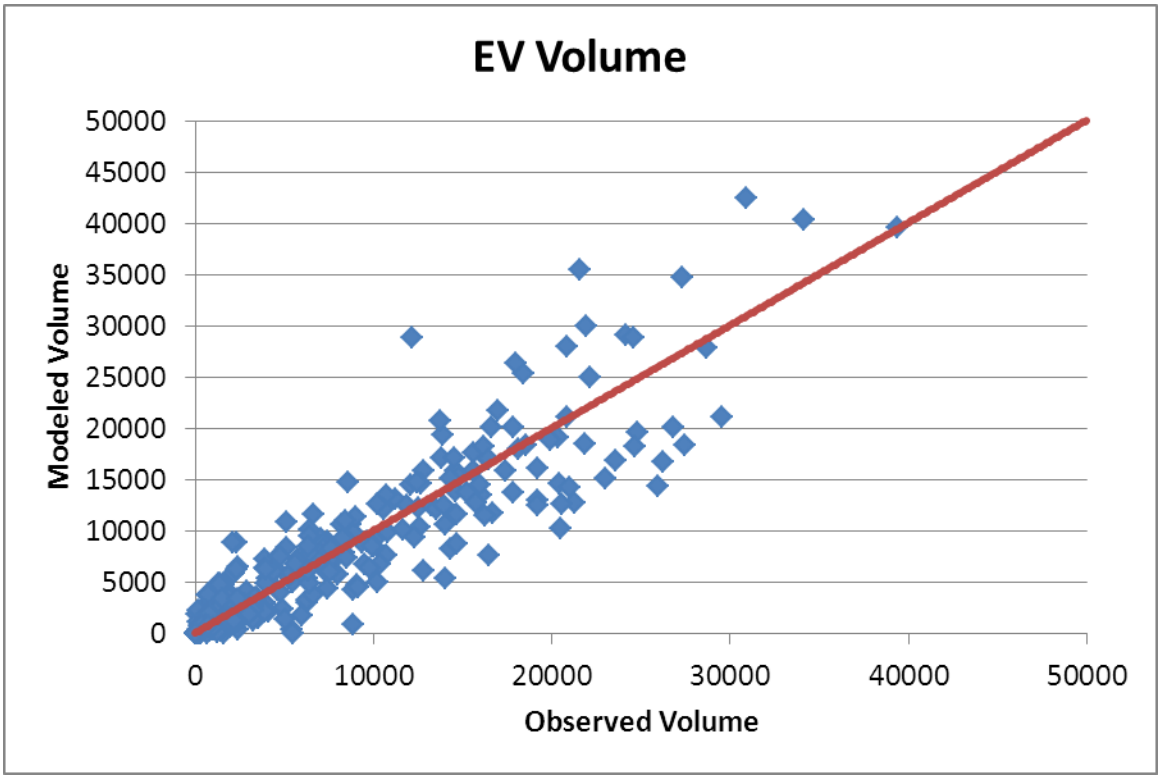


Figure 45: Scatter plot of Modeled versus Observed Evening Traffic Volume

Table 59: Daily Traffic Assignment Validation at Key Locations

Screenline Facility	Avg. Weekday Daily Traffic Observed	Predicted	Predicted less Obs.	Percent Difference
Bay Area Bridges				
US-101, Golden Gate Bridge (S)	54,774	54,173	-601	-1.1%
I-80, SF/Oakland Bay Bridge	282,277	298,043	15,766	5.6%
Cal-92, San Mateo/Hayward Bridge (W)	45,146	57,374	12,228	27.1%
Cal-84, Dumbarton Bridge (N)	50,854	66,312	15,458	30.4%
I-580, Richmond/San Rafael Bridge (E)	38,641	48,067	9,426	24.4%
I-80, Carquinez Bridge (E)	64,015	59,308	-4,707	-7.4%
I-680, Benicia/Martinez Bridge	139,171	146,757	7,586	5.5%
Cal-160, Antioch Bridge	12,235	12,638	403	3.3%
Bay Area Bridges Sub-Total	***687,113***	***742,672***	***55,559***	***8.1%***
San Francisco/San Mateo County Line				
US-101, Bayshore Freeway (N)	113,437	104,843	-8,594	-7.6%
Cal-35, Skyline Blvd. (N)	16,464	5,018	-11,446	-69.5%
Cal-1, Junipero Serra Blvd. (N)	55,466	58,490	3,024	5.5%
I-280, Foran Freeway	141,761	95,513	-46,248	-32.6%
SF/SM County Line Sub-Total	***327,128***	***263,864***	***-63,264***	***-19.3%***
San Mateo/Santa Clara County Line				
Cal-82, El Camino Real (N)	25,115	14,164	-10,951	-43.6%
US-101, Bayshore Freeway (N)	114,132	128,630	14,498	12.7%
I-280, Serra Freeway (N)	67,485	59,434	-8,051	-11.9%
SM/SC County Line Sub-Total	***206,732***	***202,229***	***-4,503***	***-2.2%***
Santa Clara/Alameda County Line				
I-680, at Scott Creek Road (N)	64,304	68,787	4,483	7.0%
I-880, Nimitz Freeway (N)	79,430	102,608	23,178	29.2%
SC/Ala County Line Sub-Total	***143,734***	***171,396***	***27,662***	***19.2%***
Alameda/Contra Costa County Line				
I-580, Knox Freeway	91,714	124,008	32,294	35.2%
I-80, Eastshore Freeway	172,435	199,496	27,061	15.7%
Cal-24, Caldecott Tunnel (E)	75,932	109,175	33,243	43.8%
I-680, in Dublin/San Ramon	160,100	185,265	25,165	15.7%
Ala/CC County Line Sub-Total	***500,181***	***617,945***	***117,764***	***23.5%***
Solano/Napa County Line				
Route 29, Napa-Vallejo Highway (N)	17,055	31,447	14,392	84.4%
Solano/Sonoma County Line				
Route 37, Sears Point Road	32,307	21,526	-10,781	-33.4%
Napa/Sonoma County Line				
Route 121, Carneros Highway (N)	12,942	6,933	-6,009	-46.4%
Route 128, Calistoga-Healdsburd Rd. (E)	1,259	904	-355	-28.2%
Napa/Sonoma County Line Sub-Total	***14,201***	***7,838***	***-6,363***	***-44.8%***
Sonoma/Marin County Line				
US-101, Redwood Highway (N)	78,941	65,985	-12,956	-16.4%
Screenline Totals	***2,007,392***	***2,124,902***	***117,510***	***5.9%***

Table 60: AM Peak Traffic Assignment Validation at Key Locations

Screenline / Facility	Avg. Weekday AM Traffic		Predicted	Percent
	Observed	Predicted	less Obs.	Difference
Bay Area Bridges				
US-101, Golden Gate Bridge (S)	20,119	24,584	4,465	22.2%
I-80, SF/Oakland Bay Bridge	62,396	81,776	19,380	31.1%
Cal-92, San Mateo/Hayward Bridge (W)	14,497	18,979	4,482	30.9%
Cal-84, Dumbarton Bridge (N)	6,877	13,288	6,411	93.2%
I-580, Richmond/San Rafael Bridge (E)	8,619	14,107	5,488	63.7%
I-80, Carquinez Bridge (E)	8,929	10,873	1,944	21.8%
I-680, Benicia/Martinez Bridge	35,289	38,371	3,082	8.7%
Cal-160, Antioch Bridge	3,067	3,153	86	2.8%
Bay Area Bridges Sub-Total	***159,793***	***205,130***	***45,337***	***28.4%***
San Francisco/San Mateo County Line				
US-101, Bayshore Freeway (N)	24,795	27,527	2,732	11.0%
Cal-35, Skyline Blvd. (N)	4,215	1,347	-2,868	-68.0%
Cal-1, Junipero Serra Blvd. (N)	11,586	16,123	4,537	39.2%
I-280, Foran Freeway	33,297	24,499	-8,798	-26.4%
SF/SM County Line Sub-Total	***73,893***	***69,495***	***-4,398***	***-6.0%***
San Mateo/Santa Clara County Line				
Cal-82, El Camino Real (N)	5,882	4,124	-1,758	-29.9%
US-101, Bayshore Freeway (N)	24,544	27,195	2,651	10.8%
I-280, Serra Freeway (N)	23,773	22,423	-1,350	-5.7%
SM/SC County Line Sub-Total	***54,199***	***53,742***	***-457***	***-0.8%***
Santa Clara/Alameda County Line				
I-680, at Scott Creek Road (N)	15,261	19,865	4,604	30.2%
I-880, Nimitz Freeway (N)	15,455	21,398	5,943	38.5%
SC/Ala County Line Sub-Total	***30,716***	***41,263***	***10,547***	***34.3%***
Alameda/Contra Costa County Line				
I-580, Knox Freeway	22,906	30,655	7,749	33.8%
I-80, Eastshore Freeway	38,704	47,967	9,263	23.9%
Cal-24, Caldecott Tunnel (E)	11,111	19,607	8,496	76.5%
I-680, in Dublin/San Ramon	40,687	48,391	7,704	18.9%
Ala/CC County Line Sub-Total	***113,408***	***146,619***	***33,211***	***29.3%***
Solano/Napa County Line				
Route 29, Napa-Vallejo Highway (N)	4,238	8,444	4,206	99.2%
Solano/Sonoma County Line				
Route 37, Sears Point Road	8,682	6,828	-1,854	-21.4%
Napa/Sonoma County Line				
Route 121, Carneros Highway (N)	3,221	2,308	-913	-28.3%
Route 128, Calistoga-Healdsburd Rd. (E)	302	390	88	29.3%
Napa/Sonoma County Line Sub-Total	***3,523***	***2,699***	***-824***	***-23.4%***
Sonoma/Marin County Line				
US-101, Redwood Highway (N)	11,711	11,684	-27	-0.2%
Screenline Totals	***460,163***	***545,903***	***85,740***	***18.6%***

Table 61: PM Peak Traffic Assignment Validation at Key Locations

Screenline / Facility	Avg. Weekday PM Traffic Observed	Avg. Weekday PM Traffic Predicted	Predicted less Obs.	Percent Difference
Bay Area Bridges				
US-101, Golden Gate Bridge (S)	11,457	10,961	-496	-4.3%
I-80, SF/Oakland Bay Bridge	69,452	81,200	11,748	16.9%
Cal-92, San Mateo/Hayward Bridge (W)	10,272	14,667	4,395	42.8%
Cal-84, Dumbarton Bridge (N)	17,435	22,045	4,610	26.4%
I-580, Richmond/San Rafael Bridge (E)	12,143	13,263	1,120	9.2%
I-80, Carquinez Bridge (E)	22,174	19,835	-2,339	-10.5%
I-680, Benicia/Martinez Bridge	39,852	40,403	551	1.4%
Cal-160, Antioch Bridge	3,570	3,265	-305	-8.5%
Bay Area Bridges Sub-Total	***186,355***	***205,639***	***19,284***	***10.3%***
San Francisco/San Mateo County Line				
US-101, Bayshore Freeway (N)	28,749	29,952	1,203	4.2%
Cal-35, Skyline Blvd. (N)	5,694	2,230	-3,464	-60.8%
Cal-1, Junipero Serra Blvd. (N)	15,817	17,179	1,362	8.6%
I-280, Foran Freeway	41,380	29,234	-12,146	-29.4%
SF/SM County Line Sub-Total	***91,640***	***78,594***	***-13,046***	***-14.2%***
San Mateo/Santa Clara County Line				
Cal-82, El Camino Real (N)	6,719	3,800	-2,919	-43.4%
US-101, Bayshore Freeway (N)	29,312	33,056	3,744	12.8%
I-280, Serra Freeway (N)	18,826	16,869	-1,957	-10.4%
SM/SC County Line Sub-Total	***54,857***	***53,724***	***-1,133***	***-2.1%***
Santa Clara/Alameda County Line				
I-680, at Scott Creek Road (N)	21,586	24,227	2,641	12.2%
I-880, Nimitz Freeway (N)	22,194	30,097	7,903	35.6%
SC/Ala County Line Sub-Total	***43,780***	***54,324***	***10,544***	***24.1%***
Alameda/Contra Costa County Line				
I-580, Knox Freeway	25,210	33,001	7,791	30.9%
I-80, Eastshore Freeway	42,646	52,735	10,089	23.7%
Cal-24, Caldecott Tunnel (E)	26,035	33,759	7,724	29.7%
I-680, in Dublin/San Ramon	44,674	49,385	4,711	10.5%
Ala/CC County Line Sub-Total	***138,565***	***168,881***	***30,316***	***21.9%***
Solano/Napa County Line				
Route 29, Napa-Vallejo Highway (N)	4,003	8,494	4,491	112.2%
Solano/Sonoma County Line				
Route 37, Sears Point Road	8,794	6,366	-2,428	-27.6%
Napa/Sonoma County Line				
Route 121, Carneros Highway (N)	3,823	1,733	-2,090	-54.7%
Route 128, Calistoga-Healdsburd Rd. (E)	390	169	-221	-56.7%
Napa/Sonoma County Line Sub-Total	***4,213***	***1,902***	***-2,311***	***-54.9%***
Sonoma/Marin County Line				
US-101, Redwood Highway (N)	28,409	23,417	-4,992	-17.6%
Screenline Totals	***560,616***	***601,341***	***40,725***	***7.3%***

3.2 Transit Assignment

After all iterations of the travel demand and highway assignment are complete (i.e. speeds have reached equilibrium), transit trips are loaded onto transit routes using a single best path search method. Transit modes ranked lower in the hierarchy (Local Bus – Light Rail/ Ferry – Express Bus – Heavy Rail – Commuter Rail) are allowed in the paths with a primary mode ranked higher in the hierarchy to allow feeder service and intermodal transfers. However, the in-vehicle time on feeder modes is weighted at 1.5 times the in-vehicle time on the main mode in the generalized cost criterion for the best path search. Access, egress, and transfer times are weighted at two times in-vehicle time on the primary mode. By using a biased search, paths which contain the primary mode are revealed most frequently.

The total number of daily boardings by mode appears in Table 62. The tour mode choice and trip mode choice models were calibrated in tandem with the transit assignment validation to achieve a compromise between matching the household survey, matching the number of transfers, matching the number of boardings, and obtaining alternative-specific constants within reasonable ranges. Therefore, even these aggregate results should not be expected to match exactly. Overall, boardings are close within 1% the observed amount. All of the modes are within 5% to the observations, as well, except for light rail, for which the number of trips dropped after moving from calibration with one iteration of the demand models to the final run with three iterations of feedback. This drop could be due to an overestimation of congestion in San Francisco in the skims used in calibration. If congestion decreased during feedback, some Muni light rail passengers may have switched to auto modes.

Table 62: Total Transit Boardings by Mode

Aggregate Mode	Observed Boardings	Modeled Boardings	Difference	% Difference
Local	1,055,388	1,110,087	54,699	5%
Light Rail	198,654	174,939	-23,715	-12%
Ferry	12,169	12,666	497	4%
Express	59,896	58,284	-1,612	-3%
Heavy Rail	344,869	332,759	-12,110	-4%
Commuter Rail	34,049	33,657	-392	-1%
Total	1,705,025	1,722,392	17,367	1%

Transit boardings by system operator appear in Table 63. There are some significant geographic discrepancies across service providers within each mode. For example, Muni Bus boardings are 17% low while AC Local boardings are 31% high; Muni Metro boardings are 25% low while VTA Light Rail boardings are 62% high. Both of these cases suggest a difference in the transit environments in San Francisco versus the East/South Bay.

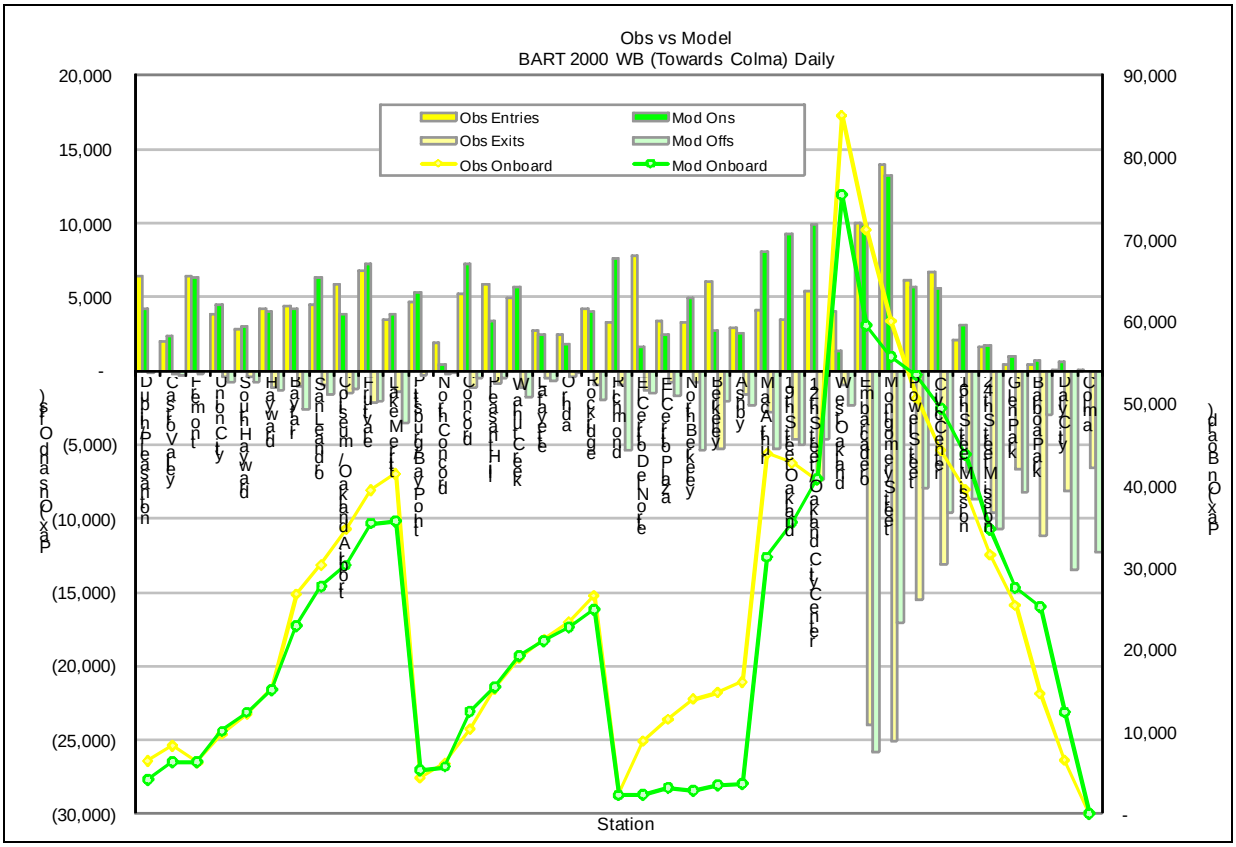
An attempt was made to shift boardings toward the San Francisco systems by introducing a coefficient on the density index of the origin rather than considering only the destination (as described in the section on Tour Mode Choice), but increasing this effect to a reasonable limit did not shift an appreciable number of trips to the denser San Francisco area. It is possible that

the decision to take or not to take transit in San Francisco is not a decision against taking a private car, but rather a decision against walking. Removing the origin density effect from the walk alternative may have more of an effect. On the other hand, this decision between walking and taking transit for short trips is strongly influenced by ownership of monthly transit passes, which are very popular in San Francisco, and not modeled at the present time. Introducing a transit pass alternative into the auto ownership model is recommended to better model the interdependence of these decisions.

