12.3 **Model Validation and Reasonableness Check**

12.3.1 DAYSIM Reasonableness Check and Validation

As mentioned in model calibration section, DAYSIM submodels were estimated using expanded 2000 household travel survey data based on 2008 land use and travel conditions. Selected DAYSIM submodels and variables were calibrated based on 2016 land use and demographic data and ACS 2012-2016 5-year data. Only mode choice models were recalibrated based on 2018 household travel survey due to time and resource constraints during SACOG's 2020 MTP/SCS development.

As reasonableness check, the sections below compare model results to 2018 household travel survey data on the following metrics:

- Usual Work Location
- Auto Ownership
- Mode Share
- Trip Length

12.3.1.1 Usual Work Location

As described in Chapter 3, usual work location is the top-level model in the DAYSIM hierarchy. Each worker is designated a usual work place based on the worker's demographic characteristics and job availability in the region. Table 12-4 compares the average one-way commute distance estimated by DAYSIM to the average observed distance from 2018 Household Travel Survey, broken out by worker type (e.g. full time vs part time).

Figure 12-2 shows the number of commute trips by travel distances. Compared to the 2018 survey, DAYSIM's average commute distance is slightly lower overall, with much of this difference due to DAYSIM predicting a higher share of short commute distances (less than ~5 miles).

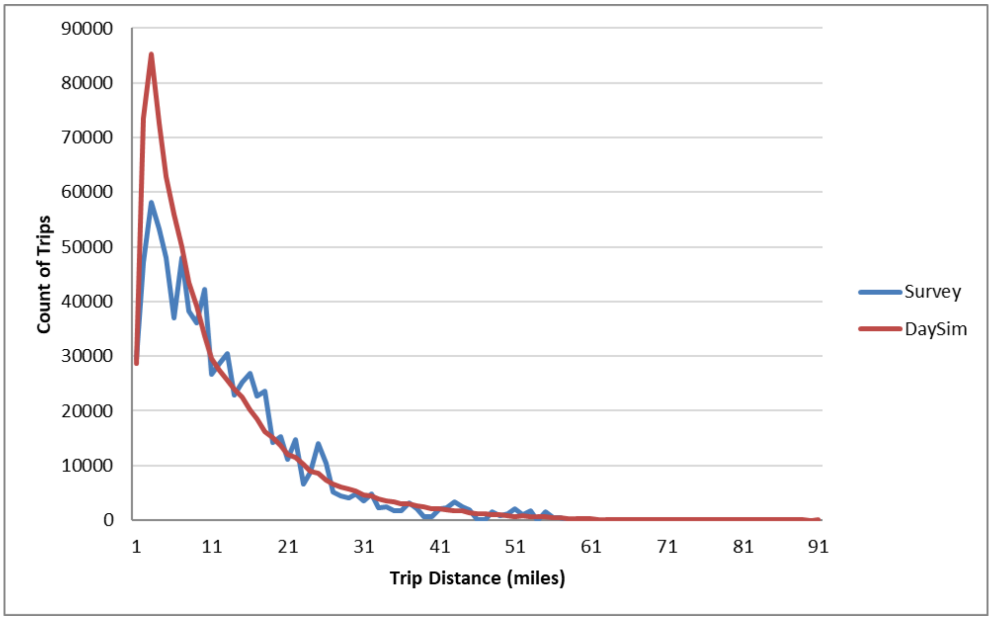
The total work location choices are constrained to TAZ-level total jobs by a shadow price process. Figure 12-3 demonstrates a good fit between the number of jobs in each TAZ and how many workers' usual work locations are in that TAZ.

Table 12-4 Average Commute Distance by Auto (2016 DAYSIM vs 2018 HTS)

Worker Type	Survey	DaySim	Ratio (DAYSIM/Survey)
Full Time	12.12	11.41	0.94
Part Time	8.76	7.66	0.87
Others	7.57	6.93	0.90
All	11.26	10.33	0.92

Source: SACOG 2020.

Figure 12-2 Commute Distance Frequency – All Workers



Source: SACOG 2020.

Figure 12-3 Jobs vs Workers at the Usual Work Locations by TAZs

Source: SACOG 2020.

12.3.1.2 Auto Ownership

The Auto Ownership submodel includes constants to predict how many vehicles a household owns (0, 1, 2, 3, or 4+) as well as the number of potential drivers (0, 1, 2, 3, or 4+). Table 12-5 presents a comparison of modeled auto ownership distribution to the distribution from 2018 Household Travel Survey by the number of vehicles vs the potential drivers in the household. At the region level, the ownership distributions by the number of vehicles or the number drivers estimated by DAYSIM match the distributions presented in 2018 Household Travel Survey well.

Table 12-5 Auto Ownership Validation

2018 HTS		**Number of Vehicles**					
	HH # of Potential Drivers	***0***	***1***	***2***	***3***	***4+***	***Total***
	1	5%	20%	4%	1%	0%	30%
	2	1%	9%	27%	7%	3%	47%
	3	0%	2%	5%	5%	2%	13%
	4+	1%	1%	2%	2%	5%	10%
	Total	7%	32%	39%	15%	8%	100%
DAYSIM							
	HH # of Potential Drivers	***0***	***1***	***2***	***3***	***4+***	***Total***
	1	6%	19%	3%	1%	0%	30%
	2	1%	8%	30%	6%	2%	47%
	3	0%	2%	4%	6%	2%	13%
	4+	0%	3%	2%	1%	4%	10%
	Total	8%	32%	39%	14%	8%	100%
Validation Ratio (DAYSIM Vs 2018 HTS)							
	HH # of Potential Drivers	***0***	***1***	***2***	***3***	***4+***	***Total***
	1	1.3	1.0	0.8	1.6	0.8	**1.0**
	2	1.5	0.9	1.1	0.8	0.6	**1.0**
	3	0.5	1.0	0.9	1.2	1.1	**1.0**
	4+	0.1	3.2	1.0	0.5	1.0	**1.0**
	Total	**1.2**	**1.0**	**1.0**	**0.9**	**1.0**	**1.0**

Source: SACOG 2020.

12.3.1.3 Mode share

As Table 12-6 shows, modeled all-purpose trip mode share distribution matches the distribution in 2018 household travel survey. Below, Table 12-7 also shows a close fit between modeled versus observed mode split for tours when considering all tour purposes. As shown in Table 12-9, modeled mode split for work tours (commutes) generally also is quite close to observed 2018 travel survey commute mode split. As Table 12-8 and Table 12-9 show, the model predicted a higher share of commute tours and trips made by walking and transit than was observed in the 2018 survey. This larger difference is still reasonable and not surprising given the small number cases in the household travel survey who walked or took transit as their primary commute mode.

Table 12-6 Mode Split Validation, 2016 Model Results vs. 2018 Household Travel Survey – All Trips

	2018 Household Travel Survey	2016 Travel Model	Validation Ratio
Walk	7.6%	7.8%	1.0
Bike	2.3%	2.5%	1.1
Drive Alone	42.4%	42.1%	1.0
Shared Drive 2	22.4%	22.4%	1.0
Shared Drive 3+	22.9%	22.7%	1.0
Transit	1.2%	1.2%	1.0
Other	1.3%	1.2%	0.9

Source: SACOG 2020.

Table 12-7 Mode Split Validation, 2016 Model Results vs. 2018 Household Travel Survey – All Tours

	2018 Household Travel Survey	2016 Travel Model	Validation Ratio
Walk	5.4%	6.1%	1.1
Bike	2.4%	2.6%	1.1
Drive Alone	37.1%	35.5%	1.0
Shared Drive 2	22.9%	23.3%	1.0
Shared Drive 3+	28.5%	28.8%	1.0
Transit	2.5%	2.0%	0.8
Other	1.3%	1.6%	1.3

Source: SACOG 2020.

