San Antonio Multimodal Model Version 5.0

Model Validation

technical

report

prepared for

Alamo Area Metropolitan Planning Organization

prepared by

Cambridge Systematics, Inc.

October 14, 2022

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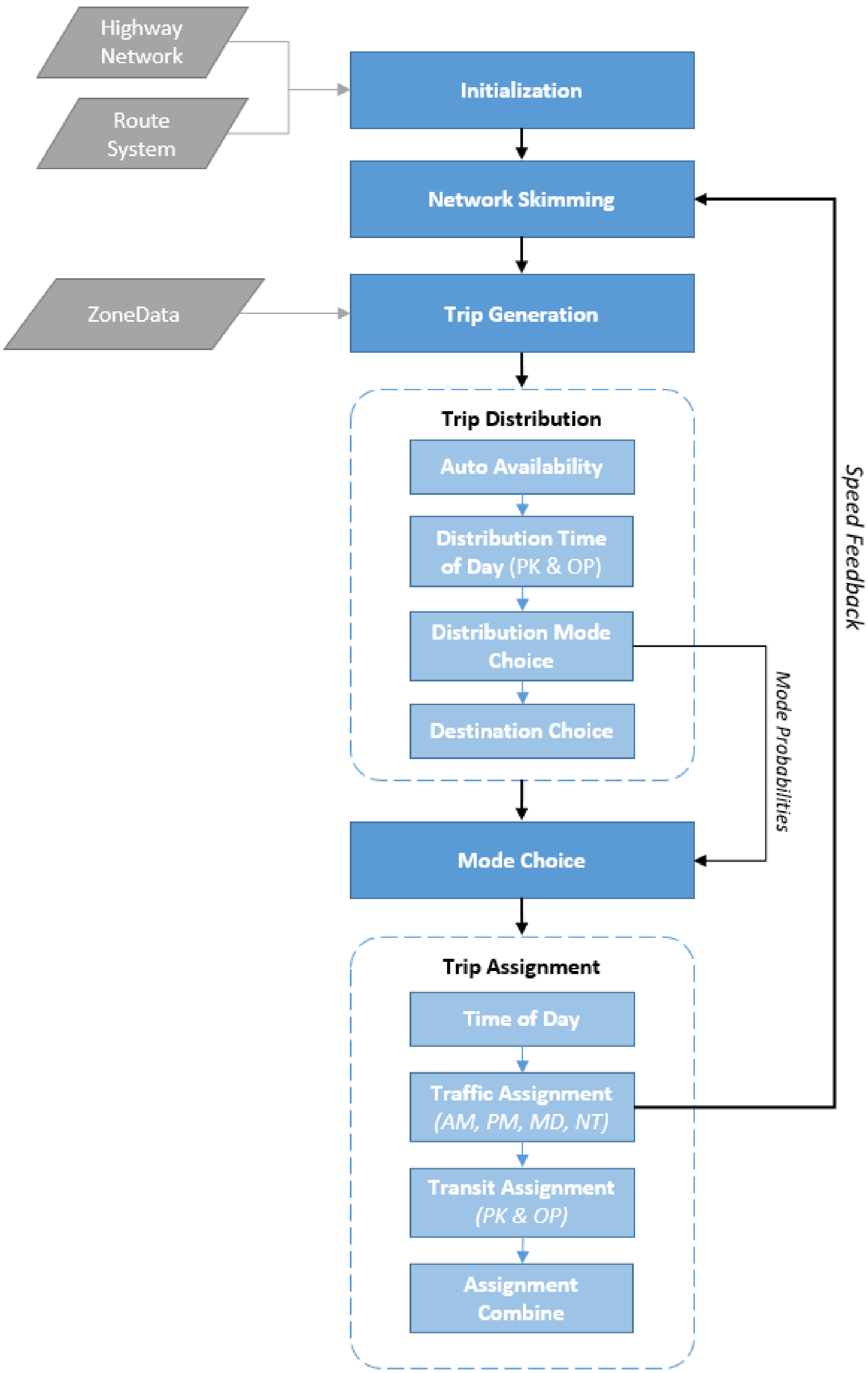
1.0 Introduction

The Alamo Area Metropolitan Planning Organization (AAMPO) and member jurisdictions use the San Antonio Multimodal Model (SAMM) as a tool to forecast traffic and travel in communities throughout the region. The primary purposes of the travel model are to support the Regional Transportation Plan (RTP) and air quality conformity analysis. Additionally, the model can support evaluation of proposed roadway and transit projects, help evaluate potential impacts of proposed development projects, and support various other studies of the region, subareas, corridors, and other planning activities. The model has been calibrated to reflect a base year of 2020 and contains future year data reflecting forecast 2050 conditions. Interim year data representing several intermediate timeframes is also maintained in the travel model dataset.

The previous version of the model featured a 2015 base year and 2045 forecast year. The model is regularly updated by AAMPO to reflect current conditions and the most recent available data. This version of the model includes moderate changes to the previous version of the model. Changes include bringing model data up to date, incorporation of new socioeconomic data at the TAZ level, and improved modeling of airport and external trips. Data sources include a household travel survey, an external station survey, an airport special generator survey, a workplace survey, a commercial truck survey, and a transit on-board survey. The household travel survey was collected in 2005, so aspects of the model relying on household travel survey data have been minimally updated.

The model’s process and functions are shown in the model flow diagram in Figure 8.1. It is an adaptation of the standard 4-step modeling process.

Figure 1.1 SAMM Flowchart



2.0 Traffic Analysis Zones

Traffic analysis zones (TAZs) contain socioeconomic data used as the foundation for trip-making in the travel model. The TAZ system is made up of 1317 internal zones and 42 external stations. The modeling area comprises Bexar, Comal, Guadalupe, Kendall and Wilson Counties. Each zone in the TAZ system is assigned population, number of households, median household income, and employment by type. Table 2.1 summarizes the socioeconomic data for the modeling area.

Table 2.1 2020 AAMPO Socioeconomic Profile

Variable	2020	2025	2035	2045	2050
Population	2,509,178	2,777,687	3,346,739	3,967,173	4,312,884
Households	840,696	943,454	1,172,305	1,421,586	1,567,165
Average Household Size	2.93	2.90	2.82	2.76	2.72
Basic Employment	363,941	382,301	435,760	493,590	525,118
Retail Employment	351,486	395,702	488,009	584,361	637,502
Service Employment	679,550	767,198	939,572	1,131,515	1,239,426
Education Employment	121,068	132,462	156,782	184,644	200,613
Total Employment	1,516,045	1,677,663	2,020,123	2,394,110	2,602,659
Population/Employment Ratio	1.66	1.66	1.66	1.66	1.66

2.1 Base Year Data Development

The 2020 base year socioeconomic dataset was developed using the following data sources:

- Texas Demographic Center (TDC) county-level estimates of population and employment;
- Latest available American Community Survey (ACS) 5-year data and 1-year data;
- 2017 Integrated Postsecondary Education Data System (IPEDS) data;
- 2018 Texas Education Agency (TEA) data;
- 2020 point-level employment data by NAICS code (InfoUSA); and
- AAMPO 2015 TAZ-level estimates
- Google Earth satellite imagery
- GIS layers showing land availability, city/municipality future plans, zoning, development type, and developability of vacant land.

TAZ data for the 2020 base year was developed using a top-down approach, starting with county-level totals provided by the TDC. Households and population were apportioned to Census block-groups based on ACS data and then further disaggregated to TAZs using the 2015 model dataset. County-level employment totals were apportioned to TAZs based on a combination of InfoUSA and TEA data. The InfoUSA point data were categorized into Basic, Retail, Service, and Education employment and aggregated to the TAZ-level. The TEA data served as a secondary source of data for Education employment. Both sets of inputs were manually checked and adjusted by comparing to the 2015 AAMPO TAZ dataset, satellite imagery, and available GIS layers of zoning, development type, and developability of vacant land.

Block-group level median household income and workers per household were obtained directly from ACS and allocated to TAZs based on share of TAZs within each block-group. Base year 2020 median household income is in express as year 2020 dollars. This provides the basis for constant dollar forecasts for all future analysis year expressed as 2020 dollars.

3.0 Transportation Networks

The transportation networks, consisting of the roadway and transit networks, contain input data for use in the travel demand model and represent conditions for the 2020 base year. Through a Master Network system, these networks also represent expected conditions for future years and can be used to run the model for any set of proposed transportation improvements. The transportation networks are used in the model to distribute trips and route vehicle and transit trips.

The transportation network development process for this version of the model builds on roadway and transit networks developed for the 2015 base year model. As part of this effort, separate networks for each model year and scenario have been replaced with a consolidated Master Network system. The Master Network system includes the base year networks along with proposed and planned roadway and transit projects in a single database. The Master Network supports creation of Scenario Networks that represent a particular set of roadways and transit routes representing a user-specified year or scenario.

3.1 Roadway Network

The AAMPO Roadway network represents all facilities functionally classified as a collector or higher functional classification. Each link in the roadway network includes attributes describing functional class, facility type, area type, number of lanes, direction (1-way/2-way), and level of access (divided/undivided). All network links include traffic counts, either pre-pandemic 2020 traffic counts or 2020 count estimates.