Figure 46 shows the number of passengers that enter or exit the BART system daily and a running count of the number of passengers remaining on board at each station as the trains move from East to West and vice versa during the travel day. The match between observed and modeled station profiles is very good. Figure 47 shows the same information for Caltrain Northbound and Southbound. The model's match with Caltrain station profiles is not as good. In the model, Caltrain is not used enough in the South Bay, and as it goes up the Peninsula, starting at Mountain View too many passengers alight before San Francisco. Investigation of Commuter Rail skimming paths revealed that, for trips to San Francisco, SamTrans Express Bus was often selected by the Commuter Rail pathfinder, which would make Commuter Rail unavailable in the mode choice model for many trips from the Peninsula to San Francisco. Eliminating express bus as a feeder mode from commercial rail paths is recommended to improve the geographic distribution of Caltrain trips, since the modes are so competitive.

Table 63: Transit Boardings by System Operator

Name	Aggregate Mode	Observed Boardings	Modeled Boardings	Difference	% Difference
MUNI Bus	Local	562,970	467,173	-95,797	-17%
AC Local	Local	186,983	244,979	57,996	31%
VTA Local	Local	149,868	190,877	41,009	27%
Samtrans Local	Local	55,365	84,431	29,066	52%
MUNI Cable Car	Local	22,813	12,893	-9,920	-43%
CCCTA Local	Local	15,486	24,833	9,347	60%
Sonoma Providers	Local	10,772	15,766	4,994	46%
Other Shuttles	Local	9,000	14,904	5,904	66%
Tri-Delta	Local	7,580	11,770	4,190	55%
Golden Gate Local	Local	7,179	4,489	-2,690	-37%
LAVTA/Wheels	Local	6,003	10,044	4,041	67%
Vallejo Local	Local	4,481	6,455	1,974	44%
Fairfield Local	Local	3,037	4,899	1,862	61%
Stanford Shuttle	Local	2,918	7,242	4,324	148%
Emery Shuttle	Local	2,860	4,319	1,459	51%
NVT/Vine	Local	2,427	33	-2,394	-99%
Union City	Local	1,920	3,706	1,786	93%
BWS	Local	971	26	-945	-97%
Air BART	Local	750	70	-680	-91%
Vacaville	Local	543	137	-406	-75%
Benicia	Local	536	-	-536	-100%
American Canyon	Local	500	2	-498	-100%
West Cat Local	Local	425	1,039	614	144%
Golden Gate Express	Express	26,204	22,838	-3,366	-13%
AC Transbay	Express	13,917	15,694	1,777	13%
Samtrans Express	Express	7,192	7,359	167	2%
VTA Express	Express	3,830	2,507	-1,323	-35%
Vallejo Express	Express	3,542	3,100	-442	-12%
West Cat Express	Express	3,101	2,230	-871	-28%
CCCTA Express	Express	1,116	1,425	309	28%
DBX	Express	867	2,245	1,378	159%
Fairfield Express	Express	128	51	-77	-60%
Other	Express	-	835	835	0%
MUNI Metro	Light Rail	168,510	126,211	-42,299	-25%
VTA LRT	Light Rail	30,144	48,728	18,584	62%
Golden Gate Ferry	Ferry	6,179	8,130	1,951	32%
East Bay Ferries	Ferry	2,546	4,145	1,599	63%
Vallejo Ferries	Ferry	2,137	151	-1,986	-93%
Tiburon Ferries	Ferry	1,307	240	-1,067	-82%
BART	Heavy Rail	344,869	332,759	-12,110	-4%
Caltrain	Commuter Rail	31,291	33,527	2,236	7%
ACE	Commuter Rail	1,743	42	-1,701	-98%
Amtrak	Commuter Rail	1,015	88	-927	-91%
Total		2,847,080	2,977,691	130,611	5%



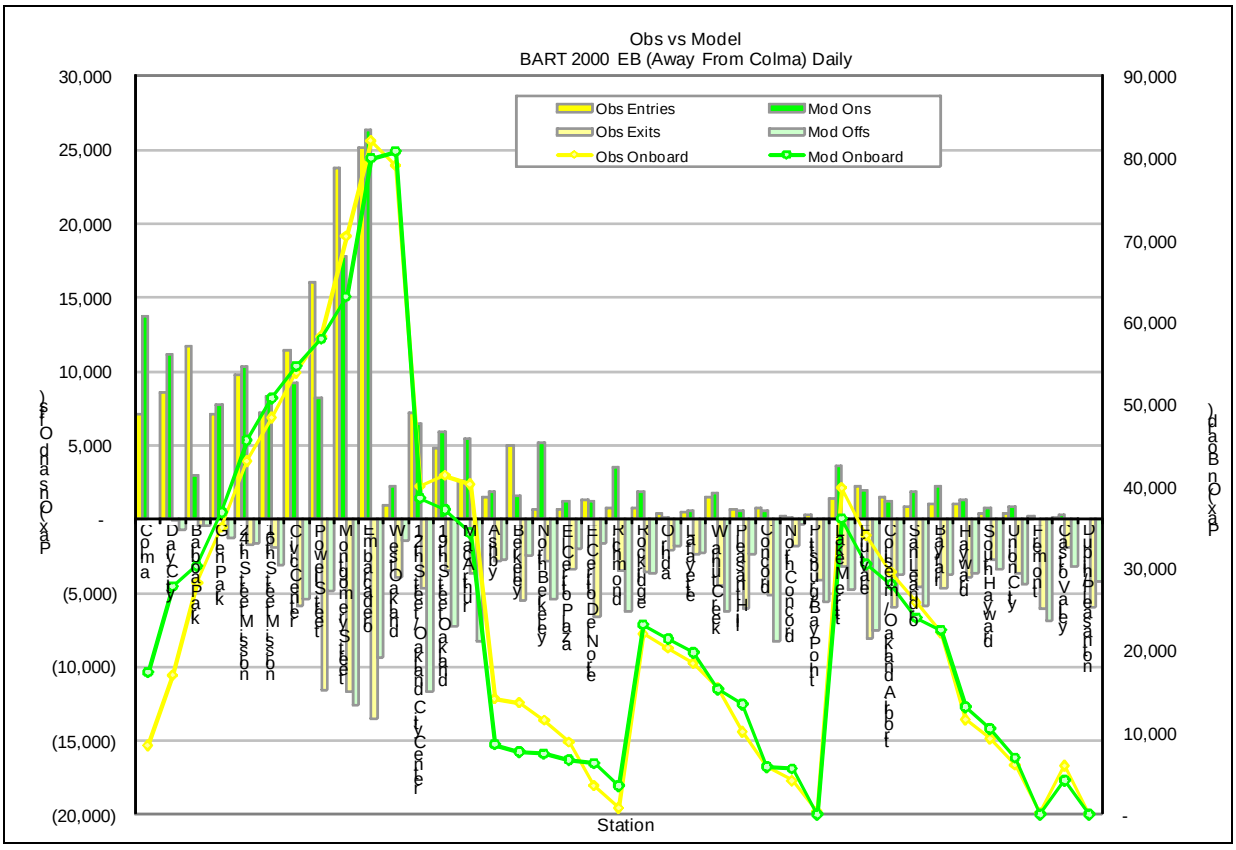
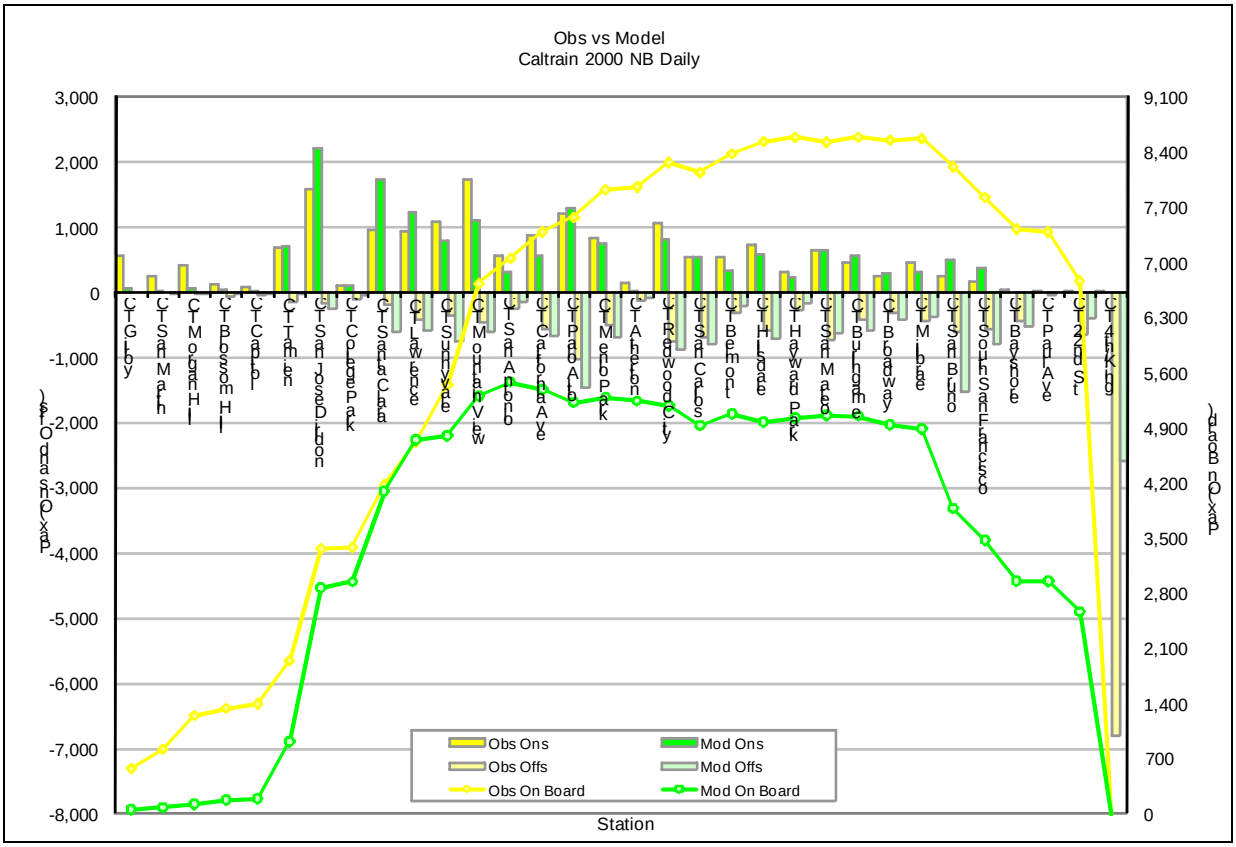


Figure 46: BART Passenger Ons, Offs, and On Board by Station



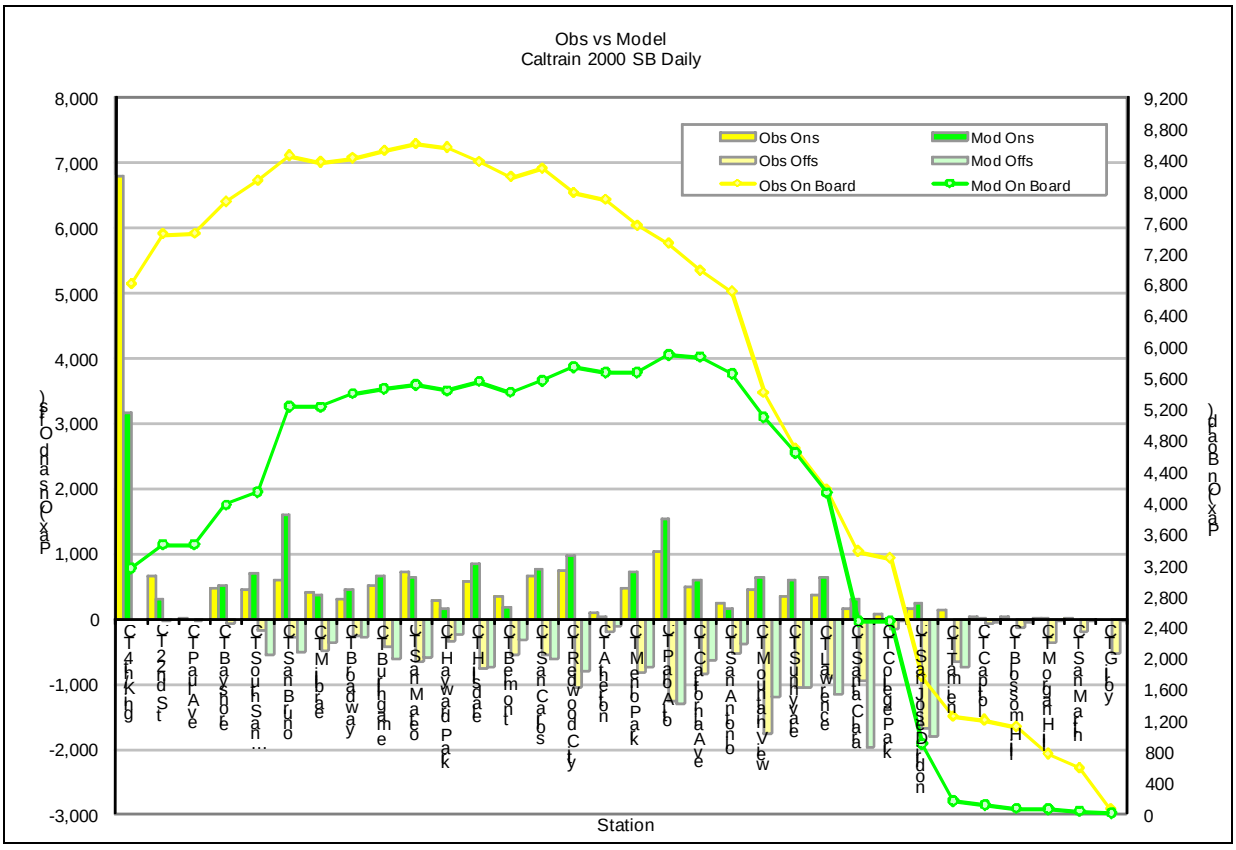


Figure 47: Caltrain Passenger Ons, Offs, and On Board by Station

4 Model Year 2005 Validation

This section presents the highway and transit assignment results for the year 2005, with comparisons to observed data from the Caltrans highway traffic count database and reported transit operator system boardings. Comparing the final results for a later base year to observed travel patterns provides a test of the model's robustness. Because the primary inputs to the model (households, employment, and transportation network supply characteristics) changed between 2000 and 2005 (Table 64 and Table 65), performing a comparison in 2005 allows us to see where the model responds appropriately to changes in inputs, and where it does not. It is possible to match the observed patterns in the year of the household travel survey to any degree of detail with enough model parameters, but the model will respond correctly to future year changes in inputs only if it is well designed and calibrated.

Table 64: Change in Demographics by County, 2000 to 2005

		Household Income Distribution (2000 $)					Person Age Distribution				
County	Households	$0-30k	$30-60k	$60-100k	$100k+	Persons	0-4	5-19	20-44	45-64	65+
San Francisco	9,225	-5%	-2%	0%	7%	19,059	2%	0%	-3%	0%	0%
San Mateo	5,959	-9%	-4%	0%	13%	14,727	0%	0%	-3%	3%	0%
Santa Clara	29,859	6%	0%	-3%	-3%	80,401	1%	1%	-4%	2%	0%
Alameda	20,410	-4%	-2%	0%	6%	61,490	0%	-1%	-1%	2%	0%
Contra Costa	24,196	-3%	-2%	0%	5%	74,574	0%	0%	-2%	2%	0%
Solano	11,635	-9%	-4%	2%	10%	27,058	-1%	-1%	-3%	3%	1%
Napa	3,855	-13%	-3%	5%	11%	9,416	0%	-1%	0%	2%	-1%
Sonoma	9,386	-6%	-2%	2%	6%	20,589	0%	-1%	-2%	3%	0%
Marin	2,535	-3%	-2%	-1%	7%	5,316	0%	0%	-5%	3%	1%
All	117,060	-3%	-2%	0%	5%	312,630	0%	0%	-3%	2%	0%

Table 65: Change in Employment by County, 2000 to 2005

	Employment					
County	RETEMPN	FPSEMPN	HEREMPN	OTHEMPN	AGREMPN	MWTEMPN
San Francisco	-10,200	-27,797	-12,289	-17,457	-24	-21,661
San Mateo	-10,459	-5,392	-8,230	-3,080	-40	-21,952
Santa Clara	-12,922	-44,775	-5,704	-26,857	-62	-80,968
Alameda	-3,301	1,853	3,777	245	-195	-22,262
Contra Costa	-331	-1,002	10,314	2,133	-	-3,376
Solano	1,455	3,154	6,065	2,565	-48	591
Napa	432	613	1,576	485	363	860
Sonoma	-436	1,557	1,492	-95	-317	-3,256
Marin	292	448	474	176	-1	-22
All	-35,470	-71,341	-2,525	-41,885	-324	-152,046

4.1 Highway Assignment

The 2005 highway network is shown in Figure 48. It shows that there are a several additional HOV 2 facilities beyond those available in 2000: on I-680, north of Walnut Creek and through Fremont; on I-580, between Albany and Richmond, on 87 in San Jose, and on 101 south of San Jose and south of Santa Rosa.

Highway counts by time period, facility type, and area type appear in Table 66. The overall pattern is similar to that in the 2000 validation, but the daily traffic volume on all matched facilities, rather than being slightly high, is slightly low by 5 percent. Daily volumes show greater deviations by facility type in 2005 than they did in 2000. While the number of counts on lower-volume facilities cautions against drawing conclusions about the volumes on collectors and arterials, the total volume on collectors is very low in 2005 (-44 percent). The volume on expressways is overestimated, as it was in 2000. Revision of the volume delay function lookup table is recommended to shift traffic between facility types. Daily percent root mean squared errors (%RMSE) are 30 percent overall, 24 percent on freeways, 51 percent on expressways, 123 percent on collectors, and 56 percent on arterials.