Table 12-8 Mode Split Validation, 2016 Model Results vs. 2018 Household Travel Survey – Commute Trips

	2018 Household Travel Survey	2016 Travel Model	Validation Ratio
Walk	5.9%	4.7%	0.8
Bike	2.1%	2.4%	1.1
Drive Alone	70.5%	74.6%	1.1
Shared Drive 2	12.4%	9.4%	0.8
Shared Drive 3+	7.5%	7.4%	1.0
Transit	1.6%	1.5%	0.9

Source: SACOG 2020.

Table 12-9 Mode Split Validation, 2016 Model Results vs. 2018 Household Travel Survey – Commute Tours

	2018 Household Travel Survey	2016 Travel Model	Validation Ratio
Walk	1.7%	2.9%	1.7
Bike	2.6%	2.8%	1.1
Drive Alone	65.9%	67.7%	1.0
Shared Drive 2	14.2%	14.0%	1.0
Shared Drive 3+	11.6%	10.2%	0.9
Transit	3.9%	2.5%	0.6

Source: SACOG 2020.

12.3.1.4 Trip length

Table 12-10 compares the average trip distance by mode, for all trip types, from the 2016 travel model and 2018 household travel survey. Table 12-11 provides the same comparison specifically for commute trips.

In both tables, the modeled average trip distance for auto modes (drive-alone and HOV) is generally very close to the average trip distance observed in the travel survey. In contrast, there is a significant difference between the model results and survey findings for transit and non-motorized trip distances. These significant differences stem from several challenges inherent to regional travel models. Specifically:

- Survey-based trip distances are based on users traveling the real street network, inclusive of minor streets not in the model, while the model can only roughly approximate such trips by having travelers use centroid connectors. This difference in network granularity disproportionately affects non-motorized trips, which are more likely to use minor streets in the model and be shorter trips.

- Survey-based trip distances are “parcel to parcel”, whereas modeled distances are TAZ-to-TAZ, assuming all trips start and end at TAZ centroids. The proportional difference between TAZ-TAZ distance and parcel-parcel distance is smaller for longer trips, but can be quite large for short trips, which comprise a larger share of trips that use non-motorized modes.

Modeled transit trip distances were shorter than transit trips recorded in the survey. This is likely because the modeled transit trip distances are based on the TAZ to TAZ driving distance following the most direct driving route, rather than the route followed by transit routes, which is usually longer than the most direct driving route. Accurate, route-based transit travel distances are not available from the model because it bases transit trip cost and assignment on travel times associated with transit, and not travel distance.

Given the above weaknesses of the model to accurately represent transit, walk, and bike travel distances, we are not concerned by the looser validation of these modes. And when we consider the auto modes, whose travel distances the model can provide with more accuracy, we see that the surveyed travel distances align closely with modeled travel distances.

Table 12-10 Average Trip Distance by Mode (All Trips) – SACSIM vs. 2018 Household Travel Survey

	2018 Household Travel Survey	2016 Travel Model	Validation Ratio
Walk	0.7	1.5	2.1
Bike	2.3	4.7	2.0
Drive Alone	7.9	7.9	1.0
Shared Drive 2	6.6	6.9	1.0
Shared Drive 3+	5.9	6.9	1.2
Transit	8.7	5.8	0.7
Other	10.0	4.6	0.5
All Modes	*6.5*	*6.8*	*1.0*

Source: SACOG 2020.

Table 12-11 Average Trip Distance by Mode (Commute Trips) – SACSIM vs. 2018 Travel Survey

	2018 Household Travel Survey	2016 Travel Model	Validation Ratio
Walk	0.9	1.8	2.1
Bike	3.6	4.1	1.2
Drive Alone	10.6	9.5	0.9
Shared Drive 2	9.0	8.7	1.0
Shared Drive 3+	9.3	8.8	0.9
Transit	12.7	7.0	0.6
All Modes	*9.6*	*8.9*	*0.9*

Source: SACOG 2020.

12.3.2 Land use and Demographic Reasonableness Check

Table 12-12 provides comparison of region wide totals of dwelling units, households, population and jobs from SACSIM against other independent data sources. SACSIM model data is within three percent of region wide totals. California Department of Finance (DOF) projects dwelling units, households, and population totals by county and jurisdiction.

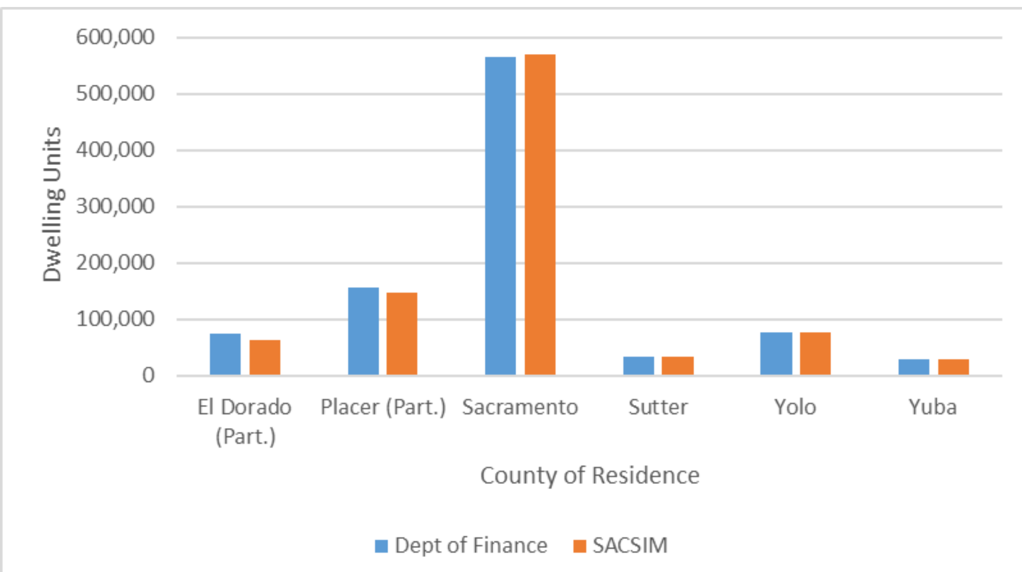
Table 12-12 Year 2016 SACOG Region Parcel Data Comparison

Variable	Observed Data	SACSIM19 Estimate	Validation Ratio
Dwelling Units[1]	932,289	921,123	0.99
Households[1]	849,779	872,699	1.03
Population[1]	2,401,837	2,412,755	1.00
Jobs[2]	1,071,199	1,060,751	0.99

Source: SACOG 2020.
[1] California Department of Finance Projections, adjusted to exclude Tahoe basin.
[2] Levy, Stephen, California Center for Continuing Study of the California Economy.

Since SACOG regional consists of six counties but excludes the Tahoe basin portion of El Dorado and Placer Counties, an adjustment must be made to compare. The DOF estimates for the City of South Lake Tahoe are excluded and the remainder is divided equally to El Dorado and Placer County unincorporated areas. Figure 12-4 provides comparisons of dwelling units by county for 2016 SACSIM MTP/SCS and 2016 DOF estimates. Table 12-13 shows a comparison of the population and average household size by county for 2016 SACSIM MTP/SCS and 2016 department of finance estimates. SACSIM model data matches county totals closely to DOF.

Figure 12-4 Year 2016 Dwelling Units by County



Source: SACOG 2020.
California Department of Finance Projections, adjusted to exclude Tahoe basin.