3.1.1 Functional Classification and Facility Type

The functional classification of each roadway link reflects the system of streets and highways. Higher level functional classifications, such as freeways have limited access, high speeds, and serve longer distance travel or through trips. Lower level functional classifications, such as minor arterials and collectors, provide local access to neighborhoods and activities and feature lower capacities and speeds. SAMM uses a two-tiered system of functional classification and facility type designations, shown in Table 3.1. The Functional Class variable identifies the primary function or each link, while the facility type variable provides additional detail such as designation as loop vs. radial highways and designation of divided or undivided arterials. The terms Expressway and Freeway are often used interchangeably. However, for the purpose of modeling, Freeways are completely access controlled whereas Expressways are only partially access controlled.

Table 3.1 Functional Class and Facility Type Definitions

Functional Class	Functional Class Description	Facility Type	Facility Type Description
0	Centroid Connectors	0	Centroid Connectors
1	Interstate Freeways	1	Radial IH Freeways (Mainlanes)
1	Interstate Freeways	2	Radial IH Freeways (Toll/HOV Lanes)
1	Interstate Freeways	3	Loop IH Freeways (Mainlanes)
1	Interstate Freeways	4	Loop IH Freeways (Toll/HOV Lanes)
2	Other Freeways	5	Radial Other Freeways (Mainlanes)
2	Other Freeways	6	Radial Other Freeways (Toll/HOV Lanes)
2	Other Freeways	7	Loop Other Freeways (Mainlanes)
2	Other Freeways	8	Loop Other Freeways (Toll/HOV Lanes)
3	Expressways	9	Radial Expressways
3	Expressways	10	Loop Expressways
4	Principal Arterials	11	Principal Arterials (Divided)
4	Principal Arterials	12	Principal Arterials (Cont. Left Turn)
4	Principal Arterials	13	Principal Arterials (Undivided)
5	Minor Arterials	14	Minor Arterials (Divided)
5	Minor Arterials	15	Minor Arterials (Cont. Left Turn)
5	Minor Arterials	16	Minor Arterials (Undivided)
6	Collectors	17	Collectors (Divided)
6	Collectors	18	Collectors (Cont. Left Turn)
6	Collectors	19	Collectors (Undivided)
7	Frontage Roads	20	Frontage Roads
8	Ramps	21	Ramps (Frontage to Mainlanes)
8	Ramps	22	Ramps (Freeway to Freeway)
8	Ramps	23	Tolled Ramps
9	Transit-only Links	24	Transit-only Link

3.1.2 Area Types

Area type is an attribute assigned to each TAZ and roadway and is based on the activity level and character of the zone. Terminal times, speed-limit to freeflow speed conversion factors, roadway capacity, and volume-delay characteristics are dependent on area type. Area type is first defined at the TAZ level based on socioeconomic characteristics and then transferred to the roadway network.

There are five area types considered in this model, as defined in Table 3.2. Outside of the central business district (CBD), area types are defined based on the activity density in each zone, calculated using the formula below.

$$Activity\ Density = \frac{Pop + (2.21 \cdot Emp)}{Acres}$$

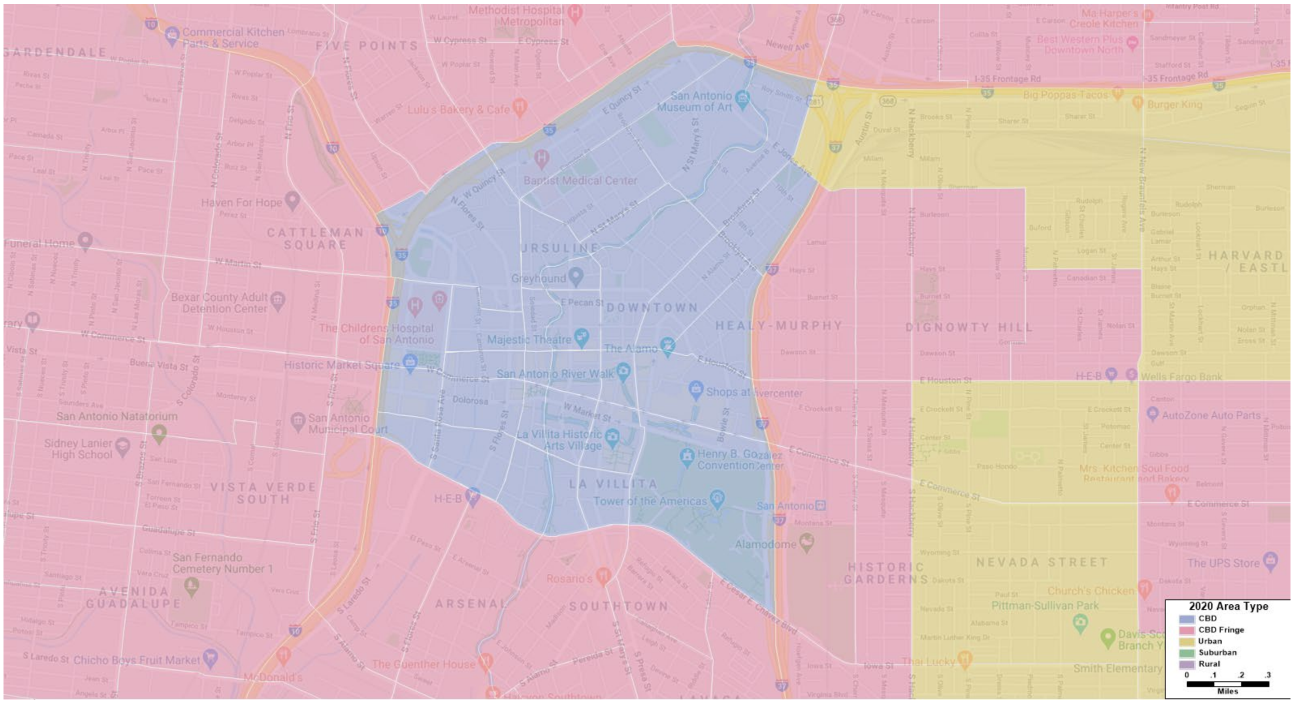
Zones identified as CBD are based on a historical definition of the CBD shown in Figure 3.1 and do not change over time. Area types resulting from the formulaic approach are calculated for the base year and for each forecast year, and then manually adjusted or "smoothed" to produce contiguous regions of each area type. The adjustment process identifies individual zones or small groups of zones surrounded by zones of a different area type. Such areas are reviewed along with aerial photography and modified as appropriate. For forecast years, TAZs can only change from less dense to more dense values over time.

Area type values from the TAZ layer are transferred to links first using an automated process, and are then manually adjusted. The manual adjustment process addresses links that lie along area type boundaries, or that cross an area type boundary. It also addresses cases where a corridor oscillates between two area types, which would result in unrealistic variation in attributes that are depending on area type. During the adjustment process, links along an area type boundary or that travel between area types are generally assigned the denser of the two potential area type values. The resulting 2020 base year area types are shown in Figure 3.2.

Table 3.2 Area Type Definition

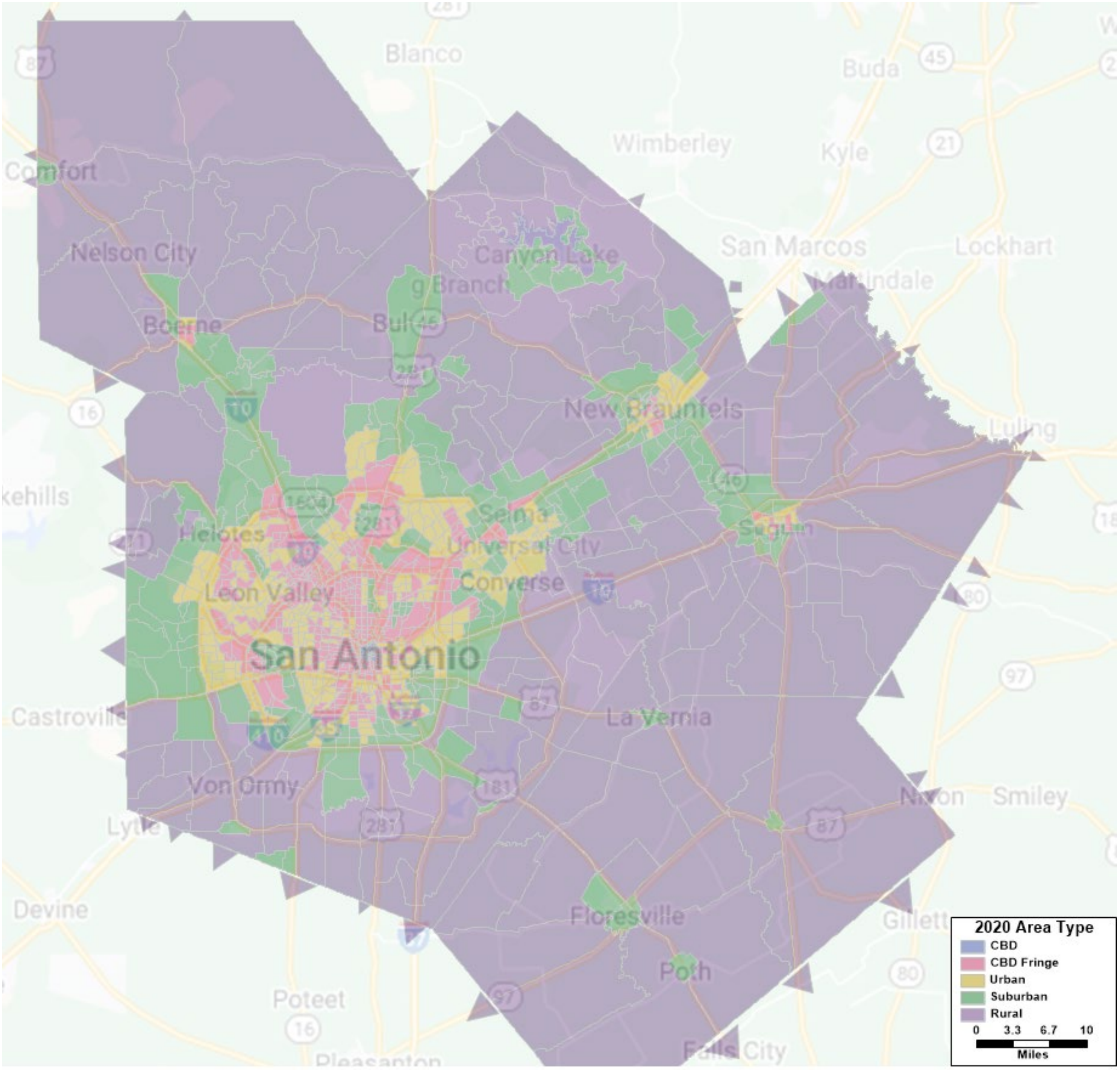
Area Type	Area Type Description	Threshold
1	Central Business District (CBD)	Historical
2	CBD Fringe (Urban Dense)	Activity Density > 15
3	Urban Residential	10 < Activity Density <= 15
4	Suburban Residential	1 < Activity Density <= 10
5	Rural	Activity Density <= 1