The traffic volumes by time of day are similar to 2000. Midday volumes are even lower at -15 percent, while the excess traffic in the peaks is now more moderate. Differences between modeled and observed volumes are broken out by volume category in Table 67. Again, the overall %RMSE and %RMSE on the highest volume category are within FHWA guidelines, but the deviations for lower volume facilities are not within the guidelines. It is possible that the variability in the observed count data is as large a source of this error as the error in the model because the Caltrans highway count database contains few observations for these lower volume facilities. Collecting a larger set of highway counts is recommended for future model validations.

A scatter plot of modeled vs. observed highway volumes appears for daily traffic in Figure 49 and by time of day in Figure 50 to Figure 54. As in 2000, no systematic pattern of deviation can be observed, except for in the early AM, where higher volume facilities are under estimated.

Traffic volumes at bridge crossings and county lines appear for daily traffic in Table 68 and for the AM and PM peaks in Table 69 and Table 70. The match between observed and modeled volumes at these key locations is better in 2005 than it was in 2000. The maximum deviation in the screen lines with a significant number of observations (those in bold) is only 18% in 2005, whereas it was 24 percent in 2000. The total of the screen lines is now only 2% high, and the excesses in the AM and PM peaks are only 12 percent and 7 percent.

Year 2005 highway count data allowed investigation of the assignment of Shared Ride traffic to HOV lanes, as several specific HOV lane counts were taken that year. At first pass, traffic in the HOV lanes was too high during the peaks compared to the observations. Therefore, we implemented a thirty second penalty for shifting from the general purpose lanes to the HOV lanes (due to shifting in and out, the total penalty for most trips would be double this value, i.e. one minute). This penalty brought the average HOV volumes in line, as shown in Table 71.

As expected when looking at one particular lane, the variability of the residuals between the observed and modeled HOV lane volumes is quite high, as shown in Figure 55. Trying to find a pattern to the residuals, we looked at the corresponding general purpose lanes to see if

over/under-prediction on the HOV lanes was correlated with errors on the general purpose lanes. No pattern was found.

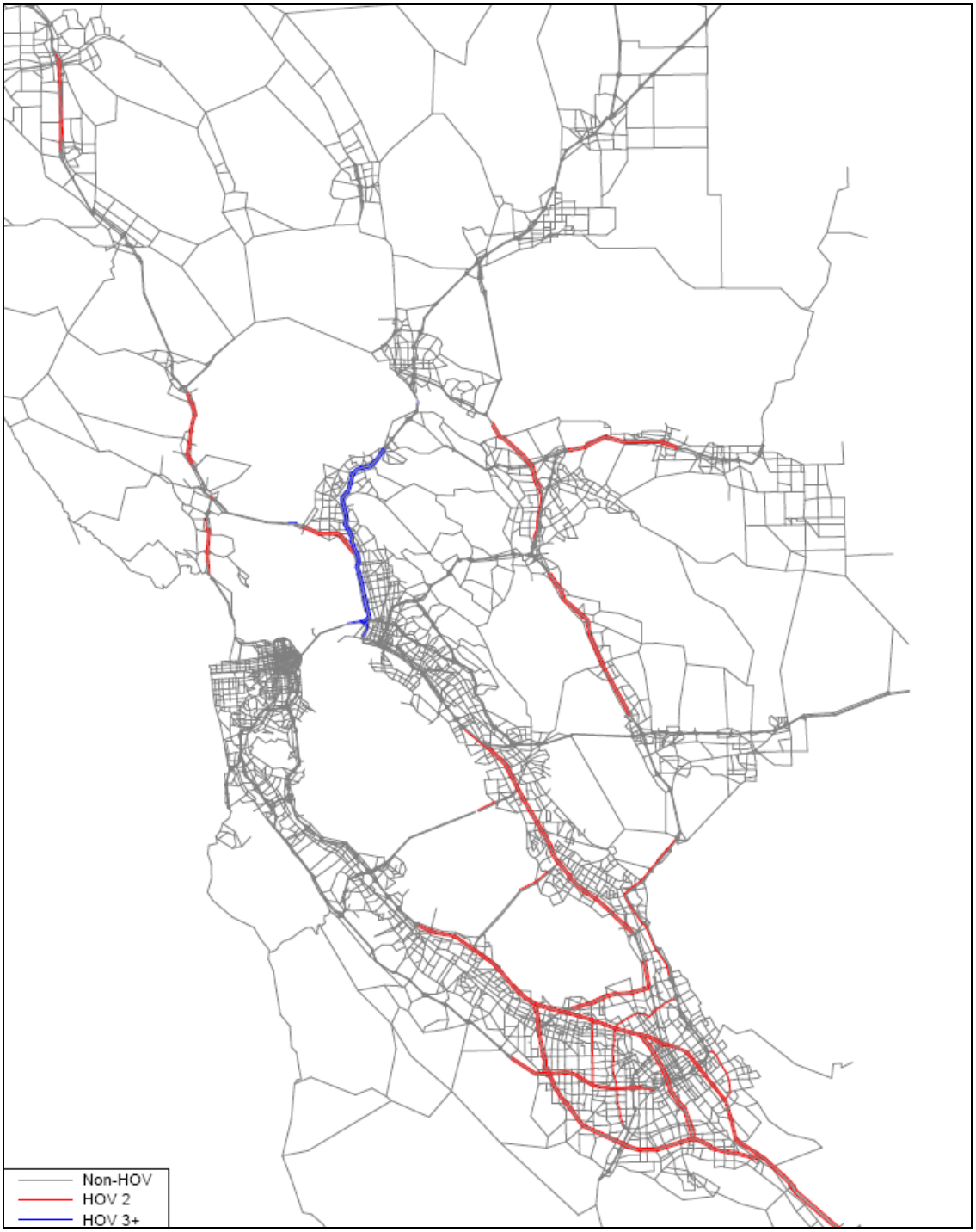


Figure 48: 2005 Highway Network

Table 66: Year 2005 Highway Counts by Period, Area Type, and Facility Type

Sum of Counts by Area Type and Facility Type
24-Hour Total

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core	Observed	-	-	-	-	-	-	44,001	44,001
0	Modeled	-	-	-	-	-	-	53,677	53,677
CBD	Observed	-	-	-	-	-	-	-	-
1	Modeled	-	-	-	-	-	-	-	-
UBD	Observed	62,449	1,763,859	48,785	-	-	-	245,212	2,120,305
2	Modeled	74,960	1,649,307	80,856	-	-	-	217,070	2,022,192
Urban	Observed	-	4,218,359	85,210	-	-	-	389,685	4,693,254
3	Modeled	-	3,803,249	92,040	-	-	-	310,511	4,205,801
Suburb.	Observed	71,835	4,706,493	208,730	16,247	16,022	-	116,864	5,136,191
4	Modeled	86,465	4,584,964	293,631	7,322	4,079	-	67,149	5,043,609
Rural	Observed	-	1,232,825	251,845	43,966	-	12,299	295,966	1,836,901
5	Modeled	-	1,195,713	281,934	26,451	-	12,686	295,482	1,812,266
Total	Observed	134,284	11,921,536	594,570	60,213	16,022	12,299	1,091,728	13,830,652
	Modeled	161,425	11,233,232	748,461	33,773	4,079	12,686	943,889	13,137,544

Difference in Sum of Counts by Area Type and Facility Type
24-Hour Total

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core	Diff	-	-	-	-	-	-	9,676	9,676
0	% Diff							22%	22%
CBD	Diff	-	-	-	-	-	-	-	-
1	% Diff								
UBD	Diff	12,511	-114,552	32,071	-	-	-	-28,142	-98,113
2	% Diff	20%	-6%	66%				-11%	-5%
Urban	Diff	-	-415,110	6,830	-	-	-	-79,174	-487,453
3	% Diff		-10%	8%				-20%	-10%
Suburb.	Diff	14,630	-121,529	84,901	-8,925	-11,943	-	-49,715	-92,582
4	% Diff	20%	-3%	41%	-55%	-75%		-43%	-2%
Rural	Diff	-	-37,112	30,089	-17,515	-	387	-484	-24,635
5	% Diff		-3%	12%	-40%		3%	-0%	-1%
Total	Diff	27,141	-688,304	153,891	-26,440	-11,943	387	-147,839	-693,108
	% Diff	20%	-6%	26%	-44%	-75%	3%	-14%	-5%
FHWA Target			*+/-7%*		*+/-25%*			*+/-10%*	

%RMSE in Counts by Area Type and Facility Type
24-Hour Total

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core	%RMSE							70%	
0	N	-	-	-	-	-	-	2	
CBD	%RMSE								
1	N	-	-	-	-	-	-	-	-
UBD	%RMSE	37%	25%	93%				44%	29%
2	N	2	29	2	-	-	-	13	46
Urban	%RMSE		25%	12%				56%	28%
3	N	-	68	2	-	-	-	24	94
Suburb.	%RMSE	53%	22%	67%	74%			74%	26%
4	N	3	97	12	3	1	-	8	124
Rural	%RMSE		25%	47%	146%		4%	38%	38%
5	N	-	33	14	20	-	3	43	113
Total	%RMSE	40%	24%	51%	123%		11%	56%	30%
	N	5	227	30	23	1	4	90	380

Sum of Counts by Area Type and Facility Type
Early AM (6 am to 10 am)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core 0	Observed	-	-	-	-	-	-	1,245	1,245
	Modeled	-	-	-	-	-	-	1,606	1,606
CBD 1	Observed	-	-	-	-	-	-	-	-
	Modeled	-	-	-	-	-	-	-	-
UBD 2	Observed	1,507	66,813	1,309	-	-	-	5,425	75,054
	Modeled	3,309	57,082	2,385	-	-	-	4,530	67,306
Urban 3	Observed	-	187,194	1,419	-	-	-	9,984	198,597
	Modeled	-	152,435	2,442	-	-	-	6,867	161,744
Suburb. 4	Observed	1,667	250,386	7,182	321	681	-	3,935	264,172
	Modeled	3,354	255,250	11,124	321	113	-	2,353	272,516
Rural 5	Observed	-	57,875	14,311	1,252	-	922	11,803	86,163
	Modeled	-	65,337	19,745	2,020	-	1,545	17,164	105,811
Total	Observed	3,174	562,268	24,221	1,573	681	922	32,392	625,231
	Modeled	6,664	530,104	35,697	2,341	113	1,545	32,520	608,983

Difference in Sum of Counts by Area Type and Facility Type
Early AM (6 am to 10 am)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core 0	Diff	-	-	-	-	-	-	361	361
	% Diff							29%	29%
CBD 1	Diff	-	-	-	-	-	-	-	-
	% Diff								
UBD 2	Diff	1,802	-9,731	1,076	-	-	-	-895	-7,748
	% Diff	120%	-15%	82%				-17%	-10%
Urban 3	Diff	-	-34,759	1,023	-	-	-	-3,117	-36,853
	% Diff		-19%	72%				-31%	-19%
Suburb. 4	Diff	1,687	4,864	3,942	-0	-568	-	-1,582	8,344
	% Diff	101%	2%	55%	-0%	-83%		-40%	3%
Rural 5	Diff	-	7,462	5,434	768	-	623	5,361	19,648
	% Diff		13%	38%	61%		68%	45%	23%
Total	Diff	3,490	-32,164	11,476	768	-568	623	128	-16,248
	% Diff	110%	-6%	47%	49%	-83%	68%	0%	-3%

%RMSE in Counts by Area Type and Facility Type
Early AM (6 am to 10 am)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core 0	%RMSE							0%	
	N	-	-	-	-	-	-	2	
CBD 1	%RMSE								
	N	-	-	-	-	-	-	-	-
UBD 2	%RMSE	329%	40%	0%				0%	50%
	N	2	29	2	-	-	-	13	46
Urban 3	%RMSE		28%	0%				0%	31%
	N	-	68	2	-	-	-	24	94
Suburb. 4	%RMSE	0%	44%	0%	0%			0%	47%
	N	3	97	12	3	1	-	8	124
Rural 5	%RMSE		11%	0%	0%		0%	0%	14%
	N	-	33	14	20	-	3	43	113
Total	%RMSE	195%	37%	0%	0%		0%	0%	44%
	N	5	227	30	23	1	4	90	380

Sum of Counts by Area Type and Facility Type
AM Peak (6 am to 10 am)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core 0	Observed	-	-	-	-	-	-	8,729	8,729
	Modeled	-	-	-	-	-	-	12,523	12,523
CBD 1	Observed	-	-	-	-	-	-	-	-
	Modeled	-	-	-	-	-	-	-	-
UBD 2	Observed	13,836	417,267	10,575	-	-	-	50,239	491,917
	Modeled	16,742	401,325	19,410	-	-	-	47,933	485,410
Urban 3	Observed	-	1,004,854	17,721	-	-	-	80,946	1,103,521
	Modeled	-	977,574	25,372	-	-	-	76,227	1,079,173
Suburb. 4	Observed	17,781	1,100,280	49,662	3,640	4,661	-	29,098	1,205,122
	Modeled	22,200	1,190,180	73,237	1,216	1,092	-	21,130	1,309,055
Rural 5	Observed	-	295,641	61,541	11,000	-	3,782	73,935	445,899
	Modeled	-	327,682	74,144	7,840	-	3,454	80,373	493,493
Total	Observed	31,617	2,818,042	139,499	14,640	4,661	3,782	242,947	3,255,188
	Modeled	38,942	2,896,761	192,163	9,056	1,092	3,454	238,186	3,379,654

Difference in Sum of Counts by Area Type and Facility Type
AM Peak (6 am to 10 am)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core 0	Diff	-	-	-	-	-	-	3,794	3,794
	% Diff							43%	43%
CBD 1	Diff	-	-	-	-	-	-	-	-
	% Diff								
UBD 2	Diff	2,906	-15,942	8,835	-	-	-	-2,306	-6,507
	% Diff	21%	-4%	84%				-5%	-1%
Urban 3	Diff	-	-27,280	7,651	-	-	-	-4,719	-24,348
	% Diff		-3%	43%				-6%	-2%
Suburb. 4	Diff	4,419	89,900	23,575	-2,424	-3,569	-	-7,968	103,933
	% Diff	25%	8%	47%	-67%	-77%		-27%	9%
Rural 5	Diff	-	32,041	12,603	-3,160	-	-328	6,438	47,594
	% Diff		11%	20%	-29%		-9%	9%	11%
Total	Diff	7,325	78,719	52,664	-5,584	-3,569	-328	-4,761	124,466
	% Diff	23%	3%	38%	-38%	-77%	-9%	-2%	4%

%RMSE in Counts by Area Type and Facility Type
AM Peak (6 am to 10 am)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core 0	%RMSE							118%	
	N	-	-	-	-	-	-	2	
CBD 1	%RMSE								
	N	-	-	-	-	-	-	-	-
UBD 2	%RMSE	37%	22%	118%				64%	28%
	N	2	29	2	-	-	-	13	46
Urban 3	%RMSE		22%	61%				63%	26%
	N	-	68	2	-	-	-	24	94
Suburb. 4	%RMSE	65%	30%	79%	97%			57%	33%
	N	3	97	12	3	1	-	8	124
Rural 5	%RMSE		37%	41%	175%		18%	43%	50%
	N	-	33	14	20	-	3	43	113
Total	%RMSE	47%	26%	60%	151%		24%	63%	33%
	N	5	227	30	23	1	4	90	380

Sum of Counts by Area Type and Facility Type
Midday (10 am to 3 pm)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core	Observed	-	-	-	-	-	-	12,544	12,544
0	Modeled	-	-	-	-	-	-	15,153	15,153
CBD	Observed	-	-	-	-	-	-	-	-
1	Modeled	-	-	-	-	-	-	-	-
UBD	Observed	17,554	471,464	15,251	-	-	-	72,188	576,457
2	Modeled	19,341	427,945	23,308	-	-	-	57,175	527,769
Urban	Observed	-	1,134,519	24,408	-	-	-	113,970	1,272,897
3	Modeled	-	946,032	24,840	-	-	-	84,413	1,055,285
Suburb.	Observed	17,838	1,286,389	61,078	4,353	5,125	-	33,291	1,408,074
4	Modeled	18,952	1,099,247	72,648	1,591	1,078	-	16,597	1,210,114
Rural	Observed	-	314,618	70,378	12,126	-	3,070	91,877	492,069
5	Modeled	-	260,497	63,868	6,025	-	3,134	66,395	399,921
Total	Observed	35,392	3,206,990	171,115	16,479	5,125	3,070	323,870	3,762,041
	Modeled	38,293	2,733,721	184,664	7,617	1,078	3,134	239,734	3,208,242

Difference in Sum of Counts by Area Type and Facility Type
Midday (10 am to 3 pm)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core	Diff	-	-	-	-	-	-	2,609	2,609
0	% Diff							21%	21%
CBD	Diff	-	-	-	-	-	-	-	-
1	% Diff								
UBD	Diff	1,787	-43,519	8,057	-	-	-	-15,013	-48,688
2	% Diff	10%	-9%	53%				-21%	-8%
Urban	Diff	-	-188,487	432	-	-	-	-29,557	-217,612
3	% Diff		-17%	2%				-26%	-17%
Suburb.	Diff	1,114	-187,142	11,570	-2,762	-4,047	-	-16,694	-197,960
4	% Diff	6%	-15%	19%	-63%	-79%		-50%	-14%
Rural	Diff	-	-54,121	-6,510	-6,101	-	64	-25,482	-92,148
5	% Diff		-17%	-9%	-50%		2%	-28%	-19%
Total	Diff	2,901	-473,269	13,549	-8,862	-4,047	64	-84,136	-553,799
	% Diff	8%	-15%	8%	-54%	-79%	2%	-26%	-15%

%RMSE in Counts by Area Type and Facility Type
Midday (10 am to 3 pm)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core	%RMSE							73%	
0	N	-	-	-	-	-	-	2	
CBD	%RMSE								
1	N	-	-	-	-	-	-	-	-
UBD	%RMSE	22%	25%	75%				44%	29%
2	N	2	29	2	-	-	-	13	46
Urban	%RMSE		29%	5%				56%	32%
3	N	-	68	2	-	-	-	24	94
Suburb.	%RMSE	49%	28%	49%	83%			75%	31%
4	N	3	97	12	3	1	-	8	124
Rural	%RMSE		30%	49%	142%		10%	53%	44%
5	N	-	33	14	20	-	3	43	113
Total	%RMSE	32%	28%	44%	123%		11%	57%	34%
	N	5	227	30	23	1	4	90	380