Table 12-13 Comparison of SACSIM Population and Household Size to Department of Finance Estimates

County	Population			Average Household Size	
	2016		%	2016	
	SACSIM19	DOF	Diff.	SACSIM19	DOF
El Dorado*	147,202	150,843	-2.41%	2.6	2.6
Placer*	363,896	361,288	0.72%	2.7	2.7
Sacramento	1,476,573	1,474,115	0.17%	2.7	2.8
Sutter	96,392	95,852	0.56%	2.9	3.0
Yolo**	214,784	203,693	5.44%	2.6	2.8
Yuba	77,464	73,047	6.05%	2.9	2.8
Total	2,376,311	2,358,837	0.74%	2.7	2.8

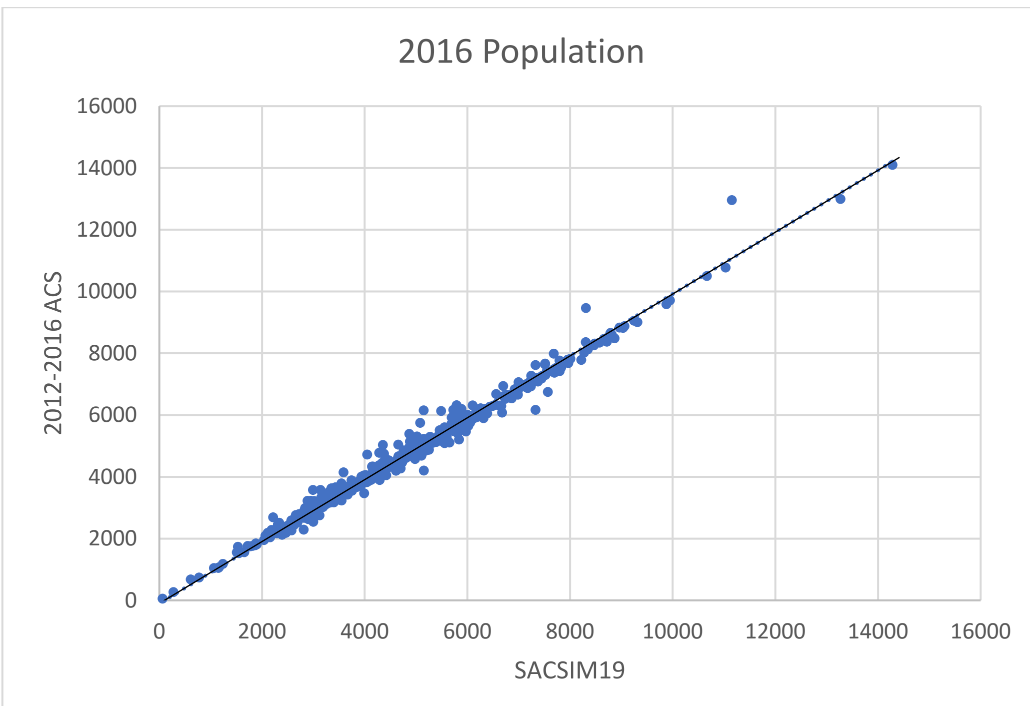
Source: SACOG 2020.

*Partial county—Tahoe Basin excluded.

**DOF has adjusted multi-family housing units in Unincorporated Yolo County in a formula to change Census identified housing units into group quarters, therefore population and households will exactly not match Census estimates.

As described in Chapter 5, the ACS 2016 5-year sample data are used to establish demographic controls at Census tract level and are then used to generating representative population file. In past SACSIM validation, SACSIM representative population was compared to the 2010 Decennial Census by Tract, since this MTP/SCS base scenario was 2016, it was deemed too out of date to use for validation purposes. In consequence, ACS 2016 5-year sample was further examined to final SACSIM population and characteristics. Figure 12-5 shows a comparison plot of ACS 2016 5-year sample household population compared to SACSIM19 2016 household population by tract. Since the ACS data is used to control the generation of the representative population file distributions, it is expected the SACSIM population match well with the ACS data. The two datasets are consistent at this much-lower level geography, too. The overall correlation between the two datasets at tract level is very high—the R-squared of a regression of ACS 2016 5-year sample data tract population using the 2016 SACSIM19 population as an independent variable was 0.98.

Figure 12-5 Comparison of 2016 Population



Source: SACOG 2020.

Table 12-14 through Table 12-17 provide comparisons between ACS 2016 5-year sample data and SACSIM19 2016 Population control household variables. These tables also show a high degree of consistency for all variables at county level.

Table 12-14 Year 2016 Household Size Distribution by County

SACSIM19 Representative Sample Data

County	1 person	2 persons	3 persons	4+ persons
El Dorado*	21%	40%	17%	22%
Placer*	24%	36%	15%	24%
Sacramento	27%	31%	16%	27%
Sutter	22%	30%	17%	31%
Yolo	24%	32%	18%	27%
Yuba	20%	32%	17%	31%
Total	25%	33%	16%	26%

ACS 2016

County	1 person	2 persons	3 persons	4+ persons
El Dorado*	23%	40%	16%	21%
Placer*	24%	36%	15%	24%
Sacramento	27%	31%	16%	26%
Sutter	22%	30%	17%	31%
Yolo	24%	32%	18%	27%
Yuba	20%	32%	17%	31%
Total	25%	33%	16%	26%

Validation Ratio SACSIM19 to ACS

County	1 person	2 persons	3 persons	4+ persons
El Dorado*	0.92	1.01	1.03	1.04
Placer*	0.99	0.99	1.00	1.02
Sacramento	0.99	1.00	1.00	1.00
Sutter	1.00	1.00	1.00	1.00
Yolo	1.00	1.00	1.00	1.00
Yuba	1.00	1.00	1.00	1.00
Total	0.99	1.00	1.00	1.01

Source: SACOG 2020.

Based on American Community Survey 2016 5-year Sample data. *Partial county—Tahoe Basin excluded.

Table 12-15 Comparison of Distribution of Workers in Household by County

SACSIM19 Representative Sample Data

County	0 worker	1 workers	2 workers	3+ persons
El Dorado*	32%	37%	28%	4%
Placer*	30%	35%	29%	6%
Sacramento	27%	40%	27%	6%
Sutter	29%	38%	26%	7%
Yolo	26%	36%	31%	7%
Yuba	32%	40%	24%	5%
Total	28%	38%	28%	6%

ACS 2016

County	0 worker	1 workers	2 workers	3+ persons
El Dorado*	31%	37%	27%	5%
Placer*	30%	35%	29%	6%
Sacramento	27%	40%	27%	6%
Sutter	29%	38%	26%	7%
Yolo	26%	36%	31%	7%
Yuba	32%	39%	24%	5%
Total	28%	38%	28%	6%

Validation Ratio SACSIM19 to ACS

County	0 worker	1 workers	2 workers	3+ persons
El Dorado*	1.02	0.98	1.00	0.98
Placer*	1.00	1.00	1.01	0.98
Sacramento	1.00	1.00	1.00	1.01
Sutter	1.00	1.00	1.00	1.01
Yolo	1.00	1.00	1.00	1.00
Yuba	0.99	1.01	1.00	0.98
Total	1.00	1.00	1.00	1.00

Source: SACOG 2020.

Based on American Community Survey 2016 5-year Sample data. *Partial county—Tahoe Basin excluded.

Table 12-16 Comparison of Household Income Distribution by County

SACSIM19 Representative Sample Data

County	< $20K	$20K - $40K	$40K - $60K	$60K - $100K	$100K+
El Dorado*	11%	16%	13%	22%	39%
Placer*	11%	14%	13%	23%	39%
Sacramento	17%	19%	16%	23%	26%
Sutter	18%	20%	16%	23%	22%
Yolo	19%	17%	15%	20%	28%
Yuba	18%	24%	18%	23%	16%
Total	16%	18%	15%	23%	28%

ACS 2016

County	< $20K	$20K - $40K	$40K - $60K	$60K - $100K	$100K+
El Dorado*	12%	17%	13%	22%	36%
Placer*	11%	14%	13%	23%	38%
Sacramento	17%	19%	16%	23%	26%
Sutter	18%	20%	16%	23%	22%
Yolo	19%	17%	15%	20%	28%
Yuba	18%	24%	18%	23%	17%
Total	16%	18%	16%	23%	28%

Validation Ratio SACSIM19 to ACS

County	< $20K	$20K - $40K	$40K - $60K	$60K - $100K	$100K+
El Dorado*	0.93	0.90	0.96	1.00	1.09
Placer*	0.98	0.99	0.98	1.01	1.01
Sacramento	1.00	1.00	1.00	1.00	1.00
Sutter	1.00	1.00	1.00	0.99	1.00
Yolo	1.01	1.00	1.00	0.99	1.00
Yuba	1.00	1.01	1.00	1.00	0.99
Total	1.00	0.99	1.00	1.00	1.01

Source: SACOG 2020.