Figure 3.1 San Antonio Historical CBD Definition



Source: San Antonio Multimodal Model (SAMM) Version 5.0.

Figure 3.2 2020 Area Types



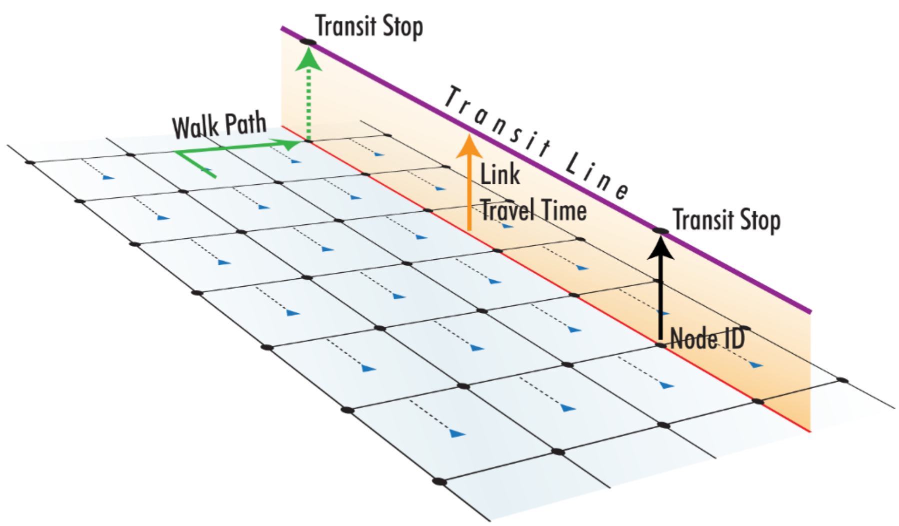
3.2 Transit Network

The travel model uses transit networks to build the shortest paths between each zone pair for transit trips. The resulting shortest paths are used as inputs to the mode choice model. The model uses information stored on the roadway network layer, including congested travel times, and a TransCAD route system to represent the transit networks. For transit pathbuilding, SAMM uses the “Pathfinder” method provided by the TransCAD software. Along with route alignments, the transit networks include information on stop locations, peak and off-peak headways, mode, base fare, and transfer fare.

The master transit route system includes base year 2020 routes coded according to 2019 route schedules and General Transit Speed Specification (GTFS) data provided by VIA[1]. It also includes future year route alignments, including anticipated improvements to the transit system as well as routes that must be modified to accommodate roadway projects.

Transit networks in TransCAD are made up of two separate but connected layers: the transit route system and the transit line layer. Information from these two layers is combined as shown in Figure 3.3 to allow representation of walk, drive, and in-vehicle components of a transit trip. Because these layers are connected, information on the transit line layer, such as link travel times and centroid data, is available to the route system; however, this also requires the roadway and transit networks to be maintained in a manner that prevents them from becoming inconsistent with each other.

Figure 3.3 Connections between the Route System and Transit Line Layer



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

4.0 Trip Generation

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

Trip generation is conducted using TxDOT's latest trip generation program, TripCAL 6. This program implements disaggregation of households by classification variables, a cross-classified production model, and regression-based attraction model.

4.1 Socioeconomic Disaggregation

The household data input to the model include total households, population, median income, and number of resident workers. TripCAL 6 disaggregates this data into a tri-variate distribution of households by income, size, and number of workers. Classification variables are as follows:

- Household size groups from 1-person to 5+ person households.
- Household worker groups from 0-worker to 2+ worker households.
- Income groups by 5 categories defined in Table 4.1.

Table 4.1 Household Income Groups

Income Group	Income Range (2020 dollars)
Low Income	Up to $19,999
Low-medium Income	$20,000 – $34,999
Medium Income	$35,000 – $49,999
High-medium Income	$50,000 – $74,999
High Income	$75,000 and up

4.2 Trip Purposes

SAMM includes 9 internal trip purposes, plus 3 external trip purposes, as defined below. With the exception of commercial truck trips, internal trips are generated as person trips. Commercial truck trips and all external trips are generated as vehicle trips and are not subject to the mode choice model.

- **Home-Based Work (HBW):** Commute trips between home and work.
- **Home-Based Education K-12 (HBED1):** Trips between home and a K-12 school by enrolled students.

- **Home-Based College/University (HBED2):** Trips between home and college/university locations by enrolled students.
- **Home-Based Shop (HBSH):** Trips between home and retail locations for the purpose of shopping.
- **Home-Based Other (HBO):** All other trips that have one end at home.
- **Non-Home-Based (NHB):** Trips by residents with neither end at home, including trips between work and non-home locations.
- **Non-Home-Based Special (NHBS):** All trips made by visitors to the region, except airport trips.
- **Airport (AIR):** Passenger trips made to and from the airport.
- **Commercial Truck and Taxi (TRTX):** Truck trips made by commercial vehicles, roughly represented as trucks over 8,500 pounds in weight and having six or more tires. Note: TripCAL names these trips "Truck and Taxi" but SAMM does not include taxi trips in this purpose.
- **External-local Commercial Trucks (EXLO-C):** Commercial truck trips having one end in the region and one end outside of the region.
- **External-local Non-Commercial (EXLO-NC):** Passenger vehicle trips having one end in the region and one end outside of the region.
- **External Through (THRU):** Passenger vehicle and commercial truck trips passing through the region without stopping (through trips with quick convenience stops are included in this purpose).

4.3 Trip Rates

Trip rates estimated from the 2005 household travel survey have been retained from the previous model, with some adjustments to match overall regional VMT.

4.3.1 Trip Production Rates

Trip production rates are provided for home-based non-commercial trips, as well as NHB trips. Because NHB trip productions do not occur at the home, only the regional trip production total is retained and trip-ends are allocated based on results of the NHB trip attraction model. Trip production rates are not provided for NHBS trips and internal commercial trips. Instead, production rates for these trip purposes are identical to trip attraction rates. External local productions were derived from the 2020 external counts and external survey, including for both commercial and non-commercial vehicles.

Production rates for HBW trips, shown in Table 4.2, are classified by number of workers, household size, and income group. Production rates for other internal non-commercial trip purposes are generated based on household size and income, with an additional urban/rural variable. This urban/rural variable allows the model to represent different trip-making characteristics for households in rural areas that are farther from activities. Rural areas generate fewer home-based non-work trips, with the difference between urban and rural trip rates having been adjusted during model validation.