Sum of Counts by Area Type and Facility Type
PM Peak (3 pm to 7 pm)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core 0	Observed	-	-	-	-	-	-	11,475	11,475
	Modeled	-	-	-	-	-	-	16,850	16,850
CBD 1	Observed	-	-	-	-	-	-	-	-
	Modeled	-	-	-	-	-	-	-	-
UBD 2	Observed	16,987	454,003	12,950	-	-	-	72,207	556,147
	Modeled	18,828	448,482	21,449	-	-	-	70,143	558,902
Urban 3	Observed	-	1,107,510	22,999	-	-	-	110,578	1,241,087
	Modeled	-	1,084,404	25,505	-	-	-	97,326	1,207,235
Suburb. 4	Observed	22,764	1,251,427	61,866	5,661	3,902	-	33,686	1,379,306
	Modeled	25,142	1,274,927	87,757	3,095	1,176	-	18,390	1,410,487
Rural 5	Observed	-	351,585	69,669	14,044	-	3,071	82,668	521,037
	Modeled	-	360,580	77,108	7,262	-	2,918	82,368	530,235
Total	Observed	39,751	3,164,525	167,484	19,705	3,902	3,071	310,614	3,709,052
	Modeled	43,970	3,168,393	211,818	10,356	1,176	2,918	285,077	3,723,709

Difference in Sum of Counts by Area Type and Facility Type
PM Peak (3 pm to 7 pm)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core 0	Diff	-	-	-	-	-	-	5,375	5,375
	% Diff							47%	47%
CBD 1	Diff	-	-	-	-	-	-	-	-
	% Diff								
UBD 2	Diff	1,841	-5,521	8,499	-	-	-	-2,064	2,755
	% Diff	11%	-1%	66%				-3%	0%
Urban 3	Diff	-	-23,106	2,506	-	-	-	-13,252	-33,852
	% Diff		-2%	11%				-12%	-3%
Suburb. 4	Diff	2,378	23,500	25,891	-2,566	-2,726	-	-15,296	31,181
	% Diff	10%	2%	42%	-45%	-70%		-45%	2%
Rural 5	Diff	-	8,995	7,439	-6,782	-	-153	-300	9,198
	% Diff		3%	11%	-48%		-5%	-0%	2%
Total	Diff	4,219	3,868	44,334	-9,349	-2,726	-153	-25,537	14,657
	% Diff	11%	0%	26%	-47%	-70%	-5%	-8%	0%

%RMSE in Counts by Area Type and Facility Type
PM Peak (3 pm to 7 pm)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core 0	%RMSE							73%	
	N	-	-	-	-	-	-	2	
CBD 1	%RMSE								
	N	-	-	-	-	-	-	-	-
UBD 2	%RMSE	28%	27%	93%				46%	31%
	N	2	29	2	-	-	-	13	46
Urban 3	%RMSE		24%	16%				53%	27%
	N	-	68	2	-	-	-	24	94
Suburb. 4	%RMSE	31%	26%	66%	60%			88%	30%
	N	3	97	12	3	1	-	8	124
Rural 5	%RMSE		29%	40%	125%		17%	42%	41%
	N	-	33	14	20	-	3	43	113
Total	%RMSE	26%	26%	49%	103%		19%	58%	31%
	N	5	227	30	23	1	4	90	380

Sum of Counts by Area Type and Facility Type
Evening (7 pm to 3 am)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core	Observed	-	-	-	-	-	-	10,008	10,008
0	Modeled	-	-	-	-	-	-	7,545	7,545
CBD	Observed	-	-	-	-	-	-	-	-
1	Modeled	-	-	-	-	-	-	-	-
UBD	Observed	12,565	354,312	8,700	-	-	-	45,153	420,730
2	Modeled	16,740	314,472	14,304	-	-	-	37,289	382,805
Urban	Observed	-	784,282	18,663	-	-	-	74,207	877,152
3	Modeled	-	642,805	13,881	-	-	-	45,678	702,364
Suburb.	Observed	11,785	818,011	28,942	2,272	1,653	-	16,854	879,517
4	Modeled	16,816	765,360	48,865	1,099	620	-	8,678	841,437
Rural	Observed	-	213,106	35,946	5,544	-	1,454	35,683	291,733
5	Modeled	-	181,616	47,069	3,304	-	1,634	49,182	282,805
Total	Observed	24,350	2,169,711	92,251	7,816	1,653	1,454	181,905	2,479,140
	Modeled	33,556	1,904,253	124,118	4,403	620	1,634	148,372	2,216,957

Difference in Sum of Counts by Area Type and Facility Type
Evening (7 pm to 3 am)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core	Diff	-	-	-	-	-	-	-2,463	-2,463
0	% Diff							-25%	-25%
CBD	Diff	-	-	-	-	-	-	-	-
1	% Diff								
UBD	Diff	4,175	-39,840	5,604	-	-	-	-7,864	-37,925
2	% Diff	33%	-11%	64%				-17%	-9%
Urban	Diff	-	-141,477	-4,782	-	-	-	-28,529	-174,788
3	% Diff		-18%	-26%				-38%	-20%
Suburb.	Diff	5,031	-52,651	19,923	-1,173	-1,033	-	-8,176	-38,080
4	% Diff	43%	-6%	69%	-52%	-63%		-49%	-4%
Rural	Diff	-	-31,490	11,123	-2,240	-	180	13,499	-8,928
5	% Diff		-15%	31%	-40%		12%	38%	-3%
Total	Diff	9,206	-265,458	31,867	-3,413	-1,033	180	-33,533	-262,183
	% Diff	38%	-12%	35%	-44%	-63%	12%	-18%	-11%

%RMSE in Counts by Area Type and Facility Type
Evening (7 pm to 3 am)

Area Type	Data Type	Facility Type							Total
		Fwy-to-Fwy 1	Freeway 2	Expwy 3	Collector 4	Ramp 5	Dummy 6	Arterial 7	
Core	%RMSE							64%	
0	N	-	-	-	-	-	-	2	
CBD	%RMSE								
1	N	-	-	-	-	-	-	-	-
UBD	%RMSE	60%	38%	92%				55%	43%
2	N	2	29	2	-	-	-	13	46
Urban	%RMSE		48%	38%				65%	52%
3	N	-	68	2	-	-	-	24	94
Suburb.	%RMSE	82%	38%	119%	64%			100%	43%
4	N	3	97	12	3	1	-	8	124
Rural	%RMSE		45%	86%	157%		19%	67%	69%
5	N	-	33	14	20	-	3	43	113
Total	%RMSE	61%	44%	82%	127%		24%	72%	52%
	N	5	227	30	23	1	4	90	380

Table 67: Modeled and Observed Volumes by Volume Category

Vol. Low	Vol. High	Obs. Vol.	Mod. Vol.	Diff.	% Diff.	N	%RMSE	FHWA Target
0	1,000	4,638	1,001	-3,637	-78%	63	222%	60%
1,000	2,500	25,459	40,581	15,122	59%	14	182%	47%
2,500	5,000	50,577	96,998	46,421	92%	14	244%	36%
5,000	10,000	207,276	178,794	-28,482	-14%	27	44%	29%
10,000	25,000	1,489,492	1,451,882	-37,610	-3%	88	44%	25%
25,000	50,000	1,509,348	1,602,198	92,850	6%	43	35%	22%
50,000	+	10,531,563	9,753,405	-778,158	-7%	124	19%	21%
Total		13,818,353	13,124,859	-693,494	-5%	373	29%	35%