Based on American Community Survey 2016 5-year Sample data. *Partial county—Tahoe Basin excluded.

Table 12-17 Comparison of Householder's Age Distribution

SACSIM19 Representative Sample Data

County	< 35 Years	35 - 64 years	>= 65 Years
El Dorado*	9%	60%	31%
Placer*	14%	57%	29%
Sacramento	21%	57%	21%
Sutter	20%	56%	24%
Yolo	28%	52%	20%
Yuba	27%	53%	20%
Total	20%	57%	23%

ACS 2016

County	< 35 Years	35 - 64 years	>= 65 Years
El Dorado*	11%	60%	29%
Placer*	14%	58%	29%
Sacramento	22%	57%	21%
Sutter	20%	56%	24%
Yolo	27%	52%	20%
Yuba	26%	54%	20%
Total	20%	57%	23%

Validation Ratio SACSIM19 to ACS

County	< 35 Years	35 - 64 years	>= 65 Years
El Dorado*	0.88	0.99	1.06
Placer*	1.00	1.00	1.00
Sacramento	1.00	1.00	1.00
Sutter	1.00	1.00	1.00
Yolo	1.02	1.00	0.99
Yuba	1.03	0.99	0.99
Total	1.00	1.00	1.00

Source: SACOG 2020.

Based on American Community Survey 2016 5-year Sample data. *Partial county—Tahoe Basin excluded.

12.3.3 Highway Assignment Validation

12.3.3.1 Highway Network Variables

The only global check of the reasonableness of the SACSIM highway network was a comparison of the model estimates of route and lane mileage to data reported in HPMS for 2016. “Route mileage” is the centerline mileage of roadways (i.e. one mile of road = one route mile, irrespective of the number of lanes). “Lane mileage” is the centerline length of a roadway multiplied by the number of lanes of roadway provided (i.e. one mile of 2-lane road = two lane miles, and one mile of 4-lane road = four lane miles, etc.).

Making a detailed comparison of the SACSIM route and lane mileage to HPMS estimates is not possible for various reasons. HPMS functional class coding is not currently coded to the SACSIM highway network, so lining up specific classes is difficult. HPMS data are also aggregated to jurisdiction (city and county), with no GIS or other network data provided. Finally, and most importantly, the SACSIM highway network is simplified, with actual roadways represented only to about collector level and above. Local streets, whose route and lane mileage are estimated in HPMS, are not included explicitly in the SACSIM highway networks. The access provided by local streets to the collector-and-above roadway network within SACSIM is coded using “centroid connectors”.

Table 12-18 provides a comparison of SACSIM and HPMS route and lane mileage of roadways, with classifications simplified to (1) freeway/interstate and (2) surface street. To the extent possible given the basic inconsistency in coding and reporting mentioned above, SACSIM and HPMS are relatively consistent for these simplified freeway/interstate and surface street categories. In total, SACSIM route mileage matches HPMS route mileage almost exactly. For freeways, SACSIM has slightly more route miles but, interestingly, slightly fewer lane-miles than HPMS. For surface streets, which only include collectors, arterials, and non-freeway expressways, SACSIM has almost the same number of route-miles as HPMS and slightly more lane-miles. Given the level of detail in HPMS provided (i.e. area totals only, with no access to a GIS or network underlying data), there is no way to resolve these minor inconsistencies between the two networks. It is possible that differences in coding of functional class, even within the collapsed categories presented, may account for this inconsistency.

Additionally, SACSIM freeway system coding was checked against “Freeway Lane Configuration Diagrams and Traffic Monitoring Stations: Sacramento Metropolitan Area”, published annually by Caltrans District 3. Other major surface streets were spot checked against aerial photos.

Table 12-18 Model Network Route- and Lane-Mile Validation

Roadway Class	Model	HPMS	Ratio
Route Mileage †			
Freeway/Interstate*	319	326	1.02
Surface Street**	3,678	3,668	1.00
Subtotal	3,997	3,994	1.00
Lane Mileage ‡			
Freeway/Interstate*	2,017	1,955	0.97
Surface Street**	8,860	9,059	1.02
Subtotal	10,877	11,015	1.01

Source: SACOG 2020, Caltrans 2016

Based on HPMS data reported in Caltrans' 2016 California Public Road Data (PRD) report.

† "Route mileage" = the centerline distance of a roadway; one mile of roadway = 1 route mile.

‡ "Lane mileage" = route miles * number of lanes; one mile of 2-lane roadway = 2 lane miles, one mile of 4-lane roadway = 4 lane miles, etc.

*"Freeway/Interstate":

- SACSIM model estimates include all classes of freeway lanes (general purpose, HOV, and auxiliary) in lane mileage estimates, but general-purpose only for calculation of route miles. Only general-purpose lanes are included for route mileage estimates to avoid double-counting.
- HPMS estimates include three classes reported in the Caltrans PRD series: "Rural Interstate", "Urban Interstate" and "Urban Other Freeway or Expressway".

**"Surface Street":

- SACSIM model estimates include all functional classes of surface street reported in Chapter 3, above: expressway, major arterial, minor arterial, collector, rural highway, rural arterial.
- HPMS estimates include Rural and Urban "Other Principal Arterial", "Minor Arterial", "Major Collector", "Minor Collector", and "Collector" classes.

NOTE - Local roadways are not possible to compare between SACSIM and HPMS. The SACSIM highway network is limited to explicitly representing roadways down to approximately "collector" class. Most local streets are represented by centroid collectors, which may represent the effective access to the collector-and-above roadway network provided by local streets. However, due to the coarseness of the centroid connectors versus the actual local roadway network, a reasonable "apples-to-apples" comparison is not possible.

12.3.3.2 Validation of Highway Vehicle Miles Traveled

Although reported in this section on traffic assignment, the amount of VMT forecasted is subject to all aspects of the model system. Although traffic assignment procedures do affect the amount of VMT, the quality of the networks, modeling of all aspects of travel demand (e.g. travel frequency, spatial distribution and mode), treatment of external travel, etc. all affect the amount of VMT forecasted. Each of the prior chapters provides validation and reasonableness checks for these other aspects of the SACSIM19.

Validation of estimates of VMT by travel demand models to estimates of observed VMT gathered through the Highway Performance Monitoring System is technically required by federal statute for agencies like SACOG which implement air quality conformity analysis[42].

This requirement has been more generally applied for validation of travel demand models used for other purposes. For example, validation to HPMS is identified as a key recommended validation task in the FHWA guidance on validation of travel demand models[43].

Table 12-19 reports the comparison of SACSIM19 estimates of VMT to HPMS-sourced estimates. At region level, SACSIM19 estimates line up very closely with HPMS-sourced estimates, with less than two percent difference for each of the three validation years (2005, 2008, and 2012). Additionally, at region level, the changes to total and per capita VMT forecasted by SACSIM19 correspond to the changes observed in HPMS data. Between 2005 and 2008, HPMS data shows a 3.3 percent decline, and SACSIM19 predicted a 2.2 percent change. Between 2005 and 2012, HPMS data shows a 4.5 percent decline in VMT per capita, compared to a SACSIM19 6.3 percent decline. Between 2005 and 2016, HPMS data shows a 6.7 percent decline, and SACSIM19 predicted 8.2% percent change. These changes are in the correct direction and the correct order of magnitude. By comparing multiple scenarios, these results provide strong evidence that the model system captures the biggest factors, roadway characteristics, demographics, population, workers, influencing vehicle travel reasonably well.