Table 4.2 HBW Trip Production Rates

Number of Workers	Income Group	1-Person	2-Person	3-Person	4-Person	5-Person
0	All	0	0	0	0	0
1	1 – Low	1.93	1.56	1.66	1.64	1.62
1	2 – Low-Medium	1.85	1.60	1.73	1.79	1.76
1	3 – Medium	1.60	1.57	1.85	1.95	1.93
1	4 – Medium-high	1.38	1.55	1.83	1.94	1.96
1	5 – High	1.23	1.58	1.88	2.02	2.04
2+	1 – Low	0	4.02	4.08	4.20	4.68
2+	2 – Low-Medium	0	3.76	3.77	3.94	4.43
2+	3 – Medium	0	3.43	3.56	3.73	4.10
2+	4 – Medium-high	0	3.18	3.30	3.47	3.82
2+	5 – High	0	3.07	3.11	3.33	3.71

Table 4.3 HBED1 Trip Production Rates

Urban/Rural	Income Group	1-Person	2-Person	3-Person	4-Person	5-Person
Urban	1 – Low	0.04	0.48	3.46	4.28	8.74
Urban	2 – Low-Medium	0.04	0.38	2.60	4.18	8.33
Urban	3 – Medium	0.04	0.20	2.13	3.97	7.65
Urban	4 – Medium-high	0.04	0.20	1.56	3.70	7.10
Urban	5 – High	0.04	0.19	1.47	3.60	6.99
Rural	1 – Low	0.02	0.26	3.24	4.07	8.52
Rural	2 – Low-Medium	0.02	0.17	2.39	3.96	8.11
Rural	3 – Medium	0.02	0.09	1.92	3.76	7.44
Rural	4 – Medium-high	0.02	0.06	1.36	3.49	6.90
Rural	5 – High	0.02	0.03	1.27	3.39	6.79

Table 4.4 HBED2 Trip Production Rates

Urban/Rural	Income Group	1-Person	2-Person	3-Person	4-Person	5-Person
Either	All	0.49	0.49	0.49	0.49	0.49

Table 4.5 HBSH Trip Production Rates

Urban/Rural	Income Group	1-Person	2-Person	3-Person	4-Person	5-Person
Urban	1 – Low	1.34	1.94	2.23	2.58	3.41
Urban	2 – Low-Medium	1.39	2.02	2.35	2.84	3.66
Urban	3 – Medium	1.40	1.97	2.52	2.98	3.84
Urban	4 – Medium-high	1.39	1.89	2.49	2.95	3.84
Urban	5 – High	1.42	1.92	2.53	3.00	3.95
Rural	1 – Low	0.80	1.34	1.55	1.74	2.51
Rural	2 – Low-Medium	0.92	1.54	1.82	2.28	3.04
Rural	3 – Medium	1.03	1.58	2.09	2.50	3.30
Rural	4 – Medium-high	1.05	1.56	2.15	2.61	3.39
Rural	5 – High	1.09	1.58	2.20	2.67	3.60

Table 4.6 HBO Trip Production Rates

Urban/Rural	Income Group	1-Person	2-Person	3-Person	4-Person	5-Person
Urban	1 – Low	1.16	1.33	1.67	1.87	2.57
Urban	2 – Low-Medium	1.18	1.46	1.75	1.99	2.80
Urban	3 – Medium	1.16	1.49	1.86	2.06	3.08
Urban	4 – Medium-high	1.12	1.50	1.81	2.08	3.27
Urban	5 – High	1.16	1.56	1.88	2.17	3.38
Rural	1 – Low	0.76	0.79	1.14	1.30	1.82
Rural	2 – Low-Medium	0.82	1.07	1.33	1.56	2.30
Rural	3 – Medium	0.84	1.13	1.49	1.68	2.66
Rural	4 – Medium-high	0.85	1.23	1.55	1.81	3.00
Rural	5 – High	0.88	1.29	1.61	1.90	3.11

Table 4.7 NHB Trip Production Rates

Urban/Rural	Income Group	1-Person	2-Person	3-Person	4-Person	5-Person
Urban	1 – Low	1.38	1.58	1.92	3.00	3.60
Urban	2 – Low-Medium	1.73	1.94	2.42	3.42	5.03
Urban	3 – Medium	1.97	2.13	2.71	3.81	6.38
Urban	4 – Medium-high	2.07	2.14	2.80	4.11	7.04
Urban	5 – High	2.20	2.21	3.00	4.38	7.91
Rural	1 – Low	1.38	1.58	1.92	3.00	3.60
Rural	2 – Low-Medium	1.73	1.94	2.42	3.42	5.03
Rural	3 – Medium	1.97	2.13	2.71	3.81	6.38
Rural	4 – Medium-high	2.07	2.14	2.80	4.11	7.04
Rural	5 – High	2.20	2.21	3.00	4.38	7.91

4.3.2 Trip Attraction Rates

Attraction rates, shown in Table 4.8, vary by area type and are applied to employment by type and total households. For NHBS trips, commercial trips, and external trips, trip attraction rates also serve as trip production rates. For NHB trips, attraction rates serve as production allocation factors.

Table 4.8 Attraction Rates

Trip Purpose	Variable	1 - CBD	2 - CBD Fringe	3 - Urban	4 - Suburban	5 - Rural
HBW	Households	0.05	0.05	0.05	0.05	0.05
	Basic Emp	1.09	1.27	1.22	1.22	1.2
	Retail Emp	0.85	1.04	1.08	1.07	1.07
	Service Emp	1.06	1.43	1.36	1.39	1.22
	Education 1 Emp	1.05	1.09	1.14	1.17	1.17
	Education 2 Emp	1.05	1.09	1.14	1.17	1.17
HBED1	Education 1 Emp	25.96	26.55	27.68	29.32	30.68
HBED2	Education 2 Emp	11.49	11.67	31.49	23.99	1.79
HBSH	Retail Emp	3.0	6.39	6.98	7.58	6.06
HBO	Households	0.52	0.52	0.52	0.52	0.52
	Basic Emp	0.51	0.53	0.42	0.35	0.29
	Service Emp	0.8	1.66	1.6	1.72	1.37
NHB	Households	0.23	0.23	0.22	0.22	0.19
	Basic Emp	0.84	0.78	0.69	0.62	0.52
	Retail Emp	5.5	5.49	4.9	4.69	3.85
	Service Emp	0.94	1.0	1.18	1.27	1.14
	Education 1 Emp	6.16	4.92	3.83	2.44	1.19
	Education 2 Emp	6.16	4.93	3.83	2.44	1.19
NHBS (Visitor)	Households	0.03	0.03	0.03	0.03	0.03
	Basic Emp	0.07	0.26	0.26	0.35	0
	Retail Emp	0.39	0.33	0.36	1.3	0
	Service Emp	0.1	0.17	0.26	0.31	0
	Education 2 Emp	0.04	0.04	0.02	0.07	0.04
TRTX	Households	0.07	0.07	0.07	0.07	0.07
	Basic Emp	0.23	0.61	1.07	0.52	0.42
	Retail Emp	0.45	1.13	0.2	0.25	1.12
	Service Emp	0.12	0.39	0.24	0.23	0.33
	Education 1 Emp	0.83	0.53	0.73	1.19	1.32
	Education 2 Emp	0.83	0.53	0.73	1.35	1.32

4.3.3 Special Generators

SAMM v5 includes special generators specified at zones throughout the region that operate differently than typical TAZs. Special generator productions and attractions are specified by purpose at these locations, with the special generator values either replacing or adding to results of the trip generation model. For special generators that replace trip generation results, employment and household values are moved to a separate set of special generator SED fields in the TAZ layer. These fields allow tracking of employment and households, but are not used by the trip generation models. Special generator values are held constant in trip balancing.

4.3.4 Airport Trip Generation

San Antonio International Airport is treated as a unique location, with passenger trips to and from the airport modeled as a separate trip purpose. Total (Non-work) airport person trips are specified as a special generator value, calibrated to match traffic counts on airport access roads. Airport trips are modeled as attractions at the airport and productions at other zones in the region. Productions are allocated to zones using the equation below, and then balanced to the special generator airport total. This equation allocates more productions at higher density and higher income zones, which typically produce more trips to the airport.

$$P_A = c1 \cdot Population \cdot \sqrt{Income} + c2 \cdot Employment$$

Where c1 and c2 are coefficients with values of 0.0000942 and 0.00925, respectively.

5.0 Trip Distribution

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

SAMM uses a destination choice model to distribute most trip purposes and uses a gravity model to distribute TRTX, EXLO-C, and EXLO-NC trips.

5.1 Destination Choice

SAMM uses a destination choice model to distribute most trip purposes. Although more computationally intensive than gravity models, destination choice models are found to be better suited to capture the change in choices resulting from congestion because they reflect the impacts of the time and distance impedances between zones.

The destination choice models match productions resulting from the trip generation model to destinations based on results of the trip attraction model. SAMM's destination choice models doubly constrain the attractions for commute trip purposes (HBNW, HBED1, and HBED2), meaning that attractions from destination choice for these trip purposes match the trip generation results by TAZ. For HBSH and HBO trips, the destination choice model is doubly constrained for special generator attractions (calculated separately and input into the model) but is singly constrained for other zones. This allows trip attractions for non-mandatory trip purposes (HBSH, HBO, and NHB) to differ slightly from trip generation results, with more accessible zones receiving more trip attractions and less accessible zones receiving fewer attractions. Prior to running destination choice visitor (NHBS) trips are combined with resident NHB trips.

5.1.1 Model Specification

The destination choice model for each trip purpose is specified as a multinomial logit model, with the choice set for each origin zone being the set of all zones. The utility for each zone pair is specified in the equation below.

$$U_{ij} = Ln(A_j) + C_{ls} \cdot Logsum_{ij} + C_d \cdot d + C_{d5} \cdot d_5 + C_{d15} \cdot d_{15} + C_{d_{35}} \cdot d_{35} + C_{Intra} \cdot Intra + C_{air} \cdot Airport$$

Where:

U_{ij} = *utility between zones i and j*
A_j = *Attractions in zone j (by purpose)*
C_{ls} = *logsum coefficient*
C_d = *coefficient on total distance*
d = *total distance between zones i and j*
C_{dn} = *coefficient on portion of distance over* n *miles*
d_n = *distance over* n *miles*
C_{intra} = *intrazonal coefficient*
$Intra$ = *Binary flag indicating intrazonal zone pairs (1 for intrazonal, 0 otherwise)*
C_{air} = *Airport coefficient*
$Airport$ = *Binary flag indicating the destination zone is the airport (1 for airport, 0 otherwise)*

Elements of the destination choice utility function are described below, with coefficient values defined in Table 5.1.