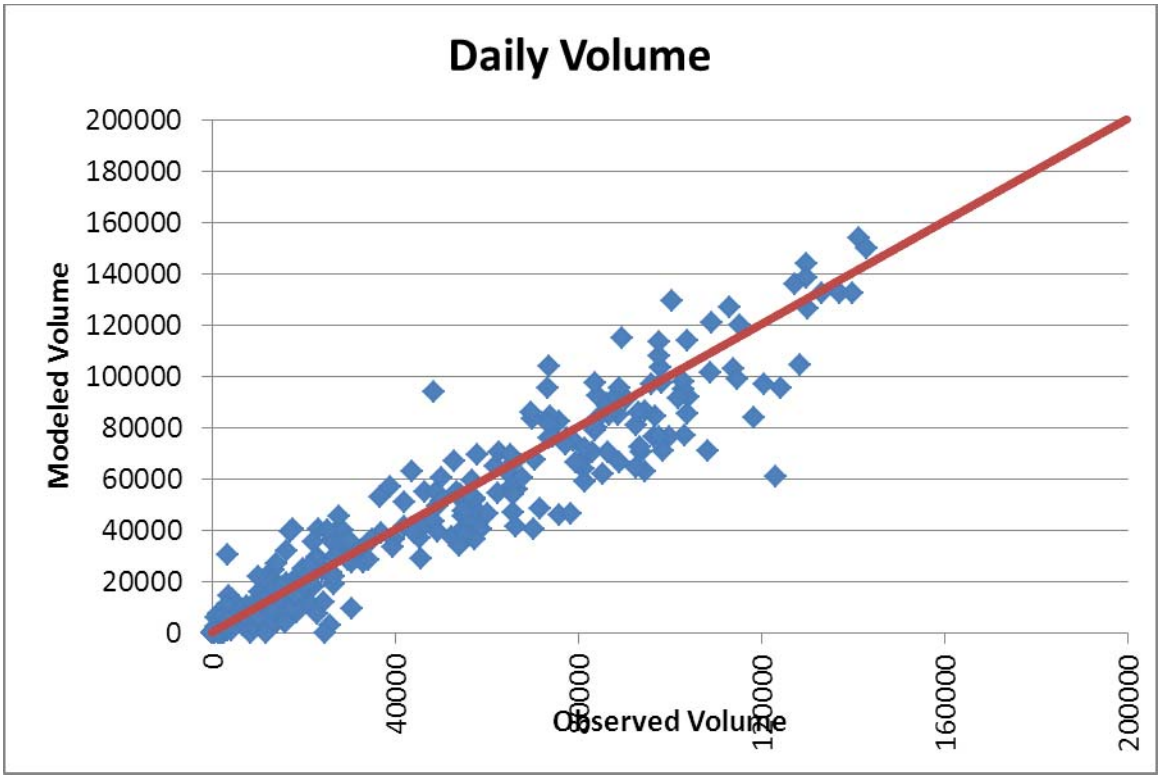


Figure 49: Scatter plot of Modeled versus Observed Daily Traffic Volume

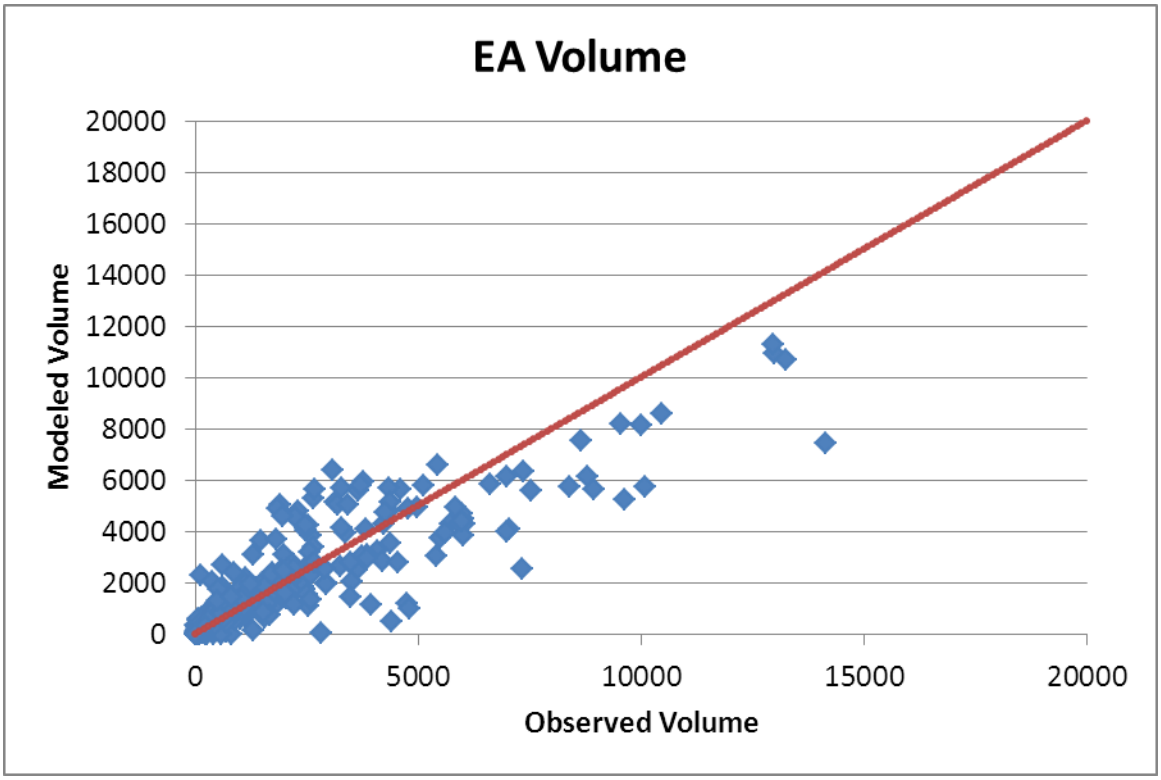


Figure 50: Scatter plot of Modeled versus Observed Early AM Traffic Volume

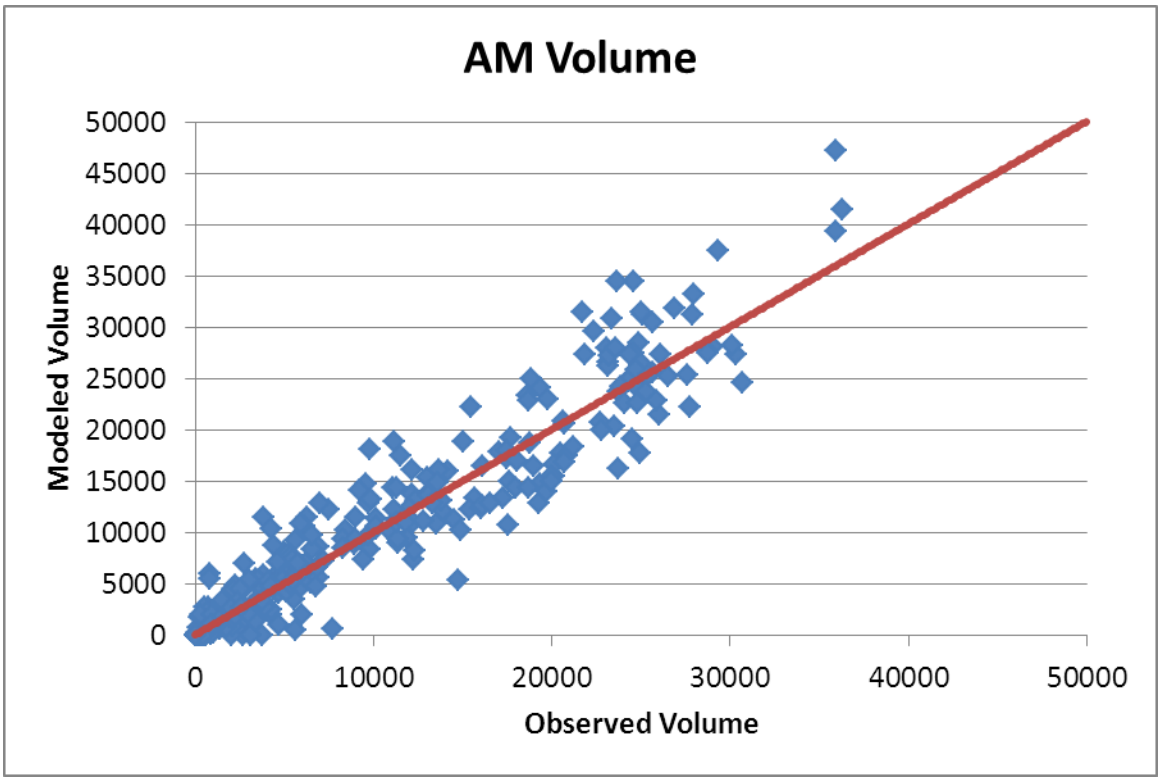


Figure 51: Scatter plot of Modeled versus Observed AM Peak Traffic Volume

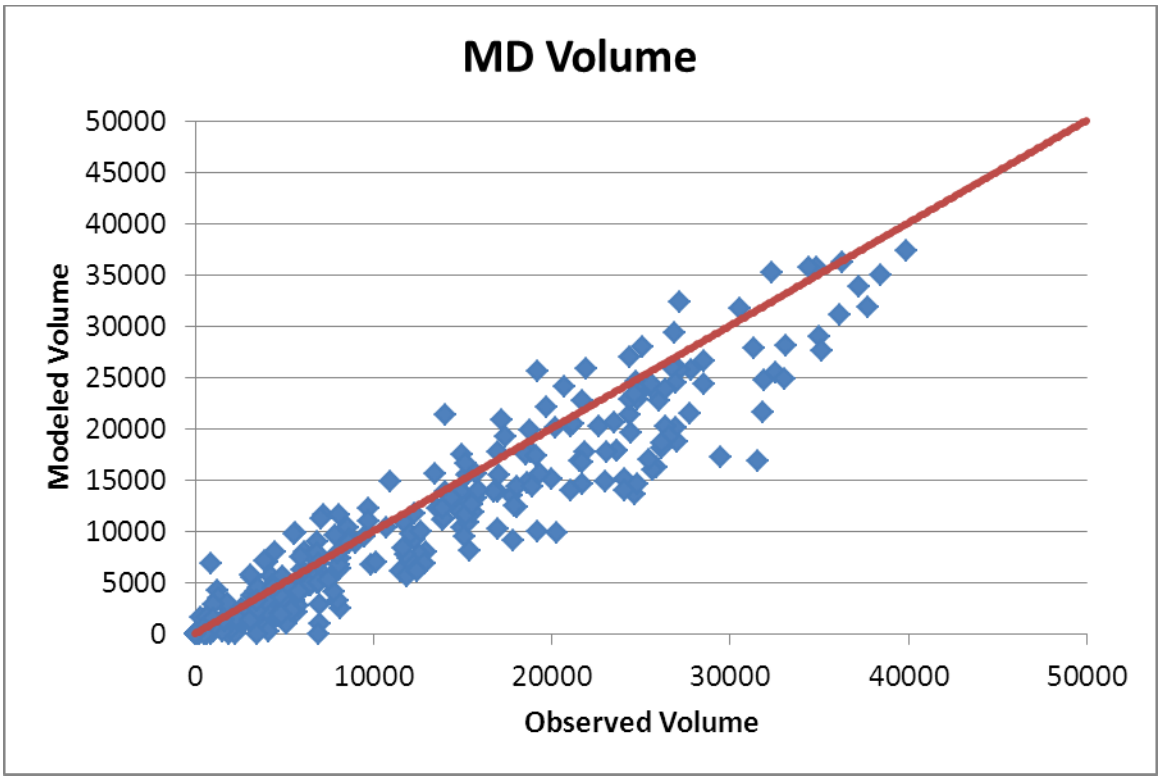


Figure 52: Scatter plot of Modeled versus Observed Midday Traffic Volume

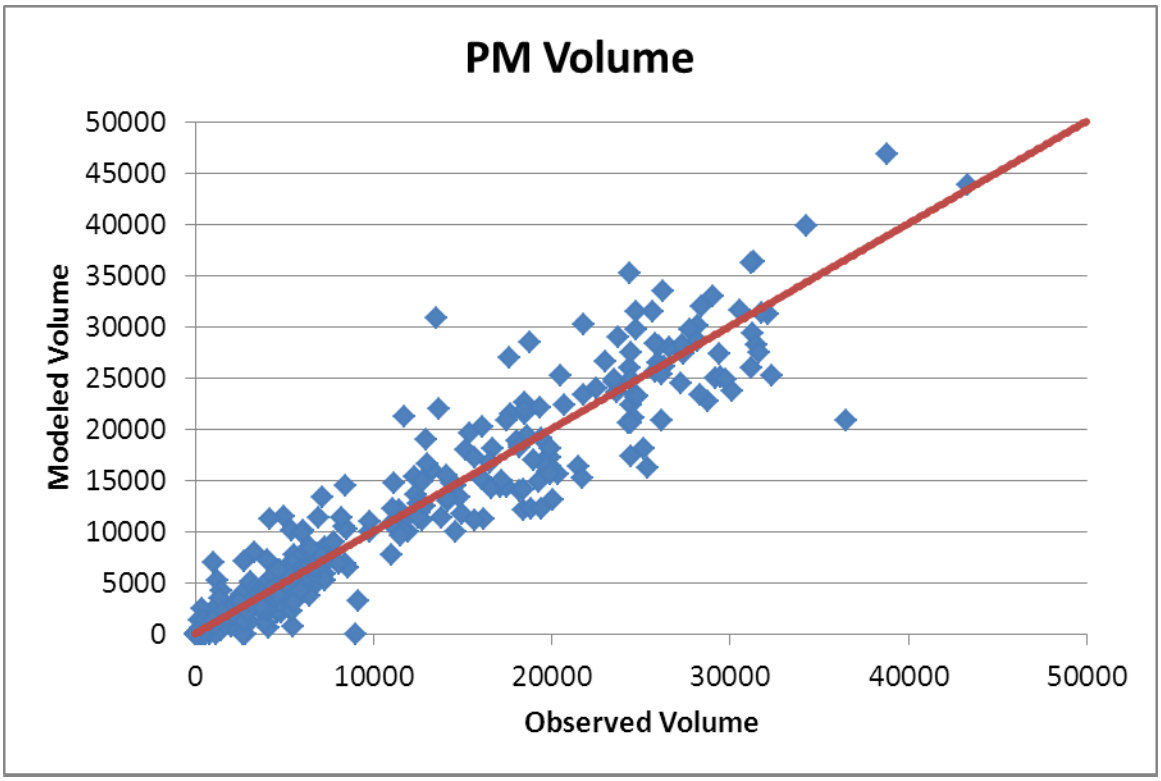


Figure 53: Scatter plot of Modeled versus Observed PM Peak Traffic Volume

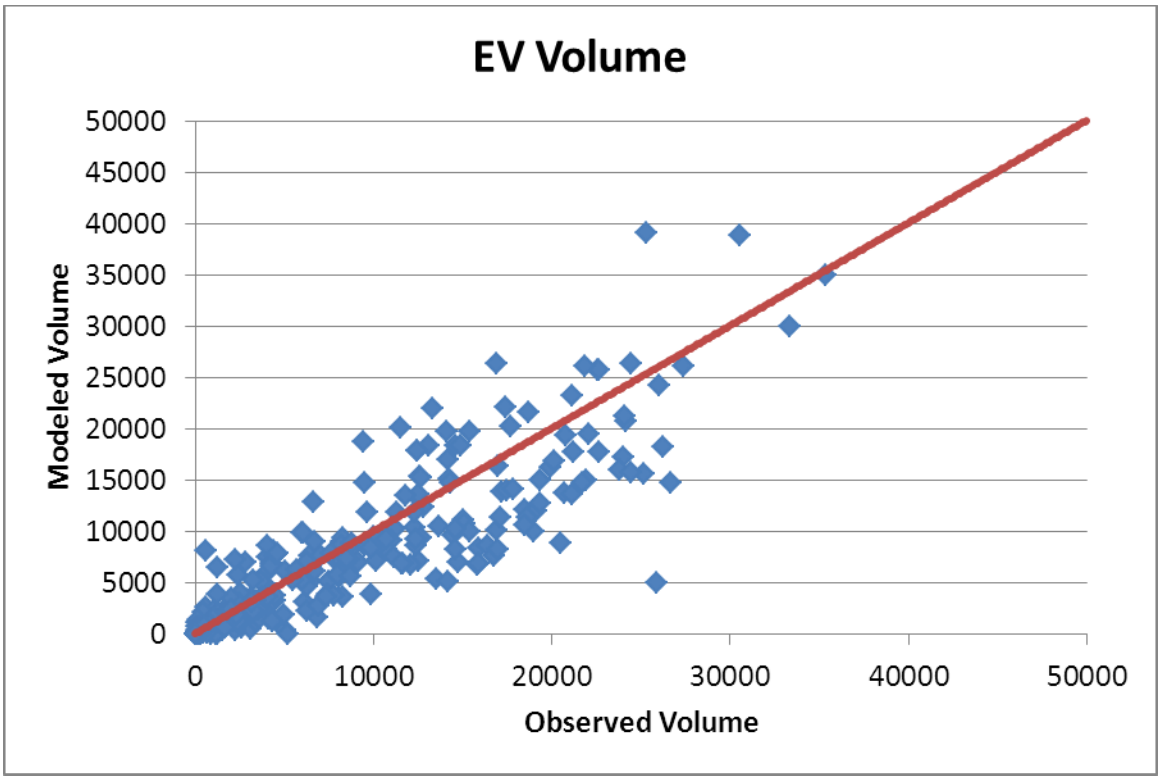


Figure 54: Scatter plot of Modeled versus Observed Evening Traffic Volume

Table 68: Daily Traffic Assignment Validation at Key Locations

Screenline **Facility**	**Avg. Weekday Daily Traffic**		**Predicted**	**Percent**
	Observed	**Predicted**	**less Obs.**	**Difference**
Bay Area Bridges				
US-101, Golden Gate Bridge (S)	92,588	112,471	19,883	21.5%
I-80, SF/Oakland Bay Bridge	282,900	282,354	-546	-0.2%
Cal-84, Dumbarton Bridge (N)	43,798	63,172	19,374	44.2%
I-580, Richmond/San Rafael Bridge (E)	42,066	51,054	8,988	21.4%
I-680, Benicia/Martinez Bridge	69,927	83,303	13,376	19.1%
Cal-160, Antioch Bridge	15,797	15,737	-60	-0.4%
Bay Area Bridges Sub-Total	***547,076***	***608,091***	***61,015***	***11.2%***
San Francisco/San Mateo County Line				
US-101, Bayshore Freeway (N)	102,928	98,186	-4,742	-4.6%
Cal-1, Junipero Serra Blvd. (N)	57,001	59,731	2,730	4.8%
I-280, Foran Freeway	141,982	89,136	-52,847	-37.2%
SF/SM County Line Sub-Total	***301,911***	***247,052***	***-54,859***	***-18.2%***
San Mateo/Santa Clara County Line				
Cal-82, El Camino Real (N)	24,407	12,341	-12,066	-49.4%
US-101, Bayshore Freeway (N)	109,230	120,923	11,693	10.7%
I-280, Serra Freeway (N)	66,312	41,537	-24,775	-37.4%
SM/SC County Line Sub-Total	***199,949***	***174,801***	***-25,148***	***-12.6%***
Alameda/Contra Costa County Line				
I-580, Knox Freeway	95,690	110,150	14,460	15.1%
I-80, Eastshore Freeway	181,215	182,575	1,360	0.8%
Cal-24, Caldecott Tunnel (E)	73,596	104,083	30,487	41.4%
I-680, in Dublin/San Ramon	174,712	181,256	6,544	3.7%
Ala/CC County Line Sub-Total	***525,213***	***578,064***	***52,851***	***10.1%***
Solano/Napa County Line				
Route 29, Napa-Vallejo Highway (N)	17,283	39,791	22,508	130.2%
Solano/Sonoma County Line				
Route 37, Sears Point Road	36,852	25,190	-11,662	-31.6%
Sonoma/Marin County Line				
US-101, Redwood Highway (N)	79,503	66,492	-13,011	-16.4%
Screenline Totals	***1,707,787***	***1,739,481***	***31,694***	***1.9%***

Table 69: AM Peak Traffic Assignment Validation at Key Locations

Screenline Facility	Avg. Weekday AM Traffic Observed	Predicted	Predicted less Obs.	Percent Difference
Bay Area Bridges				
US-101, Golden Gate Bridge (S)	28,784	34,099	5,315	18.5%
I-80, SF/Oakland Bay Bridge	62,811	79,043	16,232	25.8%
Cal-84, Dumbarton Bridge (N)	6,280	11,475	5,195	82.7%
I-580, Richmond/San Rafael Bridge (E)	9,593	14,750	5,157	53.8%
I-680, Benicia/Martinez Bridge	13,190	14,006	816	6.2%
Cal-160, Antioch Bridge	3,999	3,914	-85	-2.1%
Bay Area Bridges Sub-Total	***124,657***	***157,288***	***32,631***	***26.2%***
San Francisco/San Mateo County Line				
US-101, Bayshore Freeway (N)	24,721	25,856	1,135	4.6%
Cal-1, Junipero Serra Blvd. (N)	12,131	16,152	4,021	33.1%
I-280, Foran Freeway	32,823	22,509	-10,314	-31.4%
SF/SM County Line Sub-Total	***69,675***	***64,517***	***-5,158***	***-7.4%***
San Mateo/Santa Clara County Line				
Cal-82, El Camino Real (N)	5,526	3,529	-1,997	-36.1%
US-101, Bayshore Freeway (N)	24,401	24,987	586	2.4%
I-280, Serra Freeway (N)	23,742	16,291	-7,451	-31.4%
SM/SC County Line Sub-Total	***53,669***	***44,807***	***-8,862***	***-16.5%***
Alameda/Contra Costa County Line				
I-580, Knox Freeway	24,504	31,834	7,330	29.9%
I-80, Eastshore Freeway	36,526	45,572	9,046	24.8%
Cal-24, Caldecott Tunnel (E)	11,498	17,548	6,050	52.6%
I-680, in Dublin/San Ramon	44,574	48,074	3,500	7.9%
Ala/CC County Line Sub-Total	***117,102***	***143,028***	***25,926***	***22.1%***
Solano/Napa County Line				
Route 29, Napa-Vallejo Highway (N)	4,249	10,372	6,123	144.1%
Solano/Sonoma County Line				
Route 37, Sears Point Road	9,367	8,137	-1,230	-13.1%
Sonoma/Marin County Line				
US-101, Redwood Highway (N)	12,816	11,176	-1,640	-12.8%
Screenline Totals	***391,535***	***439,325***	***47,790***	***12.2%***

Table 70: PM Peak Traffic Assignment Validation at Key Locations

Screenline / Facility	Avg. Weekday PM Traffic		Predicted	Percent
	Observed	Predicted	less Obs.	Difference
Bay Area Bridges				
US-101, Golden Gate Bridge (S)	24,309	33,179	8,870	36.5%
I-80, SF/Oakland Bay Bridge	70,956	78,033	7,077	10.0%
Cal-84, Dumbarton Bridge (N)	16,077	20,251	4,174	26.0%
I-580, Richmond/San Rafael Bridge (E)	12,296	15,382	3,086	25.1%
I-680, Benicia/Martinez Bridge	21,764	23,435	1,671	7.7%
Cal-160, Antioch Bridge	4,328	4,092	-236	-5.5%
Bay Area Bridges Sub-Total	***149,730***	***174,372***	***24,642***	***16.5%***
San Francisco/San Mateo County Line				
US-101, Bayshore Freeway (N)	25,768	28,324	2,556	9.9%
Cal-1, Junipero Serra Blvd. (N)	15,676	17,288	1,612	10.3%
I-280, Foran Freeway	41,101	27,474	-13,627	-33.2%
SF/SM County Line Sub-Total	***82,545***	***73,085***	***-9,460***	***-11.5%***
San Mateo/Santa Clara County Line				
Cal-82, El Camino Real (N)	6,412	3,748	-2,664	-41.6%
US-101, Bayshore Freeway (N)	29,049	33,029	3,980	13.7%
I-280, Serra Freeway (N)	18,410	12,106	-6,304	-34.2%
SM/SC County Line Sub-Total	***53,871***	***48,882***	***-4,989***	***-9.3%***
Alameda/Contra Costa County Line				
I-580, Knox Freeway	26,231	35,049	8,818	33.6%
I-80, Eastshore Freeway	42,248	50,660	8,412	19.9%
Cal-24, Caldecott Tunnel (E)	24,728	31,495	6,767	27.4%
I-680, in Dublin/San Ramon	48,808	48,422	-386	-0.8%
Ala/CC County Line Sub-Total	***142,015***	***165,626***	***23,611***	***16.6%***
Solano/Napa County Line				
Route 29, Napa-Vallejo Highway (N)	4,198	11,233	7,035	167.6%
Solano/Sonoma County Line				
Route 37, Sears Point Road	9,684	7,891	-1,793	-18.5%
Sonoma/Marin County Line				
US-101, Redwood Highway (N)	27,237	24,517	-2,720	-10.0%
Screenline Totals	***469,280***	***505,605***	***36,325***	***7.7%***

Table 71: Peak Period HOV Lane Volumes

Period	Observed	Modeled	Difference	% Diff.	N	Avg. Vol.	Avg. Dev.	% RMSE
AM	89,109	104,178	15,069	16.9%	30	2,970	502	71.6%
PM	80,578	72,172	-8,406	-10.4%	27	2,984	-311	53.9%
Total	169,687	176,349	6,662	3.9%	57	2,977	117	63.6%

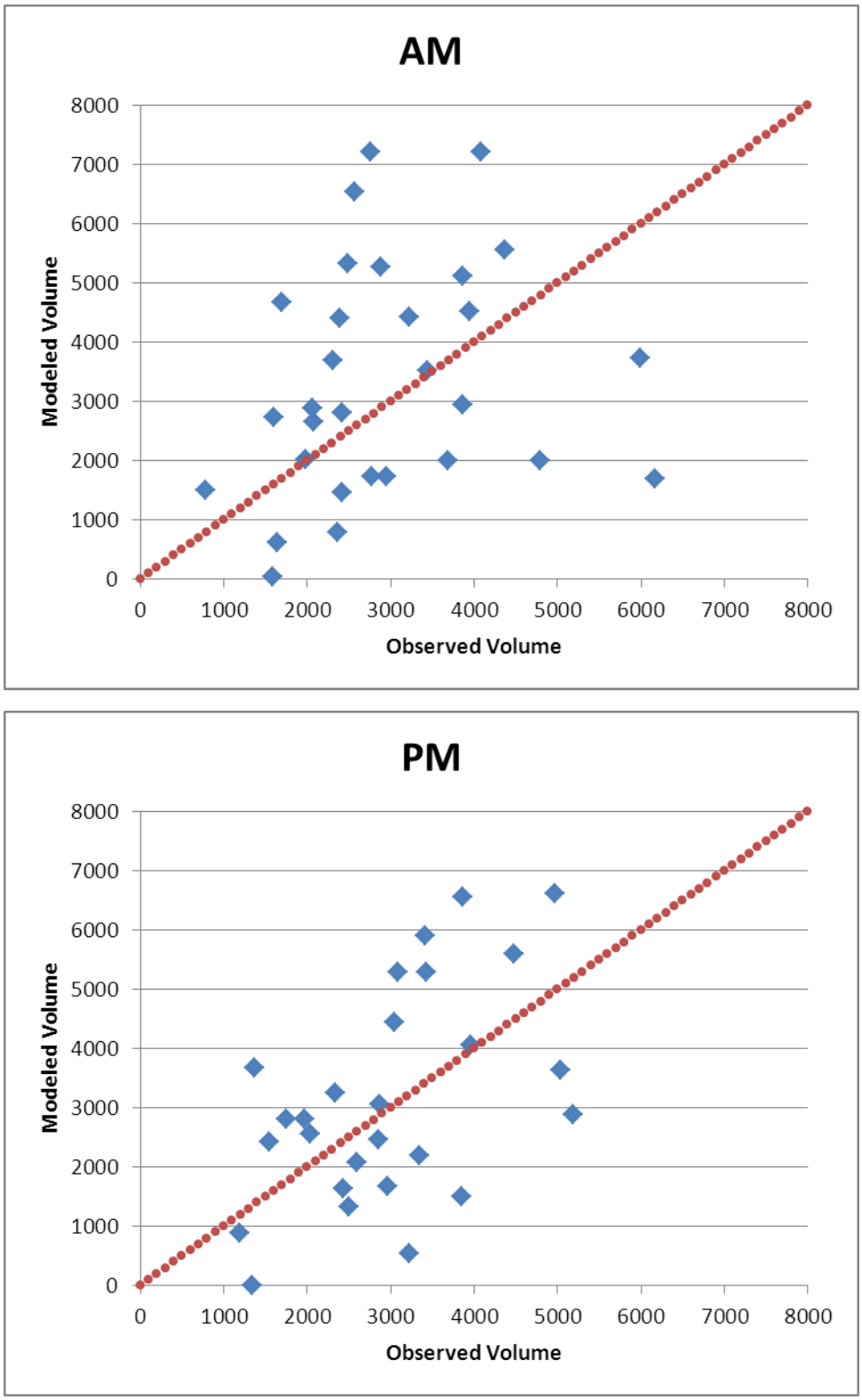


Figure 55: Scatter plot of Peak Period HOV Lane Volumes

4.2 Transit Assignment

The total number of daily boardings by mode appears in Table 72. As with 2000, overall boardings are close to the observed amount, within 0.5%. Most of the modes are close to the observations, as well, except for Commuter Rail, which is 49% low. During the calibration of the prior version of *Travel Model One*, several bugs were found in the coding of supplementary transit network links for drive access to express bus, with errors in some model years and not in others. It is possible the reduction in commuter rail boardings is due to a similar problem. Thorough investigation of the network building scripts for commuter rail access links is recommended.

It is also possible that the reduction in commuter rail boardings is due to illusory competition between Caltrain and SamTrans express buses. Several transit path building traces for the commuter rail mode from the San Mateo peninsula to downtown San Francisco were found to contain only express bus. Commuter rail would be unavailable in the mode choice model for these zonal interchanges. Caltrain's introduction of the new, faster "Baby Bullet" express trains and reduction of the frequency of local service could have exacerbated this path building problem. Testing disallowing express bus as a feeder mode from commuter rail skims is recommended to relieve this competition.

Another possible source of the commuter rail drop is the extension of BART to the San Francisco Airport, putting it in direct competition with Caltrain. In any case, the missing number of trips on commuter rail, 17,422, is still small and should not adversely affect regional analyses.