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[42] *Code of Federal Regulations,* Title 40, Sec.93.122

[43] Federal Highway Administration, *Model Validation and Reasonableness Checking Manual*, 2010 edition. http://tmip.fhwa.dot.gov/resources/clearinghouse/1397

Table 12-19 Comparison of Daily Vehicle Miles Traveled Estimates: HPMS and SACSIM19

	2005		2008		2012		2016	
County	HPMS	SACSIM	HPMS	SACSIM	HPMS	SACSIM	HPMS	SACSIM
El Dorado*	4,381	4,158	4,226	3,871	4,278	3,735	4,095	3,842
Placer*	9,010	9,681	8,927	9,790	9,035	9,894	9,161	10,101
Sacramento	33,752	34,219	34,157	34,666	34,584	33,760	35,652	34,560
Sutter	2,493	2,086	2,566	2,146	2,397	2,027	2,672	2,228
Yolo	5,967	5,368	5,763	5,807	6,074	5,862	6,071	5,842
Yuba	1,941	1,799	1,876	1,772	1,875	1,732	1,928	1,866
Region	57,544	57,311	57,516	58,051	58,244	57,010	59,579	58,439
Population	2,140		2,215		2,268		2,376	
VMT per Capita	26.9	26.8	26	26.2	25.7	25.1	25.1	24.6
Change from 2005	na	na	-3.30%	-2.20%	-4.50%	-6.30%	-6.70%	-8.20%

Source: SACOG 2020, Caltrans 2016.

Based on HPMS estimates of VMT from the Caltrans *California Public Road Data* reports.

†Adjustment by SACOG to convert average annual daily to typical weekday

* Adjusted from whole county data from El Dorado and Placer Counties to the non-Tahoe-Basin portions.

Table 12-20 Comparison of Daily Vehicle Miles Traveled Ratios: HPMS and SACSIM19

HPMS to SACSIM Validation Ratio

County	2005	2008	2012	2016
El Dorado*	0.95	0.92	0.87	0.94
Placer*	1.07	1.1	1.1	1.10
Sacramento	1.01	1.01	0.98	0.97
Sutter	0.84	0.84	0.85	0.83
Yolo	0.9	1.01	0.96	0.96
Yuba	0.93	0.94	0.92	0.97
Region	1	1.01	0.98	0.98
Population	2,140	2,215	2,268	2376
VMT per Capita	1	1.01	0.98	0.98

Source: SACOG 2020, Caltrans 2016.

Based on HPMS estimates of VMT from the Caltrans *California Public Road Data* reports.

†Adjustment by SACOG to convert average annual daily to typical weekday

* Adjusted from whole county data from El Dorado and Placer Counties to the non-Tahoe-Basin portions.

12.3.3.3 Validation of Highway Link Assignment

Year 2016 is the primary year of highway assignment validation for SACSIM19. Validation guidelines are based on the follow recommendations from the California Transpiration Commissions report, *Regional Transportation Plan Guidelines for Regional Transportation Planning Agencies, 2017*:

- At least 75% of roadway links with traffic counts should be within the Caltrans deviation threshold, which differs based on magnitude of the count.
- Estimate of correlation between the model estimates and observed counts should be at least 0.88.
- Percent Root Mean Square Error (RMSE) for the roadway links with counts in the project study area should not exceed 40%.

Table 12-21 shows how SACSIM19 2016 forecasted traffic volumes compare to traffic counts based on a region static validation using the CTC recommended measures and thresholds. A more detailed discussion of the source of the counts and limitations of using counts is provided in Observed Travel Data section above. The table includes comparisons of average weekday volumes. Also included in the table is a SACSIM19 backcast comparison to Year 2005. The table shows SACSIM19 forecasts are within the validation measure threshold ranges for all three measures in both 2005 and 2016.

Table 12-21 SACSIM19 and CTC Guidelines on Highway Assignment Validation

Validation Measures	Threshold	2005	2016
% of Locations w/ Model < Max Deviation	>75%	86%	77%
Correlation Coefficient	>0.88	0.95	0.97
RMSE for Daily Traffic Assignment	<0.40	0.36	0.38

Source: SACOG 2020.
Thresholds from California Transportation Commission, 2017 Regional Guidelines for MPOs, p.49.

While the regional guidelines serve an important role for model validation, they are only a partial indication of model performance. Highway facility classification determine how much traffic volume can travel on a given roadway at a point of time. The facility classification determines road capacity levels measured as how many vehicles per hour per lane (vphpl) a facility can sustain operations; this is a major contributor to model performance. Table 12-22 provides a comparison of forecasted 2016 model volumes to traffic counts by facility type. The table includes comparisons of average weekday volumes. Table 12-23 includes SACSIM19 back-cast traffic volume to counts from 2005. This back-cast comparison serves as both the temporal validation of SACSIM19 and the base year for air quality and conformity analysis. Count locations and quantities vary between 2005 and 2016 due to different collection efforts and available data at that time. Multiple validation tables by functional class also serve as supplementary source of count data for locations of facility types that may have a smaller count samples one year and provide additional model confidence.

SACSIM19 shows both 2016 and 2005 preforming well for freeways and major arterials roadway classifications. 2016 does not preform worst in Ramps and expressways, however, this may do to a small sample collect of these facilities types. There was more traffic count data collected on ramp and expressway facilities for 2005 which does preform slightly better. Further ramp counts and validation have been for collected and analyzed for SACSIM19 on projects since this initial traffic volume data collection. Appendix E Caltrans 2019 Validation Memos Prepared by DKS Using SACSIM19 show ramp and peak period validations along I-5 and SR-51 within Sacramento County.

Table 12-22 SACSIM19 Highway Volume Validation By Roadway Functional Class for 2016

Functional Class	No. of Counts	Sum of Counts	Sum of Model (if Counted)	Validation Ratio	Avg. Link Error	RMSE
Daily Volumes						
Freeway	371	21,477,673	21,004,075	0.98	0.13	0.18
Expressway	7	88,286	115,917	1.31	0.55	0.65
Major Arterial	571	8,310,889	9,076,389	1.09	0.29	0.38
Minor Arterial	463	4,477,209	4,445,783	0.99	0.30	0.44
Collector	425	1,434,337	1,287,477	0.90	0.53	0.79
Ramp	10	54,413	75,808	1.39	1.05	1.22
Rural Highway	24	148,190	157,637	1.06	0.18	0.19
Rural Art./Coll.	325	1,150,651	1,126,654	0.98	0.37	0.51
Total	2,196	37,141,648	37,289,740	1.00	0.24	0.38

Source: SACOG 2020.

Table 12-23 SACSIM19 Validation: Highway Volume By Roadway Functional Class for 2005

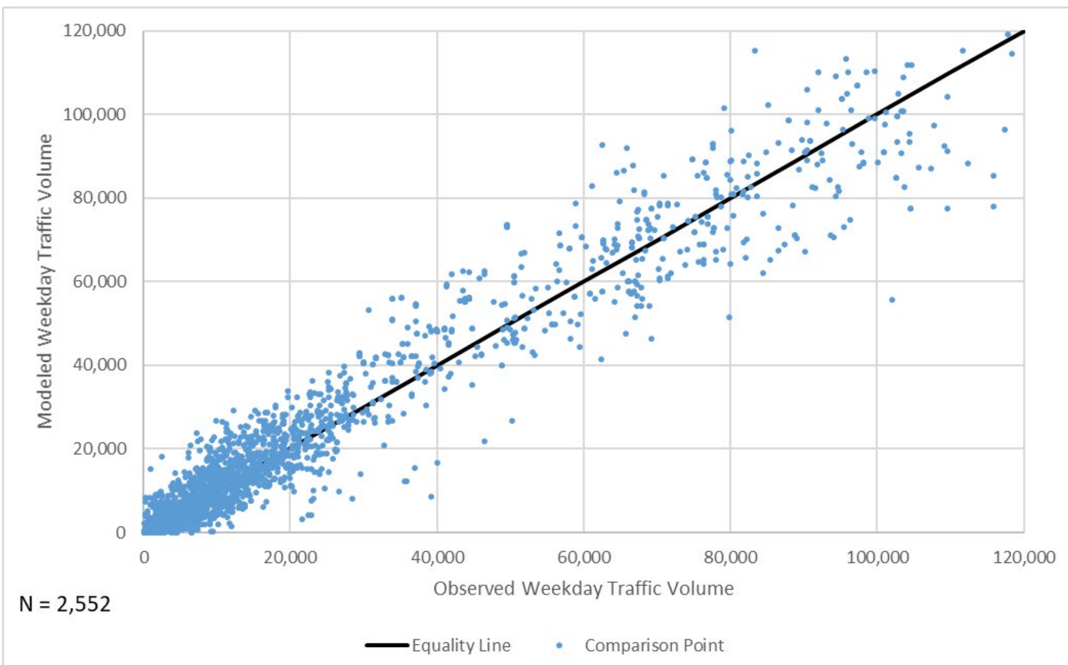
Functional Class	No. of Road Sections	Sum of Counts	Sum of Model (if Counted)	Validation Ratio	Avg. Link Error	RMSE
Daily Volumes						
Freeway	189	10,772,487	11,092,769	1.03	0.15	0.22
Expressway	12	353,236	305,954	0.87	0.16	0.34
Major Arterial	296	4,903,641	5,014,035	1.02	0.21	0.28
Minor Arterial	172	1,789,679	1,558,188	0.87	0.29	0.38
Collector	118	630,976	505,006	0.80	0.40	0.56
Ramp	264	1,199,460	1,114,769	0.93	0.53	0.85
Rural Highway	76	325,402	363,834	1.12	0.28	0.40
Rural Art./Coll.	138	511,391	543,470	1.06	0.36	0.49
Total	1,265	20,486,272	20,498,025	1.00	0.22	0.36