- **Size variable:** Natural log of the attractions resulting from trip generation (A_j).
- **Logsum:** Coefficient C_{ls} multiplied by the mode choice logsum.
- **Distance:** A piecewise distance function with breakpoints at 5, 15, and 35 miles.
- **Intrazonal:** The logsum for intrazonal zone pairs include a calibrated intrazonal component.
- **Airport:** HBW trips to the airport zone include an additional coefficient estimated during initial development of the destination choice model.

Table 5.1 Destination Choice Model Coefficients

Table Header	HBW	HBED1	HBED2	HBSH	HBO	NHB
Logsum Coefficient	0.8220	0.3460	0.3460	0.3460	0.3460	0.3000
Distance – low and low-medium income, household size of 1 or 2	-0.2606					
Distance – medium through high income, household size of 1 or 2	-0.2439					
Distance – low and low-medium income, household greater than 2	-0.2486					
Distance – medium through high income, household size greater than 2	-0.2319					
Distance – zero or insufficient autos		-0.7782	-0.5072	-0.7492	-0.6742	
Distance – sufficient autos		-0.7352	-0.4642	-0.7062	-0.6312	
Distance – NHB						-0.5611
Distance over 5 miles	0.1089	0.4960	0.4960	0.4960	0.4960	0.3462
Distance over 15 miles	0.0654	-0.0615	-0.0615	-0.0615	-0.0615	0.1473
Distance over 35 miles	-0.0220	0.1838	0.1838	0.1838	0.1838	-0.1453
Intrazonal – lower income, insufficient autos	1.324	1.058	1.206	0.838	1.206	
Intrazonal – lower income, sufficient autos	1.848	0.908	1.056	0.688	1.056	
Intrazonal – higher income, insufficient autos	-0.692	0.584	0.732	0.364	0.732	
Intrazonal – higher income, sufficient autos	-0.168	0.434	0.582	0.214	0.582	
Intrazonal – NHB						0.929
Airport – lower income, insufficient autos	-0.014					
Airport – lower income, sufficient autos	0.467					
Airport – higher income, insufficient autos	0.773					
Airport– higher income, sufficient autos	1.254					

Notes: For HBW trips, lower income is defined as income groups 1-3. For other trips, lower income is defined as income groups 1-2.

5.1.2 Model Calibration

Trip distribution models were calibrated for HBW trips, home-based non-work trips (HBNW, including HBED1, HBED2, HBSH, and HBO), and NHB trips. Calibration was conducted by modifying the piecewise distance functions and intrazonal factors, pivoting from the originally estimated values. Comparisons of trip length frequency distributions (TLFDs) for the three grouped trip purposes are shown in Figure 5.1 through Figure 5.3.

Figure 5.1 HBW Trip Length Frequency Distribution Calibration

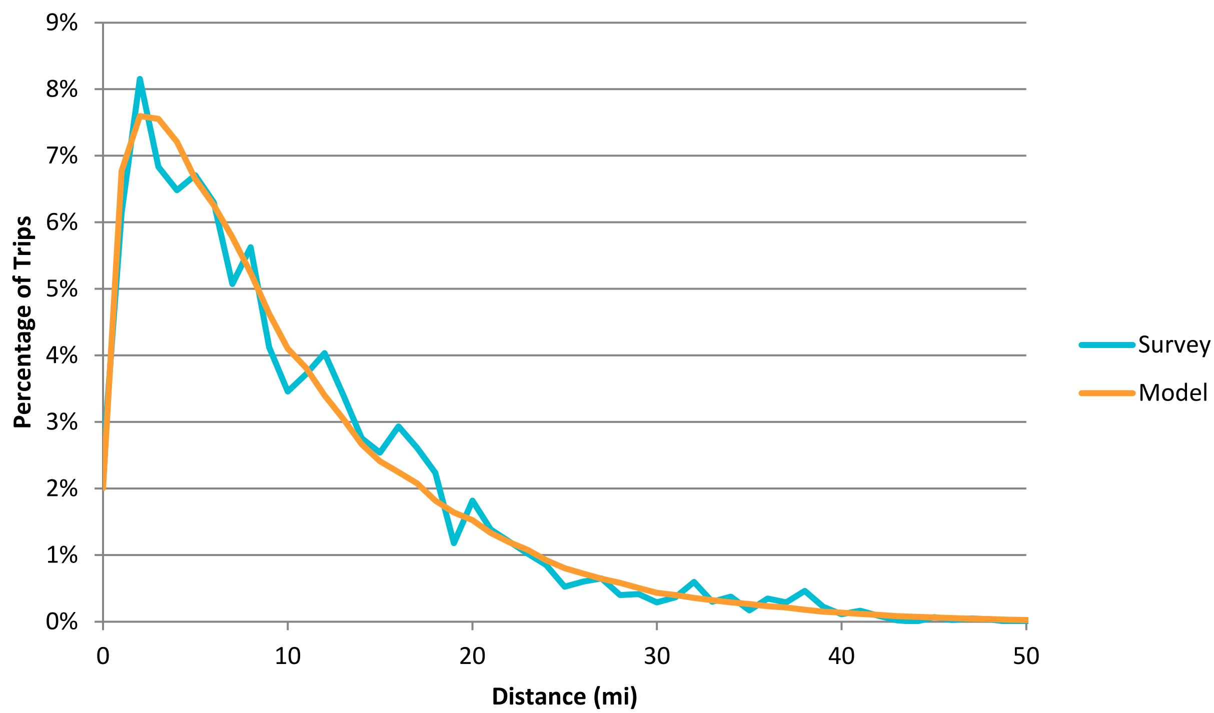


Figure 5.2 HBNW Trip Length Frequency Distribution Calibration

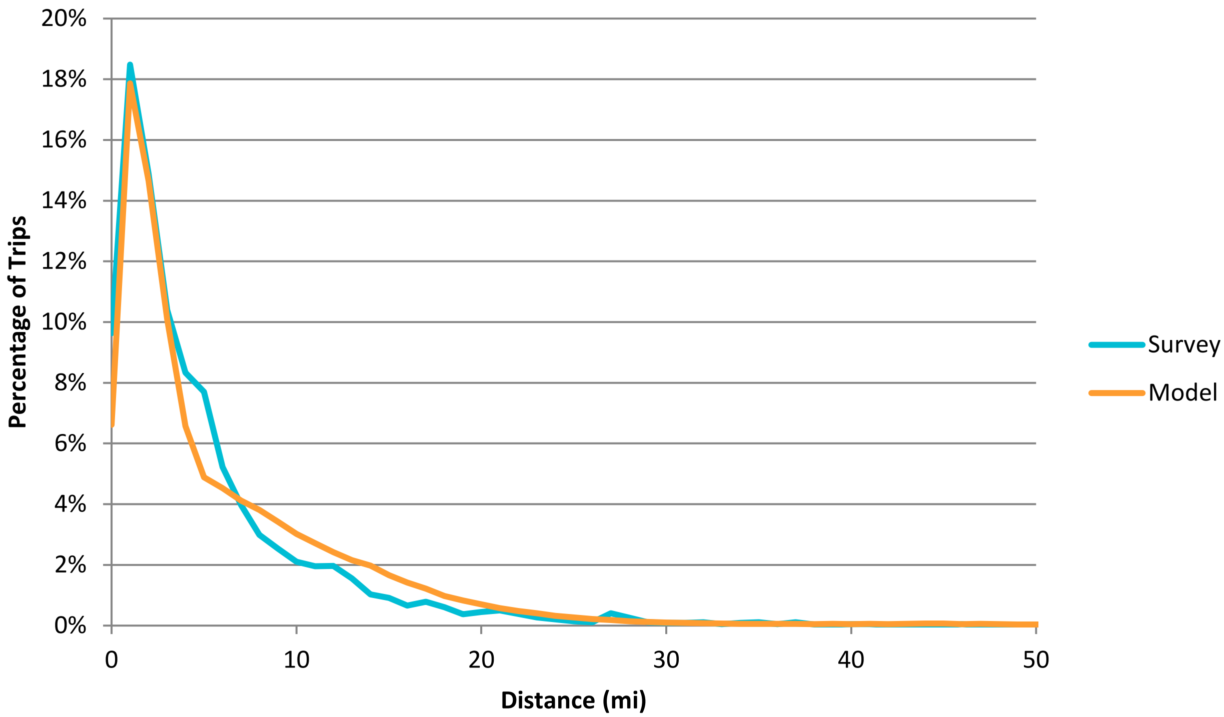
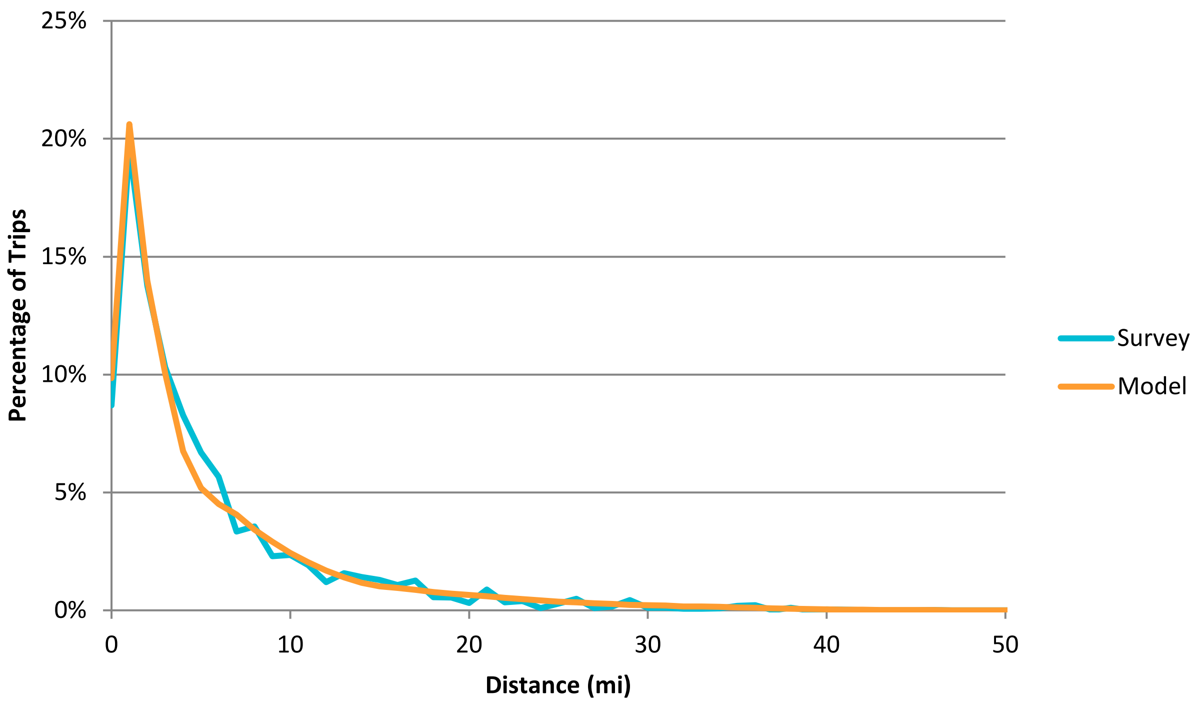