Table 72: Total Transit Boardings by Mode

Aggregate Mode	Observed Boardings	Modeled Boardings	Difference	% Difference
Local	933,628	985,608	51,980	6%
Light Rail	168,434	164,440	-3,994	-2%
Ferry	11,498	12,268	770	7%
Express	44,665	41,492	-3,173	-7%
Heavy Rail	335,860	311,992	-23,868	-7%
Commuter Rail	35,250	17,828	-17,422	-49%
Total	1,529,335	1,533,628	4,293	0%

Transit boardings by system operator appear in Table 73. The pattern across operators and geographies is similar to that in 2000. The only significant differences are that the deviation for Caltrain went dramatically negative, the deviation for Muni Metro shrunk considerably, and the deviation for Muni Bus grew slightly. These changes motivate the decision to not over-adjust the model in response to discrepancies in point estimates.

Table 73: Transit Boardings by System Operator

Name	Aggregate Mode	Observed Boardings	Modeled Boardings	Difference	% Difference
MUNIBus	Local	525,737	416,612	-109,125	-21%
ACLocal	Local	161,702	236,103	74,401	46%
VTALocal	Local	97,715	149,210	51,495	53%
SamtransLocal	Local	43,257	74,128	30,871	71%
MUNICableCar	Local	19,166	5,846	-13,320	-69%
CCCTALocal	Local	14,630	19,037	4,407	30%
SonomaProviders	Local	14,200	13,602	-598	-4%
GoldenGateLocal	Local	12,197	5,056	-7,141	-59%
Tri-Delta	Local	8,520	12,229	3,709	44%
OtherShuttles	Local	8,299	12,083	3,784	46%
LAVTA/Wheels	Local	6,356	10,008	3,652	57%
VallejoLocal	Local	3,249	6,152	2,903	89%
AirBART	Local	3,000	198	-2,802	-93%
StanfordShuttle	Local	2,691	10,546	7,855	292%
EmeryShuttle	Local	2,637	4,009	1,372	52%
FairfieldLocal	Local	2,502	6,103	3,601	144%
WestCatLocal	Local	1,876	1,371	-505	-27%
NVT/Vine	Local	1,820	108	-1,712	-94%
UnionCity	Local	1,460	2,594	1,134	78%
BWS	Local	895	-	-895	-100%
Vacaville	Local	808	281	-527	-65%
AmericanCanyon	Local	461	-	-461	-100%
Benicia	Local	450	332	-118	-26%
GoldenGateExpress	Express	17,930	13,299	-4,631	-26%
ACTransbay	Express	11,607	17,348	5,741	49%
SamtransExpress	Express	5,619	3,170	-2,449	-44%
VallejoExpress	Express	2,568	2,647	79	3%
WestCatExpress	Express	2,417	3,863	1,446	60%
VTAExpress	Express	2,407	-	-2,407	-100%
CCCTAExpress	Express	1,213	1,152	-61	-5%
DBX	Express	799	-	-799	-100%
FairfieldExpress	Express	106	13	-93	-88%
MUNIMetro	LightRail	146,998	121,311	-25,687	-17%
VTALRT	LightRail	21,436	43,129	21,693	101%
GoldenGateFerry	Ferry	6,720	8,793	2,073	31%
VallejoFerries	Ferry	1,945	953	-992	-51%
EastBayFerries	Ferry	1,627	2,217	590	36%
TiburonFerries	Ferry	1,205	305	-900	-75%
BART	HeavyRail	335,860	311,992	-23,868	-7%
Caltrain	CommuterRail	32,273	17,627	-14,646	-45%
ACE	CommuterRail	2,041	75	-1,966	-96%
Amtrak	CommuterRail	936	126	-810	-87%
Total		1,529,335	1,533,628	4,293	0%

In 2005, the San Francisco Municipal Transportation Agency performed a thorough on-board survey of the Muni bus and Metro light rail systems that provides another point of validation for the transit assignment. Observed and Modeled daily boardings by route appear in Table 74, and in a scatter plot in Figure 56. The Percent Root Mean Squared Error (%RMSE) between the observed and modeled boardings is 66%, which is acceptable. However, the %RMSE increased dramatically when moving from calibration with only one iteration of the demand models to three iterations with feedback of congested travel times, indicating that travel choices in San Francisco are very sensitive to congestion.

Table 74: SFMTA Muni Boardings by Route

Route	Submode	Observed	Estimated	Difference	% Diff
14	Local	40,449	39,329	-1,120	-3%
38	Local	30,635	36,248	5,613	18%
1	Local	29,735	34,039	4,304	14%
22	Local	25,467	4,143	-21,324	-84%
30	Local	24,943	11,899	-13,044	-52%
49	Local	21,003	1,609	-19,394	-92%
45	Local	18,770	8,050	-10,720	-57%
9	Local	17,196	13,285	-3,911	-23%
43	Local	17,030	8,164	-8,866	-52%
44	Local	16,546	15,485	-1,061	-6%
29	Local	14,771	12,134	-2,637	-18%
24	Local	14,527	13,771	-756	-5%
5	Local	14,013	8,618	-5,395	-38%
19	Local	13,291	9,455	-3,836	-29%
28	Local	12,900	1,768	-11,132	-86%
48	Local	11,789	21,270	9,481	80%
27	Local	10,686	997	-9,689	-91%
71	Local	10,643	8,794	-1,849	-17%
21	Local	9,074	7,322	-1,752	-19%
6	Local	8,298	8,585	287	3%
2	Local	7,810	3,300	-4,510	-58%
33	Local	7,107	6,529	-578	-8%
47	Local	6,657	9,028	2,371	36%
7	Local	6,432	6,241	-191	-3%
54	Local	6,167	75	-6,092	-99%
12	Local	5,704	8,209	2,505	44%
23	Local	5,576	15,090	9,514	171%
4	Local	5,374	2,441	-2,933	-55%
3	Local	4,729	1,775	-2,954	-62%
26	Local	4,629	719	-3,910	-84%
52	Local	4,577	20,610	16,033	350%
41	Local	3,976	79	-3,897	-98%
18	Local	3,944	330	-3,614	-92%
67	Local	3,159	743	-2,416	-76%
37	Local	2,125	1,403	-722	-34%
36	Local	1,676	1,546	-130	-8%
53	Local	1,675	499	-1,176	-70%
35	Local	1,256	1,254	-2	-0%
66	Local	1,222	391	-831	-68%
91	Local	466	1,220	754	162%

Route	Submode	Observed	Estimated	Difference	% Diff
56	Local	341	1,288	947	278%
90	Local	235	1,038	803	342%
89	Local	136	236	100	74%
38L	Limited	18,823	11,837	-6,986	-37%
9X	Limited	8,464	4,642	-3,822	-45%
14X	Limited	2,614	3,551	937	36%
9AX	Limited	2,532	1,819	-713	-28%
30X	Limited	2,377	1,523	-854	-36%
9BX	Limited	2,076	1,278	-798	-38%
1BX	Limited	1,743	1,234	-509	-29%
28L	Limited	1,652	5,255	3,603	218%
31AX	Limited	1,145	745	-400	-35%
31BX	Limited	1,048	772	-276	-26%
16BX	Limited	956	372	-584	-61%
16AX	Limited	912	400	-512	-56%
1AX	Limited	888	485	-403	-45%
81X	Limited	596	15	-581	-97%
82X	Limited	495	76	-419	-85%
80X	Limited	314	1	-313	-100%
PH	CableCar	9,374	2,534	-6,840	-73%
PM	CableCar	7,924	2,249	-5,675	-72%
C	CableCar	5,515	1,063	-4,452	-81%
N_JUDAH	Metro	45,621	35,450	-10,171	-22%
M_OCEANV	Metro	33,296	23,047	-10,249	-31%
L_TARAVA	Metro	29,866	19,392	-10,474	-35%
K_INGLES	Metro	25,304	11,256	-14,048	-56%
F_MARKET	Metro	19,193	7,883	-11,310	-59%
J_CHURCH	Metro	15,229	22,115	6,886	45%
Total		684,696	508,003	-176,693	-26%

	Submode	Observed	Estimated	Difference	% Diff	% RMSE
Total by Submode	Local	446,739	349,009	-97,730	-22%	68%
	Limited	46,635	34,005	-12,630	-27%	77%
	Metro	168,509	119,143	-49,366	-29%	38%
	CableCar	22,813	5,846	-16,967	-74%	75%
	Total	684,696	508,003	-176,693	-26%	66%

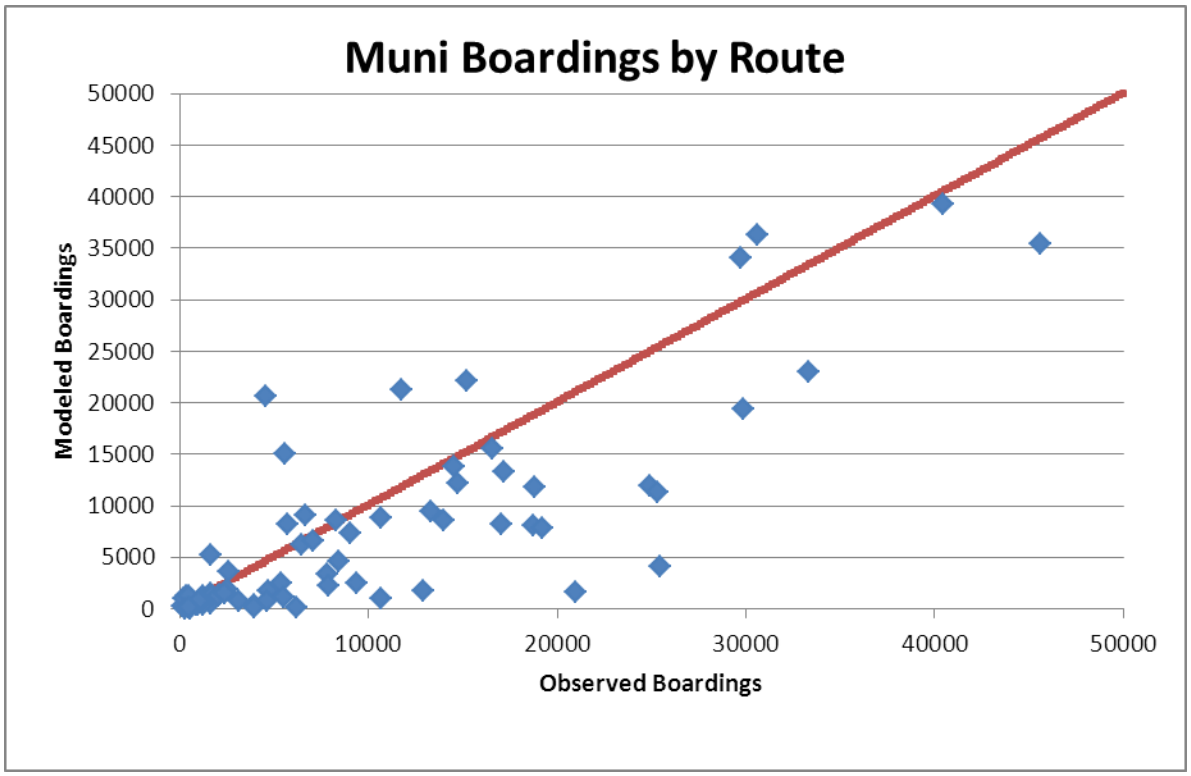


Figure 56: Scatter plot of SFMTA Muni Boardings by Route

5 Summary of Conclusions and Recommendations

This document presented the results of the calibration of *Travel Model* One, a disaggregate simulation model of resident's travel decisions based on the Coordinated Travel – Regional Activity-Based Modeling Platform (CT-RAMP) to match aggregate travel patterns in the nine-county San Francisco Bay Area represented by the Metropolitan Transportation Commission (MTC). Each step in the model was calibrated to closely match adjusted targets along several dimensions derived from the 2000 Bay Area Travel Survey, US Census, Caltrans State Highway traffic count database, and MTC's transit operator data.

The final results adequately reproduce travel patterns in the base years of 2000 and 2005. Any model that is appropriately sensitive to changes in demographics, land use characteristics, policies, and levels of service will retain some errors compared to the observed data when looking along several joint dimensions or at a fine geographic detail. However, there are some actions that could be taken to improve the results further. To address these remaining issues, the following improvements to the model are recommended:

1. Implement a university student residential choice model to improve the spatial distribution of university tours.
2. Consider disallowing Express Bus as a feeder mode in Commuter Rail paths, and investigate other possible sources of error in the building of drive access links in the transit network scripts.
3. Revise the volume delay function lookup table to shift highway trips between facility types.
4. Introduce a transit pass alternative into the auto ownership model to improve the representation in the mode choice model of the marginal cost of taking transit in San Francisco and achieve a better match with Muni boardings.
5. Revisit the calibration of the stop frequency model, where the match with the observed data worsened in the final stages of calibration which focused on mode choice and transit assignment.
6. Collect a larger set of highway counts with counts on lower volume facilities, and revisit the highway validation with the new data.
7. Implement an airport model to better match traffic volumes in south San Francisco around I-280 and 101.

Implementing these recommendations should eliminate the few remaining significant mismatches between the base year model results and observed data.

Appendix A: Chart Reference and Additional Data

Table 75: Data for Figure 15, Auto Ownership by County

County	Number of Vehicles				
	0	1	2	3+	Total
	Observed Household Distribution				
San Francisco	28.4%	42.0%	22.3%	7.4%	100.0%
San Mateo	6.0%	31.8%	39.9%	22.2%	100.0%
Santa Clara	5.6%	28.9%	41.0%	24.5%	100.0%
Alameda	10.8%	34.8%	36.2%	18.2%	100.0%
Contra Costa	6.5%	30.3%	41.1%	22.2%	100.0%
Solano	6.6%	28.9%	40.0%	24.5%	100.0%
Napa	6.2%	32.2%	39.9%	21.7%	100.0%
Sonoma	5.7%	31.5%	40.2%	22.6%	100.0%
Marin	5.0%	34.8%	42.3%	18.0%	100.0%
Total	10.0%	32.9%	37.3%	19.9%	100.0%
	Modeled Household Distribution				
San Francisco	29.2%	42.0%	21.8%	7.0%	100.0%
San Mateo	5.5%	32.3%	40.9%	21.3%	100.0%
Santa Clara	6.3%	28.6%	40.8%	24.4%	100.0%
Alameda	10.7%	31.7%	37.5%	20.1%	100.0%
Contra Costa	4.3%	31.9%	43.3%	20.5%	100.0%
Solano	6.7%	30.9%	39.9%	22.5%	100.0%
Napa	6.2%	32.8%	40.1%	20.9%	100.0%
Sonoma	5.7%	30.7%	41.2%	22.3%	100.0%
Marin	5.6%	36.5%	42.1%	15.7%	100.0%
Total	9.9%	32.5%	37.9%	19.6%	100.0%
	Difference (Modeled - Observed)				
San Francisco	0.8%	0.0%	-0.5%	-0.3%	0.0%
San Mateo	-0.5%	0.5%	0.9%	-0.9%	0.0%
Santa Clara	0.7%	-0.3%	-0.2%	-0.1%	0.0%
Alameda	-0.1%	-3.1%	1.3%	1.9%	0.0%
Contra Costa	-2.2%	1.6%	2.2%	-1.7%	0.0%
Solano	0.1%	2.0%	-0.2%	-2.0%	0.0%
Napa	0.0%	0.5%	0.2%	-0.8%	0.0%
Sonoma	0.0%	-0.8%	1.0%	-0.2%	0.0%
Marin	0.7%	1.7%	-0.1%	-2.2%	0.0%
Total	-0.1%	-0.3%	0.6%	-0.2%	0.0%

Table 76: Data for Figure 19, Daily Activity Pattern by Person Type

Adjusted Household Survey Shares				
Person type	Mandatory	Non-Mandatory	Home	Total
(FW) Full-time worker	81.3%	10.1%	8.6%	100.0%
(PW) Part-time worker	60.1%	27.5%	12.3%	100.0%
(US) University student	70.0%	22.0%	8.0%	100.0%
(NW) Non-working adult	-	81.2%	18.8%	100.0%
(RT) Retired	-	78.2%	21.8%	100.0%
(SD) Driving age schoolchild	76.3%	10.8%	12.9%	100.0%
(SP) Pre-driving age schoolchild	74.7%	13.8%	11.5%	100.0%
(PS) Pre-school child	40.6%	36.3%	23.1%	100.0%
Total	57.2%	29.9%	12.9%	100.0%

Model Shares				
Person type	Mandatory	Non-Mandatory	Home	Total
(FW) Full-time worker	81.6%	10.3%	8.1%	100.0%
(PW) Part-time worker	60.4%	27.8%	11.8%	100.0%
(US) University student	70.2%	22.1%	7.7%	100.0%
(NW) Non-working adult	-	81.2%	18.8%	100.0%
(RT) Retired	-	78.1%	21.9%	100.0%
(SD) Driving age schoolchild	76.6%	10.7%	12.7%	100.0%
(SP) Pre-driving age schoolchild	75.4%	14.2%	10.4%	100.0%
(PS) Pre-school child	41.1%	37.0%	21.9%	100.0%
Total	55.5%	31.8%	12.7%	100.0%

Difference				
Person type	Mandatory	Non-Mandatory	Home	Total
(FW) Full-time worker	0.3%	0.1%	-0.5%	-
(PW) Part-time worker	0.3%	0.2%	-0.6%	-
(US) University student	0.2%	0.1%	-0.3%	-
(NW) Non-working adult	-	0.0%	-0.0%	-
(RT) Retired	-	-0.1%	0.1%	-
(SD) Driving age schoolchild	0.2%	-0.0%	-0.2%	-
(SP) Pre-driving age schoolchild	0.7%	0.4%	-1.1%	-
(PS) Pre-school child	0.5%	0.7%	-1.2%	-
Total	-1.7%	1.9%	-0.2%	-

Table 77: Data for Figure 20, Mandatory Tour Frequency by Person Type

Person Type	Mandatory Tour Frequency					
	1 Work	2 Work	1 School	2 School	Work & School	Total
	Observed Percentages					
Full-time worker	94.9%	5.1%	-	-	-	100.0%
Part-time worker	93.2%	6.8%	-	-	-	100.0%
University student	28.8%	1.7%	54.7%	4.8%	9.9%	100.0%
Student of driving age	-	-	88.9%	6.0%	5.1%	100.0%
Student of non-driving age	-	-	96.7%	3.3%	-	100.0%
Total	62.9%	3.5%	31.7%	1.2%	0.7%	100.0%
	Model Percentages					
Full-time worker	94.9%	5.1%	-	-	-	100.0%
Part-time worker	93.2%	6.8%	-	-	-	100.0%
University student	31.8%	1.8%	50.9%	4.5%	10.9%	100.0%
Student of driving age	-	-	88.8%	6.0%	5.1%	100.0%
Student of non-driving age	-	-	96.7%	3.3%	-	100.0%
Total	64.8%	3.7%	29.3%	1.2%	1.1%	100.0%
	Difference (Modeled - Observed)					
Full-time worker	0.0%	-0.0%	-	-	-	-
Part-time worker	0.0%	-0.0%	-	-	-	-
University student	-3.0%	-0.1%	3.8%	0.3%	-1.0%	-
Student of driving age	-	-	0.1%	-0.0%	-0.0%	-
Student of non-driving age	-	-	-0.0%	0.0%	-	-
Total	-1.9%	-0.2%	2.4%	0.0%	-0.3%	-