Source: SACOG 2020.

Figure 12-6 presents a scatterplot comparing modeled daily traffic volumes against observed daily traffic volumes for over 2,500 locations where observed counts were available. Generally, there was a good fit between modeled and observed volumes, as shown by the observation points largely following the equality line.

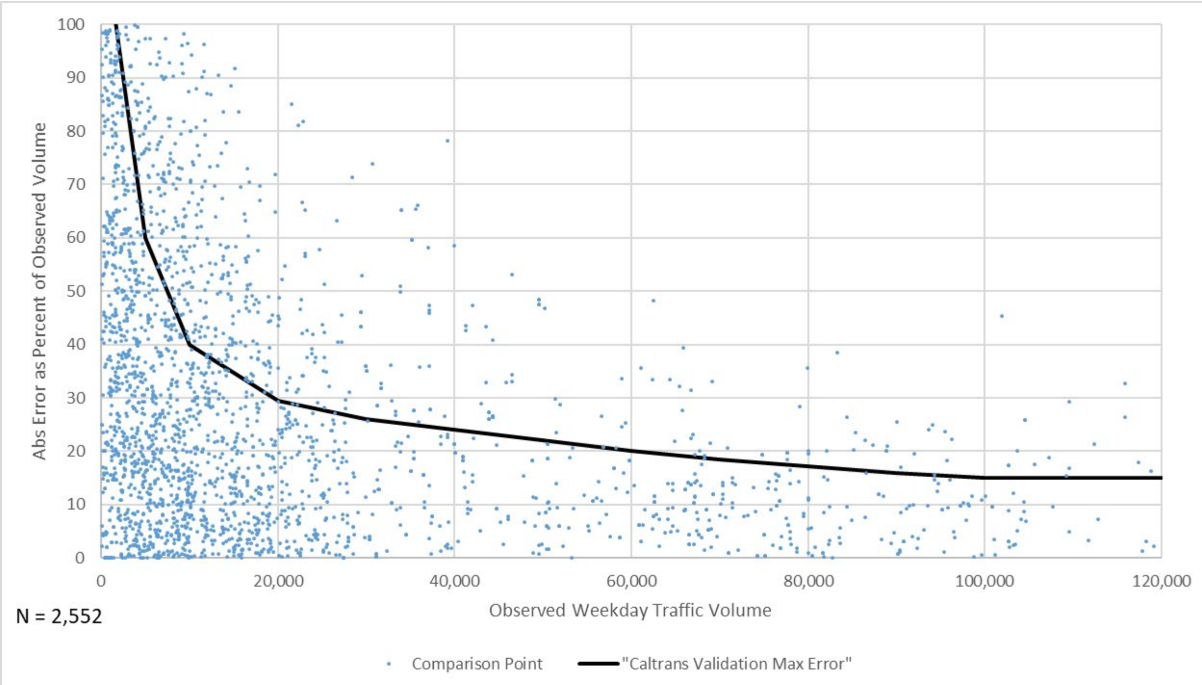
Further down, .
Figure 12-7 scatterplot points show, for each model link with observed count data, the absolute percent difference between the modeled and observed traffic on that link. The black line represents the maximum percentage difference recommended by Caltrans model validation guidelines (e.g. for weekday volumes of 100,000 or more, the absolute percent difference between modeled and observed volumes should be no more than 15%). Points below the line meet the Caltrans guidelines; points above the line do not.

Figure 12-6 2016 Weekday Modeled to Observed Volume



Source: SACOG 2020.

Figure 12-7 Year 2016 Weekday Volumes and Maximum Desirable Error



Source: SACOG 2020.
Note: "Caltrans Validation Max Error" line from California Department of Transportation, *Travel Forecasting Guidelines*, 1992.

12.3.3.4 Additional Validation for 2005 Highway Assignment

For each MTP/SCS update, SACOG also updates SACSIM-- its regional travel demand model. The travel demand model SACOG used in SCS3 was SACSIM19. The major improvements in SACSIM19 comparing to SACSIM15 used in SCS2 are listed in Chapter I - Introduction.

Due to the transition of travel model from SACSIM15 to SACSIM19, SACOG re-ran 2005 baseline and re-validated the outputs as done in SCS2. Table 12-22 and Table 12-23 show the validation results of traffic counts for SACSIM19 and SACSIM15. The overall validation measures such as the ratio of modeled volume to observed counts, average link error and RMSE from SACSIM19 and SACSIM15 are comparable. However, the ratio of modeled volumes to counts are much better on freeway, minor arterial and some other links.

Given the level of uncertainty about how much GHG was truly generated in any given year (including 2005) based on estimates of vehicle activity, the range of variation in 2005 GHG per capita between SACSIM15 and SACSIM19 is not unreasonable to expect. Additionally, given that the same model (SACSIM19) was used for both the re-estimation of the base year AND the forecast years for compliance, and difference among travel models in the base year would be accounted for consistently in the forecast years as well. Table 12-24 shows regional traffic volume compared to observed volumes backcast validation ratios for comparison for 2005, 2008, 2012, and 2016.

Table 12-24 Backcast Traffic Volume Validation Ratio Comparison

	Year							
	2005		2008		2012		2016	
Functional Class	No. of Road Sections	Validation Ratio	No. of Road Sections	Validation Ratio	No. of Road Sections	Validation Ratio	No. of Road Sections	Validation Ratio
Freeway/HOV	189	1.03	241	0.95	191	1.09	371	0.98
Arterial/Expressway/Rural Highway	556	0.98	702	1.09	481	0.91	1,065	1.06
Other Surface Streets & Ramps	520	0.92	820	1.08	368	0.49	760	0.94
Total	1,265	1.00	1,763	1.01	1,040	0.94	2,196	1.00

Source: SACOG 2020.

Validation of Measures of Roadway Congestion

Roadway congestion is an indicator with a much less specific and determined definition than roadway volumes or VMT. In general, congestion occurs on roadways when the number of drivers who wish to use a particular route exceeds the capacity of that route. This condition leads to a reduction in travel speed below the free-flow or posted speed on the roadway. For freeways, typical signs of congestion are stop-and-go driving conditions or long queues at freeway on-ramp meters waiting to enter the freeway. On the local arterial and collector system, congestion is most commonly experienced as waiting at traffic signals and accompanied by driver and passenger frustration.

"Delay" in general refers to time wasted traveling on congested facilities. However, to quantify that delay requires some presumption of what time it should take to travel on a particular route, or a standard travel time which drivers and passengers should expect. Setting a standard by which delay can be quantified is a subjective exercise. For example, some might define a standard travel time as "free-flow" or totally uncongested conditions. The standard for freeways by this definition might be 60 mph or higher, and the "standard" travel time would be 1 minute for a one-mile stretch of freeway. If the actual travel speed, with congestion, was 40 mph, the travel time would be 1.5 minutes, and the delay for each driver and passenger in that condition would be 30 seconds. Others may define the standard as modest or "tolerable" level of congestion. For the same one-mile stretch of freeway, 35 mph could be used as the standard for measurement of delay. With the same 40 travel speed in the previous example, no delay would be experienced, because the actual speed is higher than the standard.