Figure 5.3 NHB Trip Length Frequency Distribution Calibration



5.2 Gravity Models

SAMM uses a doubly constrained gravity model to distribute external-local commercial and non-commercial (EXLO-C and EXLO-NC) trips, as well as truck trips (TRTX). The gravity model applies friction factors to represent the effects of impedance between zones. As the impedance between zones increases, the number of trips between those zones decreases as represented by a decreasing friction factor. The gravity model also assumes that the number of trips between two zones is directly proportional to the number of productions and attractions contained in those zones. The gravity model is defined in the equation below.

$$T_{ij} = P_i \cdot \frac{A_j \cdot F_{ij} \cdot K_{ij}}{\sum_{i=1}^{n} \left(A_j \cdot F_{ij} \cdot K_{ij}\right)}$$

Where:

T_{ij} = trips from zone i to zone j
P_i = productions in zone i
A_j = attractions in zone j
K_{ij} = K-factor adjustment from i to zone j
i = production zone
j = attraction zone
n = total number of zones
F_{ij} = friction factor (a function of impedance between zones i and j)

K-factors are sometimes used in travel demand models to account for nuances in travel behavior and the transportation system cannot be accurately modeled with simplified aggregate modeling techniques. They are typically applied at a district or jurisdictional level to adjust regional distribution patterns. SAMM 5.0 does not utilize k-factors.

Friction factors are defined using a gamma function, defined by the equation below. Gamma function values alpha, beta, and gamma vary by external station, as shown in Table 5.2. External stations on limited access freeways, listed in Table 5.2, use a different set of gamma functions than all other external stations. External gamma functions were calibrated by monitoring traffic counts along external corridors. Gamma function parameters for TRTX trips, shown in Table 5.3, have been retained from the previous version of the model.

$$F_{ij} = \alpha t^{\beta} e^{\gamma t}$$

Where:

F_{ij} = *friction factor between zones i and j*
t = *travel time*
α, β, γ = *calibration parameters*

Table 5.2 External Station Gamma Parameters

ID	External Station	Alpha	Beta	Gamma
1325	IH 35 (Comal/Hays Cty Line)	530	0.5000	0.090
1329	SH 130 (Guadalupe/Caldwell Cty Line)	530	0.5000	0.090
1332	IH 10 (Guadalupe/Caldwell Cty Line)	530	0.5000	0.090
1345	IH 37 (Bexar/Atascosa Cty Line)	530	0.5000	0.090
1346	US 281 (Bexar/Atascosa Cty Line)	530	0.5000	0.090
1347	SH 16 (Bexar/Atascosa Cty Line)	530	0.5000	0.090
1350	IH 35 (Bexar/Atascosa Cty Line)	530	0.5000	0.090
1351	US 90 (Bexar/Medina Cty Line)	530	0.5000	0.090
1357	IH 10 (Kendall/Kerr Cty Line)	530	0.5000	0.090
	All Others	491	0.5751	0

Table 5.3 Truck Trip Gamma Parameters

Trip Purpose	Alpha	Beta	Gamma
Truck-Taxi	100	0.021	0.123

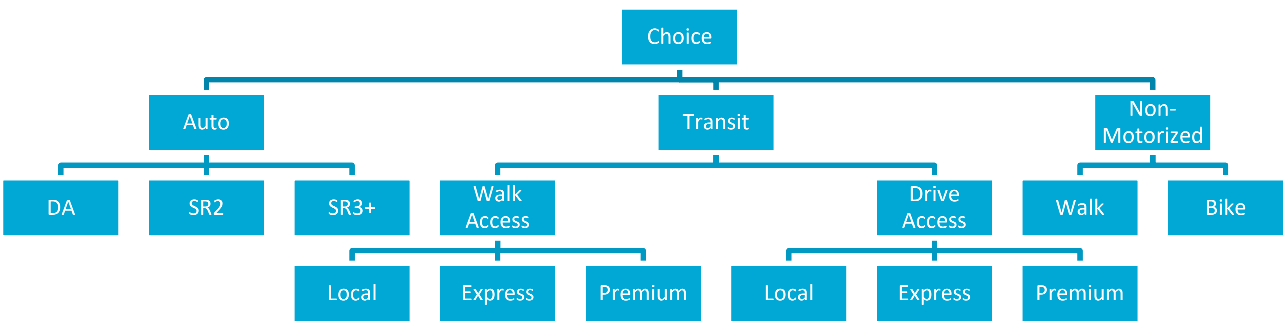
6.0 Mode Choice

The trip distribution model produces a set of person trip tables for each non-commercial internal trip purpose. Distributed person trips are segmented into peak and off-peak periods and by household size, income, and auto sufficiency. The mode choice model then separates person trip tables into the drive alone, shared ride (i.e., carpool), transit (walk access and drive access), and non-motorized (bicycle and walk) modes.

6.1 Model Structure

The nested logit mode choice model structure and estimated coefficients have been retained from the previous version of SAMM. Mode choice models were originally estimated for the 2010 base year model, using a combined dataset consisting of 2005 household travel survey data and 2010 on-board survey data. The mode choice model structure is shown in Figure 6.1. The structure includes three top-level choices of auto, transit, and non-motorized.

Figure 6.1 Nested Logit Mode Choice Model Structure



The mode choice model calculates a utility for each bottom level mode included in the mode choice structure. The utility function can be made up of impedance variables such as travel time, wait time, and cost as well as locational and socioeconomic variables. Each variable is multiplied by an estimated coefficient that describes the relative weight (positive or negative) of each variable. A mode constant that captures mode preferences not measured by the other utility variables is also added to the utility. Due to the relative nature of the mode constants, the mode constant for one mode must be set to zero. The utility equation applied to each mode is shown below.

$$u_i = c_1 X_{1i} + c_2 x_{2i} + c_3 x_{3i} + \ldots + c_n x_{ni}$$

Where:

u_i = Utility for mode i

$c_1, c_2, c_3, \ldots, c_n$ = Estimated coefficients for variables 1 through n

$x_{1i}, x_{2i}, x_{3i}, \ldots, x_{ni}$ = Values for variables 1 through n

6.2 Model Formulation

The model formulation consists of common level of service and cost elements, followed by purpose-specific coefficients and constants. All coefficients are scaled to represent values at the top level of the nested logit structure to facilitate comparison to other mode choice models and to FTA guidelines.

6.2.1 Common Utility Components

All modes and purposes include level of service and cost components in the utility functions. These common elements include in-vehicle travel time (IVTT), out of vehicle travel time (OVTT), the number of transfers for transit, and trip cost.

IVTT includes travel inside a transit vehicle or auto, with the exception of drive access to transit. OVTT includes all time outside of a vehicle such as terminal time, walk time, and wait time. Time spent in an auto driving to access transit is also treated as OVTT. Time spent waiting for an initial transit vehicle for longer than 7.5 minutes is assigned to IVTT to account for transit users timing trips based on schedules when headways exceed 15 minutes. The ratio of the OVTT coefficient to the IVTT coefficient has been constrained to 2.5 for consistency with FTA guidelines.

The cost variable is in 2020 dollars and consists of the following components:

- $0.15 / mile of auto operating (SOV, SR2, SR3, EXD, LCD)
- Parking costs divided by 2
- Transit fares (2020$)

Cost coefficients are weighted more heavily (i.e., more negative) for HBW trips than for HBNW and NHB trips.