Table 78: Data for Figure 21: Work Tour Departure and Arrival Times-Figure 24: Grade School Departure and Arrival Times, Mandatory Tour Departure, Arrival, and Duration Times

	Observed Tour Departure Hour					Modeled Tour Departure Hour					Difference (Modeled - Observed)			
Start Hour	Work	University	High School	Grade School	Start Hour	Work	University	High School	Grade School	Start Hour	Work	University	High School	Grade School
3-4	0.4%	0.2%	0.0%	0.0%	3-4	0.0%	0.0%	0.0%	0.0%	3-4	0.4%	0.2%	0.0%	0.0%
4-5	2.0%	0.2%	0.1%	0.0%	4-5	0.0%	0.0%	0.0%	0.0%	4-5	2.0%	0.2%	0.1%	0.0%
5-6	7.4%	0.4%	0.7%	0.5%	5-6	10.1%	0.1%	0.5%	0.6%	5-6	-2.7%	0.2%	0.1%	-0.1%
6-7	16.2%	4.5%	11.8%	5.4%	6-7	16.2%	2.1%	7.2%	7.1%	6-7	0.0%	2.5%	4.6%	-1.6%
7-8	29.4%	16.4%	58.2%	38.6%	7-8	29.9%	14.4%	38.0%	39.2%	7-8	-0.5%	2.0%	20.1%	-0.6%
8-9	22.4%	23.2%	15.0%	43.7%	8-9	22.3%	19.6%	35.1%	37.7%	8-9	0.1%	3.5%	-20.1%	6.0%
9-10	7.3%	9.0%	3.2%	3.3%	9-10	7.0%	3.9%	4.7%	4.9%	9-10	0.3%	5.1%	-1.5%	-1.6%
10-11	3.3%	5.8%	1.5%	0.8%	10-11	2.7%	2.5%	2.1%	2.0%	10-11	0.6%	3.3%	-0.6%	-1.2%
11-12	2.0%	5.4%	1.0%	1.6%	11-12	2.7%	3.7%	2.0%	1.9%	11-12	-0.7%	1.6%	-1.0%	-0.4%
12-13	2.3%	2.9%	1.4%	1.4%	12-13	2.1%	5.4%	2.3%	1.8%	12-13	0.2%	-2.4%	-1.0%	-0.4%
13-14	2.1%	4.1%	1.2%	0.5%	13-14	2.2%	3.7%	1.3%	0.9%	13-14	-0.1%	0.4%	-0.2%	-0.4%
14-15	1.8%	2.7%	0.7%	0.4%	14-15	1.6%	4.5%	1.2%	0.8%	14-15	0.2%	-1.8%	-0.5%	-0.4%
15-16	0.9%	3.0%	1.0%	1.3%	15-16	1.0%	5.5%	1.0%	0.7%	15-16	-0.1%	-2.6%	0.0%	0.6%
16-17	0.9%	3.8%	1.1%	0.7%	16-17	0.9%	9.5%	1.6%	1.0%	16-17	0.0%	-5.7%	-0.6%	-0.3%
17-18	0.8%	8.1%	1.4%	0.6%	17-18	0.6%	10.6%	1.5%	0.8%	17-18	0.1%	-2.5%	-0.1%	-0.2%
18-19	0.5%	8.1%	1.9%	0.9%	18-19	0.4%	11.0%	1.1%	0.6%	18-19	0.1%	-2.9%	0.8%	0.2%
19-20	0.3%	1.9%	0.2%	0.2%	19-20	0.2%	1.1%	0.1%	0.1%	19-20	0.1%	0.7%	0.1%	0.1%
20-21	0.1%	0.1%	0.0%	0.0%	20-21	0.1%	1.1%	0.1%	0.0%	20-21	0.0%	-1.0%	-0.1%	0.0%
21-22	0.1%	0.1%	0.0%	0.0%	21-22	0.0%	1.1%	0.1%	0.0%	21-22	0.0%	-1.0%	-0.1%	0.0%
22-23	0.0%	0.1%	0.0%	0.0%	22-23	0.0%	0.0%	0.0%	0.0%	22-23	0.0%	0.1%	0.0%	0.0%
23-0	0.0%	0.0%	0.0%	0.0%	23-0	0.0%	0.1%	0.0%	0.0%	23-0	0.0%	-0.1%	0.0%	0.0%
0-1	0.0%	0.0%	0.0%	0.0%	0-1	0.0%	0.0%	0.0%	0.0%	0-1	0.0%	0.0%	0.0%	0.0%
1-2	0.0%	0.0%	0.0%	0.0%	1-2	0.0%	0.0%	0.0%	0.0%	1-2	0.0%	0.0%	0.0%	0.0%
2-3	0.0%	0.0%	0.0%	0.0%	2-3	0.0%	0.0%	0.0%	0.0%	2-3	0.0%	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	*Total*	100.0%	100.0%	100.0%	100.0%	*Total*	0.0%	0.0%	0.0%	0.0%

	Observed Tour Arrival Hour					Modeled Tour Arrival Hour					Difference (Modeled – Observed)			
End Hour	Work	University	High School	Grade School	End Hour	Work	University	High School	Grade School	End Hour	Work	University	High School	Grade School
3-4	0.0%	0.0%	0.0%	0.0%	3-4	0.0%	0.0%	0.0%	0.0%	3-4	0.0%	0.0%	0.0%	0.0%
4-5	0.0%	0.0%	0.0%	0.0%	4-5	0.0%	0.0%	0.0%	0.0%	4-5	0.0%	0.0%	0.0%	0.0%
5-6	0.0%	0.0%	0.0%	0.0%	5-6	0.6%	0.0%	0.0%	0.0%	5-6	0.6%	0.0%	0.0%	0.0%
6-7	0.0%	0.0%	0.0%	0.0%	6-7	1.1%	0.3%	0.2%	0.0%	6-7	1.0%	0.3%	0.2%	0.0%
7-8	0.1%	0.3%	0.6%	0.0%	7-8	0.2%	1.4%	0.7%	0.2%	7-8	0.1%	1.1%	0.1%	0.2%
8-9	0.2%	2.0%	0.2%	0.2%	8-9	0.3%	1.8%	0.7%	0.4%	8-9	0.1%	-0.2%	0.5%	0.2%
9-10	0.3%	1.9%	0.4%	0.1%	9-10	0.4%	1.3%	0.5%	0.5%	9-10	0.1%	-0.5%	0.2%	0.3%
10-11	0.5%	3.5%	0.6%	0.4%	10-11	1.6%	4.0%	2.4%	2.1%	10-11	1.1%	0.5%	1.8%	1.8%
11-12	0.8%	2.9%	1.3%	1.6%	11-12	1.7%	4.3%	3.0%	2.8%	11-12	0.8%	1.4%	1.7%	1.2%
12-13	2.6%	7.4%	3.0%	4.2%	12-13	1.7%	4.0%	3.2%	3.3%	12-13	-0.9%	-3.4%	0.2%	-0.9%
13-14	2.1%	5.9%	3.4%	4.4%	13-14	2.3%	6.7%	7.5%	8.1%	13-14	0.3%	0.8%	4.2%	3.8%
14-15	2.8%	7.6%	12.4%	12.2%	14-15	3.3%	7.1%	10.0%	11.3%	14-15	0.5%	-0.5%	-2.4%	-0.9%
15-16	5.6%	9.4%	35.6%	30.5%	15-16	6.9%	13.5%	22.0%	24.1%	15-16	1.2%	4.0%	-13.6%	-6.5%
16-17	11.6%	8.8%	13.3%	14.2%	16-17	10.8%	8.8%	13.0%	13.8%	16-17	-0.8%	0.0%	-0.3%	-0.3%
17-18	20.8%	10.2%	10.0%	13.6%	17-18	19.4%	11.1%	12.5%	12.3%	17-18	-1.4%	0.9%	2.5%	-1.3%
18-19	22.1%	7.9%	8.4%	10.9%	18-19	20.8%	12.7%	9.8%	9.1%	18-19	-1.3%	4.8%	1.3%	-1.8%
19-20	13.6%	4.8%	3.3%	3.6%	19-20	8.6%	6.1%	3.9%	3.4%	19-20	-5.0%	1.3%	0.6%	-0.2%
20-21	6.0%	8.9%	3.1%	1.8%	20-21	7.8%	5.8%	3.3%	2.9%	20-21	1.8%	-3.1%	0.2%	1.1%
21-22	4.2%	10.0%	2.3%	1.3%	21-22	7.5%	6.6%	3.8%	3.0%	21-22	3.3%	-3.4%	1.4%	1.7%
22-23	3.2%	5.9%	1.5%	0.7%	22-23	2.6%	2.4%	1.7%	1.3%	22-23	-0.5%	-3.5%	0.2%	0.6%
23-0	1.6%	1.9%	0.7%	0.3%	23-0	2.5%	2.2%	1.7%	1.3%	23-0	0.9%	0.3%	1.1%	1.0%
0-1	1.0%	0.3%	0.0%	0.1%	0-1	0.0%	0.0%	0.0%	0.0%	0-1	-1.0%	-0.3%	0.0%	-0.1%
1-2	0.6%	0.1%	0.0%	0.0%	1-2	0.0%	0.0%	0.0%	0.0%	1-2	-0.6%	-0.1%	0.0%	0.0%
2-3	0.3%	0.4%	0.1%	0.0%	2-3	0.0%	0.0%	0.0%	0.0%	2-3	-0.3%	-0.4%	-0.1%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	*Total*	100.0%	100.0%	100.0%	100.0%	*Total*	0.0%	0.0%	0.0%	0.0%

	Observed Tour Duration					Modeled Tour Duration					Difference (Modeled – Observed)				
Hours	Work	University	High School	Grade School	End Hour	Work	University	High School	Grade School	End Hour	Work	University	High School	Grade School	
0-1	0.7%	7.2%	0.9%	1.0%	0-1	1.9%	17.9%	1.7%	0.8%	0-1	1.3%	10.7%	0.8%	-0.2%	
1-2	1.1%	8.6%	1.9%	2.0%	1-2	1.0%	12.6%	1.8%	1.0%	1-2	-0.1%	4.0%	-0.1%	-1.0%	
2-3	1.8%	11.0%	4.3%	2.0%	2-3	0.6%	9.5%	1.9%	1.4%	2-3	-1.2%	-1.5%	-2.4%	-0.6%	
3-4	2.5%	13.8%	3.4%	3.7%	3-4	3.3%	13.7%	4.9%	3.8%	3-4	0.8%	-0.1%	1.5%	0.2%	
4-5	4.0%	13.1%	2.4%	4.7%	4-5	3.0%	9.9%	5.1%	4.3%	4-5	-1.1%	-3.3%	2.7%	-0.4%	
5-6	3.6%	5.7%	3.4%	4.1%	5-6	3.4%	9.8%	8.2%	7.0%	5-6	-0.2%	4.1%	4.8%	2.9%	
6-7	2.8%	7.2%	7.0%	14.1%	6-7	3.1%	5.6%	6.7%	8.1%	6-7	0.3%	-1.6%	-0.3%	-6.0%	
7-8	2.9%	6.2%	25.8%	24.3%	7-8	5.5%	8.9%	17.1%	19.5%	7-8	2.6%	2.7%	-8.7%	-4.8%	
8-9	6.6%	5.3%	22.9%	11.7%	8-9	4.8%	7.0%	20.6%	22.3%	8-9	-1.8%	1.7%	-2.3%	10.6%	
9-10	17.3%	5.1%	9.1%	13.2%	9-10	17.7%	2.6%	11.1%	11.6%	9-10	0.5%	-2.5%	2.0%	-1.6%	
10-11	21.3%	4.9%	6.8%	10.5%	10-11	20.6%	1.6%	9.9%	9.8%	10-11	-0.7%	-3.3%	3.1%	-0.7%	
11-12	15.3%	3.9%	4.9%	4.2%	11-12	14.9%	0.5%	4.8%	4.7%	11-12	-0.4%	-3.4%	-0.1%	0.4%	
12-13	8.9%	2.4%	2.4%	1.6%	12-13	7.1%	0.1%	1.7%	1.6%	12-13	-1.8%	-2.3%	-0.7%	0.0%	
13-14	4.4%	1.8%	1.1%	0.6%	13-14	6.4%	0.1%	1.6%	1.6%	13-14	2.0%	-1.7%	0.4%	1.0%	
14-15	2.5%	1.0%	1.3%	0.8%	14-15	2.6%	0.0%	1.3%	1.2%	14-15	0.1%	-0.9%	0.0%	0.4%	
15-16	1.4%	0.7%	0.0%	0.5%	15-16	2.0%	0.0%	0.9%	0.8%	15-16	0.6%	-0.6%	0.9%	0.3%	
16-17	2.3%	1.3%	0.5%	1.0%	16-17	1.3%	0.0%	0.5%	0.5%	16-17	-1.0%	-1.3%	0.0%	-0.6%	
17-18	0.3%	0.2%	0.0%	0.0%	17-18	0.5%	0.0%	0.1%	0.1%	17-18	0.2%	-0.2%	0.1%	0.1%	
18-19	0.1%	0.4%	0.3%	0.0%	18-19	0.2%	0.0%	0.0%	0.0%	18-19	0.1%	-0.4%	-0.3%	0.0%	
19-20	0.1%	0.1%	0.8%	0.0%	19-20	0.0%	0.0%	0.0%	0.0%	19-20	-0.1%	-0.1%	-0.8%	0.0%	
20-21	0.1%	0.0%	0.5%	0.0%	20-21	0.0%	0.0%	0.0%	0.0%	20-21	-0.1%	0.0%	-0.5%	0.0%	
21-22	0.0%	0.0%	0.0%	0.0%	21-22	0.0%	0.0%	0.0%	0.0%	21-22	0.0%	0.0%	0.0%	0.0%	
22-23	0.0%	0.0%	0.0%	0.0%	22-23	0.0%	0.0%	0.0%	0.0%	22-23	0.0%	0.0%	0.0%	0.0%	
23-24	0.0%	0.0%	0.0%	0.0%	23-24	0.0%	0.0%	0.0%	0.0%	23-24	0.0%	0.0%	0.0%	0.0%	
Total	0.0%	0.0%	0.0%	0.0%	*Total*	0.0%	0.0%	0.0%	0.0%	*Total*	0.0%	0.0%	0.0%	0.0%	

Table 79: Data for

Figure 25, At-work Sub-tour Frequency

At-work Sub-tour Freq. Alt.	Raw Survey		Adjusted Targets		Model		Diff. (Model - Targets)	
	Num. Work Tours	Percent	Num. Work Tours	Percent	Num. Work Tours	Percent	Num. Work Tours	Percent
None	2,351,604	86.5%	1,902,828	70.0%	1,898,928	69.9%	3,900	-0.1%
One eating	157,916	5.8%	566,430	20.8%	567,960	20.9%	1,530	0.1%
One business	35,410	1.3%	127,013	4.7%	127,644	4.7%	631	0.0%
One maintenance	29,945	1.1%	107,411	4.0%	107,116	3.9%	295	0.0%
Two business	1,447	0.1%	5,192	0.2%	4,988	0.2%	204	0.0%
One business/one eating	2,635	0.1%	9,453	0.3%	9,600	0.4%	147	0.0%
Other	139,368	5.1%	-	0.0%	-	0.0%	-	0.0%
Total	2,718,326	100.0%	2,718,326	100.0%	2,716,236	100.0%	2,090	0.0%

Table 80: Data for Figure 27-Figure 34, Joint, Individual Non-mandatory, and At-Work Tour Departure, Arrival, and Duration Times