For this and other reasons, SACOG has always focused more on the presence of congestion on roadways rather than amount of delay. Specifically, SACOG estimates and tracks how much of the total VMT occurs on roadways that are above an assigned capacity threshold. SACOG defines a congested VMT (CVMT) as VMT that occurs on roadways with volume-to-capacity (VC) ratios of 1.0 or greater. Capacity in this calculation is based on values used in the regional travel demand model (SACSIM) for trip assignment purposes and that vary by roadway functional classification (i.e., freeway lane capacities are higher than arterial lanes). The SACSIM average capacity values are not based on field measured traffic throughput at each location, but on reasonable values for roadways are approaching their operating capacity. An example of C-VMT is a vehicle and its drivers and passenger going westbound on I-80 in the morning commute period between Madison Avenue and the I-80/Capital City Freeway "Split," or on Hazel Avenue between Madison and Winding Way during commute hours and in the peak direction.

Table 12-28 provides observed data on congestion and delay in the Sacramento region for years 2005, 2008 and 2012. One measure of delay is provided: one published annually by Caltrans in the Mobility Performance Report (MPR). This comparison is provided for reasonableness checking of SACSIM19, and not for rigorous validation[44]. Key similarities in both estimates of congestion: Both

[44] SACOG is working on adapting travel speed data from the National Performance Monitoring Research Dataset (NPMRDS) for comparison to 2016 model estimates of speed on congested roadways for a future validation of estimates of congestion.

show 2005 as being the highest of the three years; both show significant decreases in overall congestion level from 2005 to 2012, which makes sense given the impact of the Great Recession on the amount of travel in the region in 2012. One key difference between the two estimates of congestion: MPR data shows a much bigger decline in congestion between 2005 and 2008 than between 2008 and 2012, while the SACSIM19 backcasts show a very slight decline in congestion between 2005 and 2008, and a much larger decline from 2008 to 2012. Without independent estimates of congestion for these same years, its impossible to determine which of these results are more reasonable. Anecdotally, the decline in congestion in the Sacramento region seemed more tied to the impact of the Great Recession after 2008, and not between 2005 and 2008.

Some of the reasons that this comparison cannot be considered a rigorous validation are that SACSIM19 utilizes equilibrium assignment, which is a “static” and “link-based” process, while the MPR congestion is purely based on link speed, relative to a minimum speed threshold.

- The assignment is “static”, because time is not explicitly represented in the assignment algorithm—for each of the four assignment time periods, the entire demand period is assigned at once, with various parameters and factors to “translate” the entire demand period (three hours in the case of the AM and PM peak periods, five hours for the midday period, and thirteen hours for the late evening/early morning period) into hourly equivalents.
- The assignment is “link-based” because the volume/delay functions are implemented based on link (i.e. roadway segment) definitions of capacity and demand. So, for surface street intersections, the capacity and operations of at-grade intersections is not explicitly represented—instead, a general assumption about the throughput for at-grade intersections is built into the vehicles-per-lane-per-hour capacities assigned to links (see Chapter 3 for more details on vplph capacities of different roadway types). For example, its normally assumed that the effective capacity of a freeway lane is about 2,000 vplph, but the vplph for an major arterial in SACSIM19, for example, is 850 vplph. Part of the difference relates to design standards, presence of “friction” from parking lanes and driveways, etc., but the biggest factor accounting for the difference is the fact that major arterial roadways intersect at grade with other streets, and vehicles traveling on one street “compete” for capacity with vehicles on other streets—with the “competition” for capacity mediated by traffic signals, lane markings, traffic laws, etc. The generalized link capacities for surface streets are factored to represent a reasonable throughput of vehicles at intersections.

The limitations of this vehicle assignment process for estimating delay relate to these three characteristics of equilibrium assignment, compared to actual factors accounting for delay. On surface streets, most delay occurs at intersections, where conflicting flows of vehicles compete for capacity to get through the intersections. Delay accumulates in part due to the necessity to stop when conflicting flows are being served, and in part due to queuing of vehicles in cases when flows overwhelm the capacity of the intersection. On freeways, some delay occurs at bottleneck locations, where demand overwhelms capacity, but a larger portion of delay accumulates from the upstream effects of queues of vehicle backing up and blocking access to or from ramps and connecting lanes. Since the equilibrium assignment process does not explicitly account for surface street intersections or the effects of queuing of vehicles through time are not captured in this process, only a portion of the causes of delay are accounted for in SACSIM19.

Table 12-25 Comparison of Congested Vehicle Miles Traveled and Delay

Congestion/Delay Measure	2005	2008	2011/12
Freeway Vehicle Hours Delay (daily)†	5,399	3,448	2,989
Congested Vehicle Miles Traveled (weekday, in 000's)*	4,415	4,387	3,342
Annual Average Growth Rates	**'05 to '08**	**'08 to '12**	**'05 to '11/12**
Freeway Vehicle Hours Delay†	-14%	-4%	-8%
Congested Vehicle Miles Traveled*	-0%	-7%	-4%

Source: SACOG 2020.

† Caltrans District 3 "Mobility Performance Reports". Caltrans defines delay as the difference between travel time at 35mph and actual travel time, for state highways where actual travel times are below 35mph. All segments included in the monitoring reports for the SACOG region are freeways.
*SACSIM15 estimates of congested vehicle miles traveled.

12.3.3.5 Gateways Assignment Validation and Reasonableness Check

As described in Chapter 3, SACSIM19 uses an external sub module outside of DAYSIM to predict trips in and out of the SACOG region. Highway network links used during the assignment are used to represent roadway connections outside the SACOG region. These roadway links are called "gateways." Since these trips are determined separately from the DAYSIM simulation, an additional validation check on the gateways was performed for reasonableness. Table 12-26 shows the gateway SACSIM traffic volumes compared to counts using the CTC guidelines. The gateways meet all validation acceptance criterions including 100 percent of the locations within the acceptable range of deviation between traffic volume to observed count.

Table 12-26 SACSIM19 Gateways Assignment Validation

Validation Measures	Threshold	2016
% of Locations w/ Model < Max Deviation	>75%	100%
Correlation Coefficient	> 0.88	0.997
RMSE for Daily Traffic Assignment	<0.40	0.24

Source: SACOG 2020.
Thresholds from California Transportation Commission, 2017 Regional Guidelines for MPOs, p.49.

12.3.3.6 Dynamic Validation

For dynamic validation results, please refer to Appendix E Caltrans 2019 Validation Memos Prepared by DKS Using SACSIM19.

12.3.4 Transit Network and Assignment Validation

12.3.4.1 Transit Network Validation

As with highway networks, direct, independent checks of modeled transit networks against actual transit networks are difficult to perform. But as a generic check we compared vehicle service hours estimated in the model against observed vehicle service hours provided by transit operators.