6.2.2 Home-Based Work Utility Components

Mode choice coefficients for HBW trips are listed in Table 6.1. Elements of the HBW utility functions are discussed below.

- **Income Specific Constants**: Estimation showed that shared ride and transit modes are more attractive to low-income (income < $35,000) travelers as indicated by the positive coefficients. Similarly, shared ride and transit modes are less attractive to higher income (income > $50,000) travelers. Walk is also less attractive to higher income travelers. Originally estimated income-specific constants have been replaced by calibrated alternative specific constants developed using 2018 on-board survey and 2019 boarding data.
- **Household Vehicles:** The model estimates imply that shared ride and walk to transit modes are much more attractive to households with zero vehicles, as expected. Conversely, drive alone and drive to transit are more attractive to households with 'sufficient' vehicles (at least as many vehicles as household members).

- **Household Size:** Significant coefficients were estimated for small households (<=2 members) and shared ride modes. The shared ride mode coefficients are negative, meaning that larger households are more likely to choose shared ride modes.

- **Density Factor:** Significant positive coefficients were estimated on the attraction zone density factor for transit and bike modes.

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

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

Table 6.1 HBW Mode Choice Model Coefficients

Variable	Value	Effective VOT ($/hr)
IVTT Coef	-0.0198	
OVTT Coef	-0.0495	
OVTT Share of total time (Drive access to transit only)	-3.600	
Cost Coef – Low Income	-0.23539	$8.41
Cost Coef – Low-medium Income	-0.16502	$12.00
Cost Coef – Medium Income	-0.11767	$16.83
Cost Coef – High-medium Income	-0.07161	$27.65
Cost Coef – High Income	-0.05522	$35.86
Bike Distance Coef	-0.40803	
Walk Distance Coef	-1.34474	

6.2.3 Home-Based Non-Work Utility Components

Mode choice coefficients for HBW trips are listed in Table 6.2. Elements of the home-based non-work utility functions are discussed below. Originally estimated purpose-specific and income-specific constants have been replaced by calibrated constants, developed using 2018 on-board survey and 2019 boarding data.

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

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

- **HBSH Purpose Specific Constants:** HBSH travelers are more likely to drive alone than HBO travelers. HBSH trips may involve carrying parcels, which make it harder to use transit or non-motorized modes.
- **Income Specific Constants**: As expected, the walk mode is more attractive to low-income (income < $35,000) travelers as indicated by the positive coefficient. Conversely, walk and walk-transit modes are less attractive to higher income (income > $50,000) travelers.
- **Household Vehicles:** Unlike HBW trips, only walk to transit modes are more attractive to households with zero vehicles. Shared ride modes are less attractive to households with zero vehicles. A potential explanation for this is that HBW trips are more regular than HBNW and are therefore easier to coordinate carpooling with non-household members. If there are sufficient vehicles in the household the drive alone mode is more attractive than otherwise, as expected.
- **Household Size:** A significant coefficient was estimated for small households (<=2 members) and the shared ride 3 mode. The shared ride mode coefficients are negative, meaning that larger households are more likely to choose shared ride modes.
- **Density Factor:** A significant positive coefficient was estimated on the attraction zone density factor for shared ride, transit, and bike modes.
- **In-Vehicle Travel Time:** The estimated value for in-vehicle time of -0.0125 is within the FTA recommended range of -0.010 to -0.020 for HBNW trip purposes.
- **Non-Motorized Distance:** Travelers are more sensitive to walk distance than bike distance, which reflects the faster bike travel speed.

Table 6.2 Home-Based Non-Work Mode Choice Model Coefficients

Variable	Value	Effective VOT ($/hr)
IVTT Coef	-0.0125316	
OVTT Coef	-0.0313292	
OVTT Share of total time (Drive access to transit only)	-3.6	
Cost Coef – Low Income	-0.2979664	$4.21
Cost Coef – Low-medium Income	-0.2088848	$6.00
Cost Coef – Medium Income	-0.1489516	$8.41
Cost Coef – High-medium Income	-0.0906516	$13.82
Cost Coef – High Income	-0.0698996	$17.93
Bike Distance Coef	-0.571182	$2.19
Walk Distance Coef	-0.8958692	$1.40

6.2.4 Non-Home-Based and Airport Utility Components

Mode choice coefficients for HBW trips are listed in Table 6.3 and discussed below. Originally estimated alternative specific constants have been replaced by calibrated constants, developed using 2018 on-board survey and boarding data.

- **Airport:** Non-work trips to the airport zone were found to be more likely to use SR2 and SR3 modes.
- **Peak Travel:** A positive coefficient for SR3 implies that this mode is more attractive in the peak, perhaps because it is easier to coordinate peak period trips.
- **Density Factor:** A significant positive coefficient was estimated on the attraction zone density factor for local bus and walk modes.
- **In-Vehicle Travel Time:** The in-vehicle time is constrained to be -0.015, which is in the middle of the FTA recommended range of -0.010 to -0.020 for NHB trip purposes. The estimated value for in-vehicle time was outside the recommended range.
- **Non-Motorized Distance:** Travelers are more sensitive to walk distance than bike distance, which reflects the faster bike travel speed.

Table 6.3 NHB and Airport Mode Choice Model Coefficients

Variable	Value	Effective VOT ($/hr)
IVTT Coef	-0.015	
OVTT Coef	-0.0375	
OVTT Share of total time (Drive access to transit only)	-3.6	
Cost Coef – NHB	-0.17308	$7.24
Cost Coef – Airport	-0.08654	$14.48
Bike Distance Coef	-1.21203	
Walk Distance Coef	-2.12122	

7.0 Time of Day

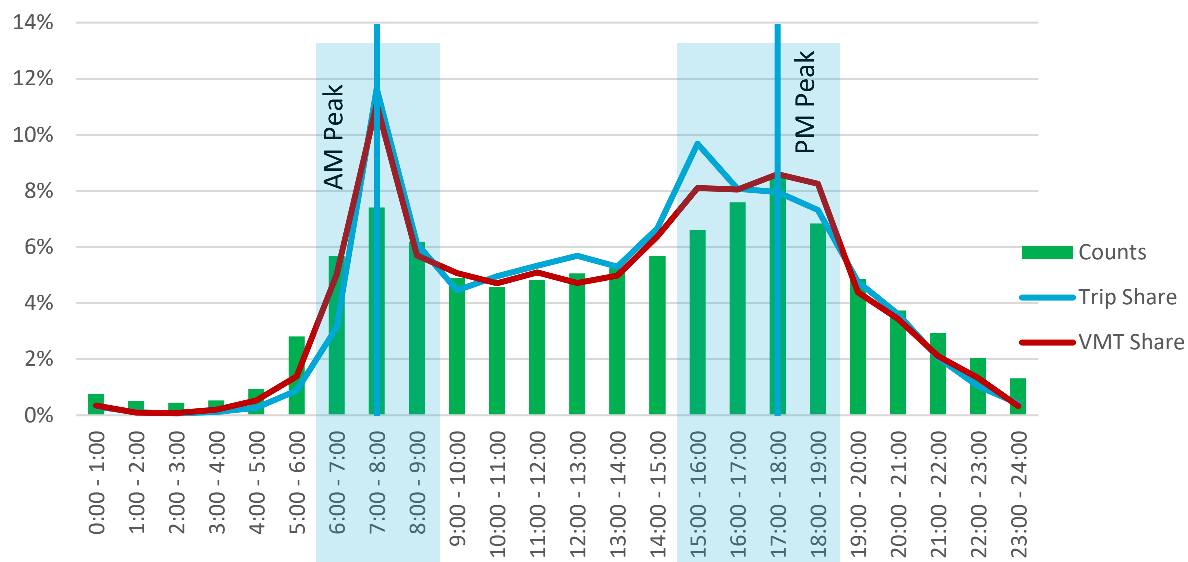
There are two occurrences where time of day factors are used in the model: prior to trip distribution, to split the daily balanced productions and attractions to peak and off-peak; and prior to traffic assignment, to split the vehicle matrices into four time periods for assignment as defined in Table 7.1. Peak periods and hours were identified by evaluating household travel survey and traffic count data as shown in Figure 7.1.

Table 7.1 Modeled Time Periods

Time Period Name	Peak or Off-Peak	Peak Period Definition	Peak Hour Definition
AM Peak	Peak	6:00 – 9:00 AM	7:00 – 8:00 AM
PM Peak	Peak	3:00 – 7:00 PM	5:00 – 6:00 PM
Mid-Day (MD)	Off-Peak	9:00 AM – 3:00 PM	n/a
Night-Time (NT)	Off-Peak	7:00 PM – 6:00 AM	n/a

Each trip in the household survey is assigned to a specific time periods based on the midpoint of the trip. This allows development of time of day factors, with the resulting trip time of day distribution used to develop time of day factors. In addition, reported trips were multiplied by zone to zone distance to produce an observed distribution of VMT for each one-hour period. Resulting the resulting trip and VMT distributions are shown in Figure 7.1 along with the distribution of traffic count volumes by time of day. Separating daily travel into four time periods allows the model to better represent congestion that occurs primarily during the peak periods. Modeling by time of day is also important for air quality analysis, as varying temperatures throughout the day impact ozone precursor generation.