	Observed Tour Departure Hour									Modeld Tour Departure Hour									Difference (Modeled - Observed)							
Start Hour	Escort	Shop	Maint.	Eat Out	Visit	Discr.	Joint	At-work	Start Hour	Escort	Shop	Maint.	Eat Out	Visit	Discr.	Joint	At-work	Start Hour	Escort	Shop	Maint.	Eat Out	Visit	Discr.	Joint	At-work
3-4	1.0%	0.5%	0.3%	0.6%	0.1%	0.6%	0.0%	0.0%	3-4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3-4	-1.0%	-0.5%	-0.3%	-0.6%	-0.1%	-0.6%	0.0%	0.0%
4-5	0.2%	0.1%	0.0%	0.5%	0.1%	0.4%	0.0%	0.0%	4-5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4-5	-0.2%	-0.1%	0.0%	-0.5%	-0.1%	-0.4%	0.0%	0.0%
5-6	0.9%	0.5%	0.8%	0.9%	0.4%	2.2%	0.6%	0.0%	5-6	2.3%	0.8%	1.4%	0.9%	1.2%	1.4%	0.6%	0.0%	5-6	1.4%	0.3%	0.6%	0.0%	0.8%	-0.8%	0.0%	0.0%
6-7	2.2%	1.1%	2.8%	4.2%	2.2%	3.4%	1.7%	0.1%	6-7	3.2%	1.4%	2.2%	1.8%	2.5%	2.7%	1.7%	0.1%	6-7	1.1%	0.3%	-0.6%	-2.4%	0.3%	-0.7%	0.0%	0.0%
7-8	13.1%	1.9%	6.9%	8.0%	3.7%	5.8%	6.1%	0.7%	7-8	14.1%	2.0%	8.9%	4.2%	5.9%	6.1%	6.1%	0.3%	7-8	1.0%	0.2%	1.9%	-3.9%	2.3%	0.3%	0.0%	-0.4%
8-9	14.6%	6.3%	11.8%	8.5%	4.4%	8.3%	11.6%	3.2%	8-9	18.3%	8.5%	12.6%	6.7%	8.6%	9.5%	11.6%	1.6%	8-9	3.7%	2.2%	0.7%	-1.8%	4.2%	1.1%	0.0%	-1.7%
9-10	3.1%	7.3%	10.1%	4.0%	5.6%	6.3%	13.3%	3.9%	9-10	4.2%	8.8%	10.5%	6.2%	7.3%	7.8%	13.3%	2.2%	9-10	1.1%	1.4%	0.4%	2.3%	1.7%	1.5%	0.0%	-1.7%
10-11	2.4%	9.3%	9.5%	3.4%	4.9%	4.8%	18.4%	20.8%	10-11	5.4%	9.3%	9.6%	6.3%	6.6%	7.3%	18.4%	10.6%	10-11	2.9%	0.0%	0.0%	2.9%	1.7%	2.4%	0.0%	-10.1%
11-12	5.0%	8.8%	7.5%	6.2%	5.1%	4.5%	13.4%	14.7%	11-12	5.5%	9.3%	8.8%	6.5%	6.2%	7.1%	13.4%	12.2%	11-12	0.5%	0.6%	1.3%	0.3%	1.2%	2.6%	0.0%	-2.5%
12-13	4.5%	7.3%	6.6%	3.7%	3.6%	3.1%	6.6%	29.3%	12-13	5.7%	10.0%	8.4%	7.0%	6.4%	7.2%	6.6%	7.7%	12-13	1.1%	2.7%	1.8%	3.2%	2.8%	4.1%	0.0%	-21.6%
13-14	4.5%	7.7%	7.5%	2.0%	3.7%	2.8%	7.1%	14.7%	13-14	6.0%	6.9%	5.3%	5.2%	4.6%	5.1%	7.1%	37.9%	13-14	1.4%	-0.8%	-2.2%	3.2%	0.9%	2.3%	0.0%	23.2%
14-15	14.8%	7.3%	6.4%	1.4%	8.2%	4.7%	4.8%	7.0%	14-15	6.8%	7.2%	5.5%	6.1%	5.4%	5.6%	4.8%	16.4%	14-15	-8.0%	-0.1%	-0.9%	4.6%	-2.8%	0.8%	0.0%	9.3%
15-16	9.1%	7.9%	9.0%	1.8%	7.9%	5.6%	3.0%	2.5%	15-16	8.7%	7.9%	5.9%	8.0%	6.9%	6.8%	3.0%	5.6%	15-16	-0.4%	0.0%	-3.0%	6.2%	-0.9%	1.3%	0.0%	3.1%
16-17	7.6%	7.8%	6.9%	9.0%	6.6%	9.3%	3.2%	1.8%	16-17	3.6%	5.9%	4.6%	6.9%	6.2%	6.0%	3.2%	2.7%	16-17	-4.0%	-1.9%	-2.3%	-2.1%	-0.4%	-3.4%	0.0%	0.9%
17-18	7.1%	6.6%	4.4%	8.8%	6.7%	10.2%	4.1%	0.8%	17-18	5.3%	6.7%	5.4%	9.6%	8.3%	7.8%	4.1%	1.8%	17-18	-1.9%	0.1%	1.0%	0.7%	1.5%	-2.4%	0.0%	1.0%
18-19	3.6%	6.8%	3.6%	17.3%	13.2%	13.5%	2.5%	0.3%	18-19	7.3%	8.9%	7.0%	13.9%	12.0%	11.1%	2.5%	0.8%	18-19	3.7%	2.1%	3.4%	-3.3%	-1.2%	-2.3%	0.0%	0.4%
19-20	2.1%	7.9%	4.1%	13.9%	15.5%	9.0%	2.8%	0.1%	19-20	0.7%	1.8%	1.3%	3.1%	2.7%	2.3%	2.8%	0.1%	19-20	-1.4%	-6.1%	-2.8%	-10.8%	-12.8%	-6.6%	0.0%	0.1%
20-21	2.3%	3.1%	0.8%	3.8%	4.3%	3.4%	0.6%	0.0%	20-21	1.1%	2.2%	1.3%	3.7%	3.8%	2.7%	0.6%	0.1%	20-21	-1.1%	-0.9%	0.5%	0.0%	-0.5%	-0.7%	0.0%	0.0%
21-22	1.1%	1.6%	0.5%	1.1%	2.3%	1.6%	0.0%	0.0%	21-22	1.6%	2.2%	1.3%	3.9%	4.7%	3.0%	0.0%	0.0%	21-22	0.5%	0.6%	0.8%	2.8%	2.4%	1.5%	0.0%	0.0%
22-23	0.6%	0.3%	0.3%	0.7%	1.3%	0.3%	0.0%	0.0%	22-23	0.2%	0.1%	0.1%	0.0%	0.3%	0.2%	0.0%	0.0%	22-23	-0.5%	-0.2%	-0.3%	-0.7%	-1.0%	-0.1%	0.0%	0.0%
23-0	0.2%	0.1%	0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	23-0	0.2%	0.1%	0.1%	0.0%	0.4%	0.2%	0.1%	0.0%	23-0	0.0%	0.0%	0.0%	0.0%	0.3%	0.2%	0.0%	0.0%
0-1	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0-1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0-1	-0.1%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%
1-2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1-2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1-2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2-3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2-3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2-3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	*Total*	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	*Total*	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

	Observed Tour Return Hour									Observed Tour Return Hour								Difference (Modeled-Observed)							
End Hour	Escort	Shop	Maint.	Eat Out	Visit	Discr.	Joint	At-work	End Hour	Escort	Shop	Maint.	Eat Out	Visit	Discr.	Joint	At-work	End Hour	Escort	Shop	Maint.	Eat Out	Visit	Discr.	Joint	At-work
3-4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3-4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3-4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
4-5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4-5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4-5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5-6	0.2%	0.0%	0.0%	0.0%	0.3%	0.1%	0.0%	0.0%	5-6	0.9%	0.3%	0.5%	0.2%	0.2%	0.3%	0.0%	0.0%	5-6	0.7%	0.3%	0.5%	0.2%	-0.1%	0.2%	0.0%	0.0%
6-7	0.8%	0.1%	0.5%	0.7%	0.0%	0.6%	0.1%	0.1%	6-7	2.1%	1.1%	1.5%	0.8%	0.6%	1.1%	0.1%	0.1%	6-7	1.4%	1.0%	1.0%	0.1%	0.6%	0.5%	0.0%	0.0%
7-8	3.5%	0.3%	0.5%	0.6%	0.3%	1.5%	0.6%	0.3%	7-8	7.1%	0.5%	1.3%	0.5%	0.4%	0.6%	0.6%	0.3%	7-8	3.5%	0.2%	0.9%	-0.2%	0.1%	-0.9%	0.0%	0.0%
8-9	14.4%	0.7%	1.3%	1.2%	1.5%	1.5%	1.8%	1.6%	8-9	11.4%	1.1%	1.7%	0.8%	0.6%	0.9%	1.8%	1.6%	8-9	-3.0%	0.5%	0.5%	-0.4%	-0.9%	-0.6%	0.0%	0.0%
9-10	6.0%	2.3%	4.4%	1.7%	0.3%	1.7%	2.7%	2.2%	9-10	8.0%	1.0%	1.3%	0.7%	0.5%	0.7%	2.7%	2.2%	9-10	2.0%	-1.3%	-3.2%	-1.0%	0.2%	-1.1%	0.0%	0.0%
10-11	2.6%	4.9%	6.0%	1.0%	0.6%	2.5%	6.5%	10.6%	10-11	4.7%	5.5%	6.7%	3.5%	2.8%	3.6%	6.5%	10.6%	10-11	2.1%	0.6%	0.7%	2.5%	2.2%	1.1%	0.0%	0.0%
11-12	2.5%	5.8%	6.8%	1.2%	4.5%	2.9%	7.9%	12.2%	11-12	5.2%	5.6%	6.4%	3.6%	2.9%	3.7%	7.9%	12.2%	11-12	2.7%	-0.2%	-0.4%	2.3%	-1.7%	0.9%	0.0%	0.0%
12-13	5.0%	6.3%	9.4%	2.5%	2.8%	4.0%	14.1%	7.7%	12-13	5.4%	5.8%	5.9%	3.4%	2.7%	3.6%	14.1%	7.7%	12-13	0.3%	-0.4%	-3.5%	0.9%	-0.1%	-0.3%	0.0%	0.0%
13-14	4.0%	8.0%	7.8%	4.1%	2.4%	3.8%	9.7%	37.9%	13-14	5.8%	9.1%	8.7%	5.3%	4.3%	5.7%	9.7%	37.9%	13-14	1.8%	1.1%	0.8%	1.2%	1.9%	2.0%	0.0%	0.0%
14-15	7.6%	8.1%	8.8%	5.1%	3.8%	4.1%	10.7%	16.4%	14-15	6.5%	8.7%	8.1%	5.6%	4.6%	5.9%	10.7%	16.4%	14-15	-1.2%	0.6%	-0.7%	0.6%	0.8%	1.8%	0.0%	0.0%
15-16	16.3%	8.4%	7.8%	6.1%	4.9%	6.2%	9.5%	5.6%	15-16	7.8%	9.7%	8.8%	7.0%	5.8%	6.9%	9.5%	5.6%	15-16	-8.5%	1.3%	1.1%	0.9%	0.9%	0.7%	0.0%	0.0%
16-17	8.3%	10.2%	10.7%	4.0%	6.7%	5.6%	11.2%	2.7%	16-17	6.9%	10.0%	9.0%	7.8%	7.0%	7.8%	11.2%	2.7%	16-17	-1.5%	-0.2%	-1.7%	3.8%	0.3%	2.2%	0.0%	0.0%
17-18	9.1%	9.5%	10.2%	5.8%	6.7%	9.6%	5.5%	1.8%	17-18	5.9%	8.7%	7.8%	8.5%	7.4%	7.9%	5.5%	1.8%	17-18	-3.3%	-0.8%	-2.4%	2.7%	0.7%	-1.8%	0.0%	0.0%
18-19	6.9%	9.0%	8.0%	13.7%	9.6%	9.4%	5.4%	0.8%	18-19	8.1%	8.4%	7.4%	9.6%	8.4%	8.3%	5.4%	0.8%	18-19	1.2%	-0.5%	-0.6%	-4.1%	-1.2%	-1.1%	0.0%	0.0%
19-20	4.7%	8.3%	5.6%	11.9%	9.8%	8.6%	5.5%	0.1%	19-20	4.8%	7.2%	6.8%	9.3%	9.0%	8.7%	5.5%	0.1%	19-20	0.1%	-1.1%	1.2%	-2.6%	-0.8%	0.0%	0.0%	0.0%
20-21	3.2%	7.6%	4.2%	14.6%	7.5%	11.3%	3.9%	0.1%	20-21	2.9%	6.5%	7.0%	11.1%	12.2%	11.3%	3.9%	0.1%	20-21	-0.4%	-1.1%	2.8%	-3.5%	4.6%	0.0%	0.0%	0.0%
21-22	2.1%	7.2%	5.2%	12.3%	12.8%	12.1%	2.0%	0.0%	21-22	3.8%	7.2%	7.2%	14.0%	17.1%	13.6%	2.0%	0.0%	21-22	1.7%	0.1%	2.0%	1.7%	4.3%	1.5%	0.0%	0.0%
22-23	1.6%	2.3%	1.1%	7.2%	10.9%	6.9%	1.0%	0.0%	22-23	1.9%	2.3%	2.6%	5.5%	8.1%	6.1%	1.0%	0.0%	22-23	0.3%	0.0%	1.5%	-1.7%	-2.8%	-0.8%	0.0%	0.0%
23-0	0.6%	0.7%	0.7%	4.1%	6.2%	4.2%	1.8%	0.0%	23-0	0.9%	1.0%	1.4%	2.8%	5.3%	3.4%	1.8%	0.0%	23-0	0.3%	0.3%	0.6%	-1.3%	-0.9%	-0.7%	0.0%	0.0%
0-1	0.2%	0.3%	0.6%	1.1%	5.0%	2.0%	0.2%	0.0%	0-1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0-1	-0.2%	-0.3%	-0.6%	-1.1%	-5.0%	-2.0%	0.0%	0.0%
1-2	0.1%	0.1%	0.3%	0.7%	1.9%	0.8%	0.0%	0.0%	1-2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1-2	-0.1%	-0.1%	-0.3%	-0.7%	-1.9%	-0.8%	0.0%	0.0%
2-3	0.0%	0.0%	0.1%	0.2%	1.3%	0.8%	0.0%	0.0%	2-3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2-3	0.0%	0.0%	-0.1%	-0.2%	-1.3%	-0.8%	0.0%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	*Total*	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	*Total*	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

	Observed Tour Duration									Observed Tour Duration									Difference (Modeled-Observed)							
Duration	Escort	Shop	Maint.	Eat Out	Visit	Discr.	Joint	At-work	Duration	Escort	Shop	Maint.	Eat Out	Visit	Discr.	Joint	At-work	Duration	Escort	Shop	Maint.	Eat Out	Visit	Discr.	Joint	At-work
0-1	64.9%	25.2%	20.5%	12.5%	8.2%	4.8%	6.6%	35.4%	0-1	40.9%	25.2%	17.9%	20.1%	15.4%	12.9%	6.6%	35.4%	0-1	-24.0%	0.1%	-2.5%	7.6%	7.3%	8.1%	0.0%	0.0%
1-2	17.0%	31.6%	27.0%	29.2%	15.5%	24.6%	26.3%	48.4%	1-2	37.0%	23.3%	16.4%	18.0%	14.6%	10.9%	26.3%	48.4%	1-2	20.0%	-8.4%	-10.6%	-11.2%	-0.9%	-13.8%	0.0%	0.0%
2-3	5.4%	19.9%	19.4%	15.9%	19.8%	23.2%	23.2%	7.2%	2-3	4.4%	13.6%	15.4%	16.1%	13.9%	19.0%	23.2%	7.2%	2-3	-1.0%	-6.3%	-4.0%	0.2%	-5.8%	-4.2%	0.0%	0.0%
3-4	2.1%	9.3%	7.8%	9.2%	16.5%	15.2%	14.9%	4.1%	3-4	4.3%	12.4%	14.6%	14.7%	13.7%	17.1%	14.9%	4.1%	3-4	2.2%	3.1%	6.8%	5.5%	-2.7%	1.9%	0.0%	0.0%
4-5	1.5%	3.2%	6.1%	5.7%	12.5%	8.1%	11.9%	2.4%	4-5	1.7%	5.8%	6.9%	6.3%	6.4%	7.7%	11.9%	2.4%	4-5	0.2%	2.7%	0.8%	0.6%	-6.1%	-0.3%	0.0%	0.0%
5-6	1.3%	2.5%	5.1%	3.7%	10.7%	5.7%	3.4%	0.7%	5-6	1.6%	5.1%	6.2%	5.6%	6.0%	6.8%	3.4%	0.7%	5-6	0.3%	2.5%	1.1%	1.9%	-4.7%	1.1%	0.0%	0.0%
6-7	0.8%	1.4%	1.7%	3.4%	5.3%	4.3%	3.7%	1.3%	6-7	1.4%	3.1%	3.9%	3.3%	3.7%	4.1%	3.7%	1.3%	6-7	0.6%	1.6%	2.2%	-0.1%	-1.5%	-0.3%	0.0%	0.0%
7-8	1.1%	1.1%	2.9%	3.1%	1.7%	2.6%	3.8%	0.3%	7-8	1.4%	2.6%	3.5%	2.8%	3.4%	3.6%	3.8%	0.3%	7-8	0.2%	1.6%	0.6%	-0.3%	1.7%	1.0%	0.0%	0.0%
8-9	0.3%	1.1%	2.3%	2.0%	3.5%	2.1%	0.7%	0.1%	8-9	1.2%	2.4%	3.5%	2.7%	3.6%	3.6%	0.7%	0.1%	8-9	0.8%	1.3%	1.2%	0.7%	0.1%	1.4%	0.0%	0.0%
9-10	1.1%	0.9%	1.9%	4.6%	0.7%	2.4%	2.5%	0.0%	9-10	1.1%	1.9%	3.0%	2.3%	3.6%	3.2%	2.5%	0.0%	9-10	0.0%	1.0%	1.1%	-2.3%	2.9%	0.9%	0.0%	0.0%
10-11	1.2%	0.7%	1.7%	2.7%	2.9%	2.4%	0.4%	0.0%	10-11	1.1%	1.6%	2.5%	1.9%	3.4%	2.8%	0.4%	0.0%	10-11	-0.1%	0.8%	0.8%	-0.8%	0.5%	0.4%	0.0%	0.0%
11-12	1.1%	0.8%	0.9%	3.7%	1.0%	1.3%	1.4%	0.0%	11-12	0.9%	1.1%	1.8%	1.6%	2.8%	2.2%	1.4%	0.0%	11-12	-0.2%	0.3%	0.9%	-2.1%	1.8%	0.9%	0.0%	0.0%
12-13	0.7%	0.5%	1.0%	2.0%	0.7%	1.0%	0.7%	0.0%	12-13	0.8%	0.9%	1.6%	1.5%	2.9%	2.0%	0.7%	0.0%	12-13	0.1%	0.3%	0.5%	-0.6%	2.2%	1.1%	0.0%	0.0%
13-14	0.2%	0.9%	0.5%	0.5%	0.3%	0.7%	0.2%	0.0%	13-14	0.7%	0.6%	1.3%	1.3%	2.6%	1.7%	0.2%	0.0%	13-14	0.6%	-0.3%	0.7%	0.8%	2.2%	1.0%	0.0%	0.0%
14-15	0.3%	0.1%	0.3%	0.2%	0.2%	0.4%	0.0%	0.0%	14-15	0.9%	0.3%	0.8%	0.8%	1.9%	1.2%	0.0%	0.0%	14-15	0.6%	0.2%	0.4%	0.7%	1.7%	0.8%	0.0%	0.0%
15-16	0.1%	0.1%	0.2%	0.2%	0.4%	0.2%	0.1%	0.0%	15-16	0.5%	0.1%	0.4%	0.5%	1.2%	0.7%	0.1%	0.0%	15-16	0.4%	0.0%	0.2%	0.3%	0.8%	0.5%	0.0%	0.0%
16-17	0.9%	0.5%	0.3%	0.8%	0.1%	0.6%	0.1%	0.0%	16-17	0.2%	0.0%	0.2%	0.3%	0.6%	0.3%	0.1%	0.0%	16-17	-0.7%	-0.5%	-0.1%	-0.5%	0.5%	-0.3%	0.0%	0.0%
17-18	0.0%	0.0%	0.0%	0.7%	0.0%	0.2%	0.0%	0.0%	17-18	0.1%	0.0%	0.0%	0.1%	0.2%	0.1%	0.0%	0.0%	17-18	0.1%	0.0%	0.0%	-0.6%	0.2%	-0.1%	0.0%	0.0%
18-19	0.0%	0.0%	0.1%	0.0%	0.0%	0.2%	0.0%	0.0%	18-19	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	18-19	0.0%	0.0%	-0.1%	0.0%	0.1%	-0.2%	0.0%	0.0%
19-20	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	19-20	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	19-20	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
20-21	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20-21	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20-21	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
21-22	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	21-22	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	21-22	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
22-23	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	22-23	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	22-23	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
23-24	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	23-24	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	23-24	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	*Total*	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	*Total*	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%