Figure 7.1 Hourly Trip Distribution and Peak Hour Determination



7.1.1 Trip Distribution Time of Day

Table 7.2 shows peak and off-peak time of day factors derived from the expanded household survey. These factors are used to separate daily trips resulting from trip generation into peak and off-peak trips for use in trip distribution. For each purpose, the peak and off-peak time of day factors sum up to 1.

Table 7.2 Trip Distribution Time of Day Factors

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

7.1.2 Traffic Assignment Time of Day

Directional time of day factors by trip purpose are based on the expanded household survey. The mode choice model outputs person trip tables for the peak and off-peak time periods. Traffic assignment time of day separates peak trips into AM and PM peak periods and off-peak trips into mid-day and night time trips. This process is performed directionally, converting trips in production-attraction (PA) format to origin-destination (OD) format. During this process, shared ride trips are converted from person trips into vehicle trips. For 2-person autos, person trips are divided by 2 to arrive at vehicle trips. Shared ride 3+ trips are converted from person to vehicle trips using an average auto occupancy of 3.2. Because limited data were available to support time of day factors for airport trips, time of day factors for the AIR trip purpose are assumed to be the same as those for HBO. Truck and External time of day factors are assumed equivalent to NHB factors.

7.1.3 Peak Period to Peak Hour Factors

While the model considers multi-hour AM and PM peak periods, traffic assignment is based on hourly capacity. This requires conversion of hourly capacities to peak period capacities prior to traffic assignment. This conversion is done based on the relative share of traffic in the AM and PM peak periods that occur during the respective peak hours. Hourly capacities are divided by the peak hour factors shown in Table 7.3 to compute peak period capacities. MD and NT trips are assumed to be uniformly distributed across the time period.

Table 7.3 Peak Hour Factors by Time Period

Period	Peak Period	Peak Hour	Peak Hour Factor
AM Peak	6:00 – 9:00 AM	7:00 – 8:00 AM	0.384
PM Peak	3:00 – 7:00 PM	5:00 – 6:00 PM	0.287
Mid-Day	9:00 AM – 3:00 PM	n/a	0.167
Night-Time	7:00 PM – 6:00 AM	n/a	0.091

8.0 Trip Assignment

Trip assignment is the final phase of the four-step travel model. It identifies specific paths taken by vehicle and transit trips. The resulting traffic volumes and transit boarding data are available for peak periods and for a 24-hour period. Due to limited data, trips made with non-motorized modes are not assigned to the network.

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

8.1 Traffic Assignment

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

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

8.1.1 Traffic Assignment Validation

Traffic assignment validation compares roadway volumes resulting from traffic assignment to traffic count data. This process, called traffic assignment validation, ensures that the model reasonably represents observed traffic patterns. Traffic counts were collected by TxDOT in early 2020 (pre-pandemic) in coordination with AAMPO and reflect typical school season weekday traffic volumes. In addition, AAMPO staff developed estimated counts on links without traffic counts based on a review of available count data. Travel model results were compared to traffic count data using a variety of techniques, including regional comparisons and inspection of individual link values.

Overall Activity Level

Overall vehicle trip activity has been validated through a comparison of count data to model results on all links where count data is available using two statistics: model volume to count volume ratio and model VMT as compared to count VMT. These statistics were reviewed at functional class, area type, and regional levels, as shown in Table 8.1.

Table 8.1 Regional Activity Validation by Functional Class and Area Type

Link Type	Model Volume / Count Volume	Model VMT / Count VMT	Target
Interstate Freeways	0.99	0.99	+/- 10%
Other Freeways	1.00	1.00	+/- 10%
Expressways	1.09	1.07	+/- 10%
Principal Arterials	1.02	1.01	+/- 10%
Minor Arterials	1.01	1.00	+/- 15%
Collectors	1.02	1.05	+/- 25%
Frontage Roads	1.02	1.00	n/a
Ramps	1.08	1.08	n/a
CBD	1.01	1.02	n/a
Fringe	0.99	0.98	n/a
Urban	1.03	1.02	n/a
Suburban	1.05	1.02	n/a
Rural	1.07	1.08	n/a
All Links	**1.01**	**1.01**	**+/- 5%**

Measures of Error

While the model should accurately represent the overall level of activity, it is also important to verify the model has an acceptably low level of error. It is expected the model will not perfectly reproduce count volumes on every link, but the level of error should be monitored. The plot shown in Figure 8.1 demonstrates the ability of the model to match individual traffic count data points and notes the resulting R-squared value.

Another pair of measures, root mean square error (RMSE) and percent RMSE, measure the average error and percent error by link. Table 8.2 lists RMSE values and target values for each functional classification and area type. General guidelines suggest that % RMSE should be below 40 percent region-wide, with values below 30 percent for high volume facility types such as freeways. The % RMSE measure tends to over-represent errors on low volume facilities, so values on collectors are not particularly meaningful. Table 8.3 shows RMSE by volume group. This table demonstrates that RMSE tends to increase for links with higher volumes, while % RMSE tends to decrease for links with higher volumes.

Figure 8.1 Model / Volume Count Comparison

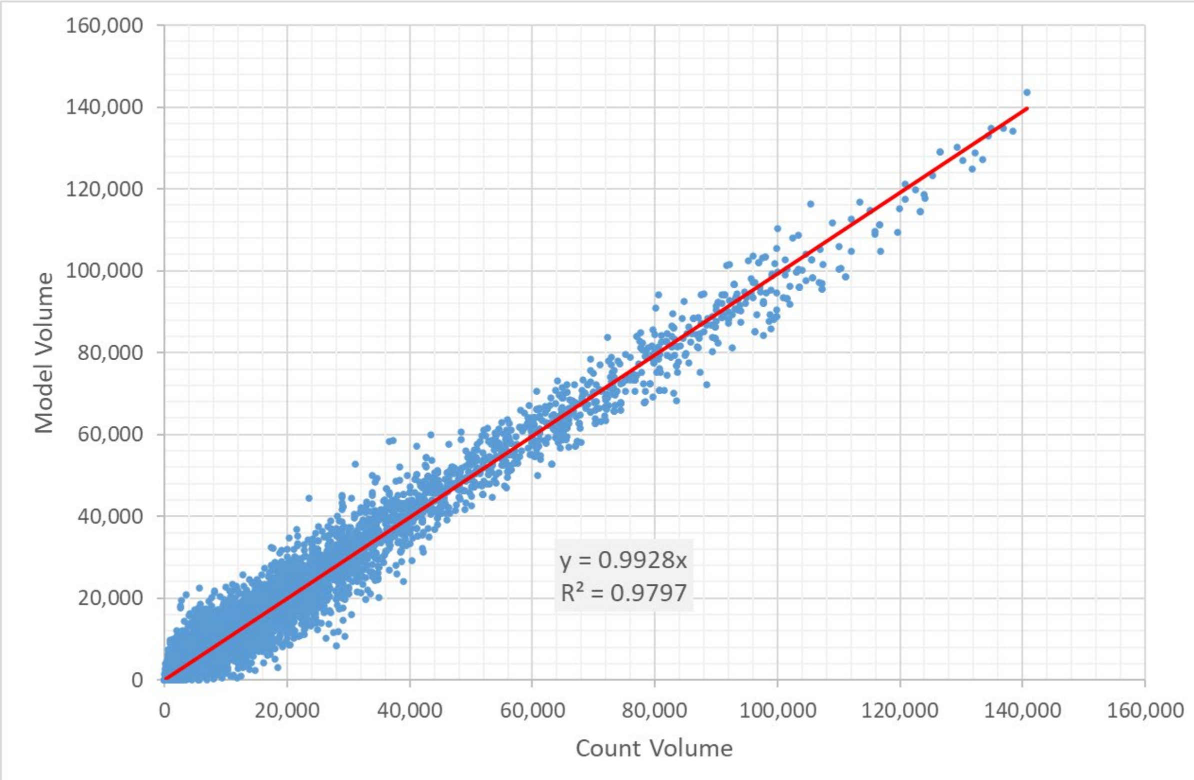


Table 8.2 RMSE Statistics by Functional Class and Area Type

Link Type	RMSE	% RMSE	Target
Interstate Freeways	4,261	8.2%	< 20%
Other Freeways	3,145	7.2%	< 20%
Expressways	3,148	17%	< 30%
Principal Arterials	4,498	24%	< 30%
Minor Arterials	3,271	33%	< 40%
Collectors	2,085	53%	n/a
Frontage Roads	2,392	36%	n/a
Ramps	2,271	30%	n/a
CBD	2,908	26%	n/a
Fringe	3,388	21%	n/a
Urban	3,065	25%	n/a
Suburban	2,700	27%	n/a
Rural	1,806	31%	n/a
All Links	**3,023**	**24%**	**< 40%**

Table 8.3 RMSE Statistics by Volume Group

Volume Group	RMSE	% RMSE
0 - 4,999	1,807	75%
5,000 - 9,999	2,637	36%
10,000 - 19,999	3,349	24%
20,000 - 29,999	4,637	19%
30,000 and up	4,891	9%

8.2 Transit Assignment

The model assigns transit person trips resulting from the mode choice model to the transit route system. Each trip is assigned from zone centroid to zone centroid using walk or drive access links, transit routes, and walk egress links. The transit assignment step does not include capacity constraint, so increasing transit volumes do not result in diversion of transit trips to other transit service.

Transit assignment results include the total number of boardings at each transit stop, as well as transit volumes on all stop to stop transit route segments. However, transit results are generally best evaluated at the systemwide or route group level.