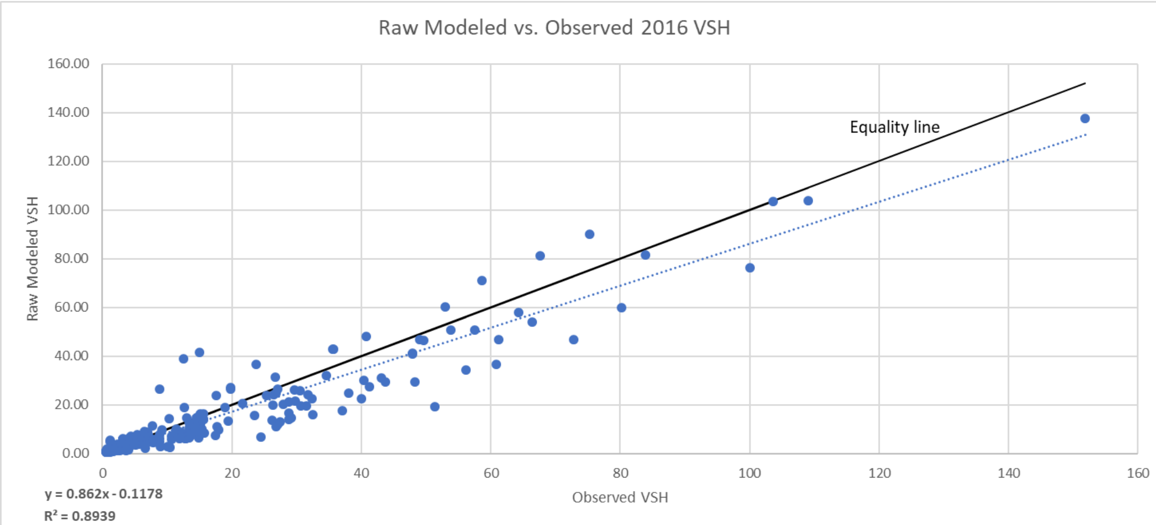
Vehicle service hours (VSH) are a common way of estimating the amount of transit service provided for passengers. One VSH is defined as one transit vehicle operating in revenue service (i.e. available for passengers to use, and not operations of vehicles for maintenance purposes) for one hour. VSH includes the time spent on a route picking up or dropping off passengers, plus turnaround or layover times (i.e. times built into schedules for vehicles to wait or layover at the end of a route, or time needed to turn around at the end of a route). VSH does not include the time that a transit vehicle spends traveling between the bus yard and its first/last stop of the day.

Figure 12-8 provides a comparison of observed data and model estimates of weekday VSH for each route operating in the SACOG region in 2016. Overall “fit” between model estimates and observed data is good, with an r-squared correlation between observed and modeled VSH of about 0.89. However, SACSIM’s VSH predictions are somewhat lower than observed VSH, with a beta between modeled and observed VSH of 0.86.

Table 12-28 summarizes 2016 weekday VSH for three different transit service types: light rail, express or commuter buses, and regular fixed route buses. Overall, modeled VSH is somewhat lower than VSH reported by transit operators, with a beta of 0.86. VSH estimates for local buses are low compared to operator-reported VSH (beta of 0.8), though light rail estimated VSH is very close to operator-report VSH (beta of 1.02). VSH estimates for express buses are, on average, high, with a beta of 1.28.

One reason for this discrepancy is that SACSIM’s ability to estimate transit vehicle travel times, and therefore service hours, is somewhat coarse. It relies on average headways within five different time periods and, rather than true end-to-end travel time, estimates travel times based on applying a time factor multiple to the congested link travel time. The overestimation of commuter bus VSH is largely due to difficulty representing commuter service headways. E.g., some lines were modeled as having a higher headway than in reality to capture the fact that, although infrequent, commuter bus departure times are tailored to commuters’ schedules and therefore are perceived as having a higher level of service. For example, a commuter bus that only runs twice each morning has a higher utility than a local bus because it leaves at times that conveniently align with riders’ work schedules, therefore to capture the line’s utility it is modeled with a somewhat shorter headway. This shorter headway in turn leads to higher modeled VSH.

Figure 12-8 Year 2016 Transit Line Vehicle Service Hours: Model Estimates and Observed Data



Source: SACOG 2020. Observed VSH provided by transit operators or Google Transit Feed Specification (GTFS).

Table 12-27 Line-Level Transit Network Comparison: Model Estimates and Observed Data

	Regression Statistics (β * Model VSH= Actual VSH)	
Variable	R-Squared	Beta
2016 Vehicle Service Hours ‡	0.89	0.86

Source: SACOG 2020.
‡Model estimated line-level VSH regressed against operator-reported VSH for sample of 229 routes.

Table 12-28 Year 2016 Transit Vehicle Service Hours by Type of Service: Model Estimates and Observed Data

	Weekday Vehicle Service Hours		
Service Type	Observed	Modeled	Validation Ratio
Light Rail	301	307	1.02
Fixed Route Bus	3,318	2,651	0.80
Express Bus	320	411	1.28
All Service Types	3,939	3,368	0.86

Source: SACOG 2020.

12.3.4.2 Transit Assignment Validation

SACSIM's transit modeling, at a high level, involves the following steps:

1. Generate and distribute transit trips using DAYSIM. DAYSIM was calibrated such that the number of transit trips it predicts results in a transit mode share (I.e., the percent of total trips that were made on transit) that matches SACOG's 2018 household travel survey. Per the 2018 household travel survey, transit mode share was about 1.2%.
2. Using Cube's PT module, SACSIM assigns these transit trips to the modeled transit network.
3. Based on how trips were assigned to the transit network, SACSIM calculates the total boardings for each line. A single trip can entail multiple boardings, e.g., one transit trip that requires one transfer results in two boardings.

Below, Table 12-29 summarizes transit assignment validation results by transit mode, while Figure 12-9 plots observed versus modeled boardings at the line level. SACSIM's estimate of boardings exceeded observed boardings by about 22% for local bus routes and 24% for LRT routes, or slightly outside the California Transportation Commission's validation threshold of +/- 20% for transit boardings[45].

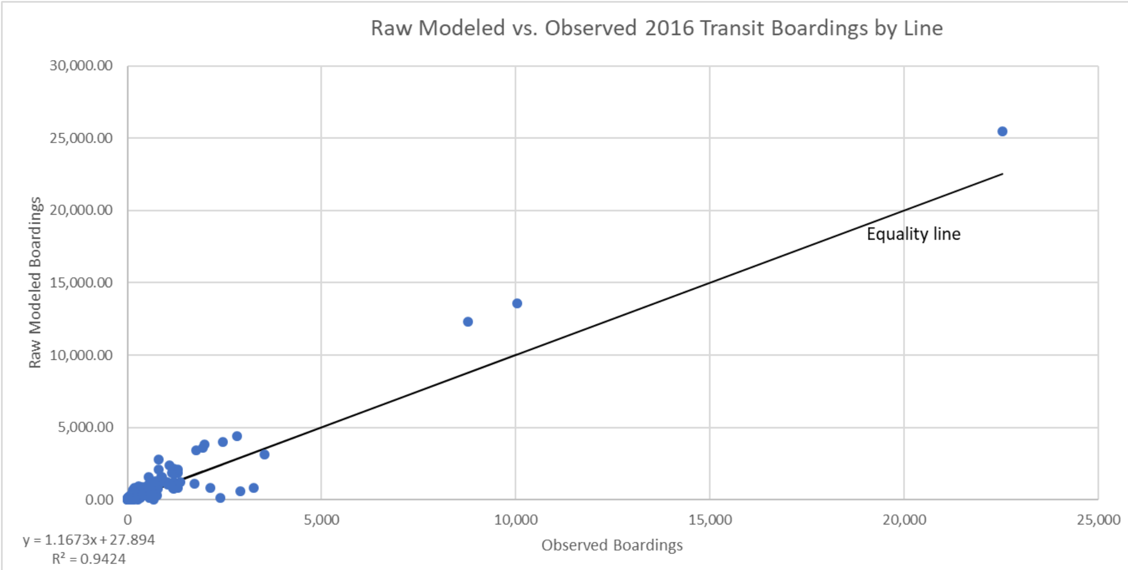
Table 12-29 Weekday Transit Passenger Boardings by Service Type: Comparison of Model to Counts

	Weekday Boardings			Boardings per Trip	
Service Type	Observed	Modeled	Validation Ratio	Modeled Transit Trips	Boardings per Trip
Light Rail	41,732	51,804	1.24	46,384	1.12
Express Bus	5,566	5,658	1.02	5,459	1.04
Local Bus	73,309	89,433	1.22	49,505	1.81
All Service Types	120,608	146,896	1.22	101,348	1.45

Source: SACOG 2020.
Model estimates included only for lines for which observed boardings data were available from operators.

[45] California Transportation Commision, 2017. *2017 Regional Transportation Plan Guidelines for Metropolitan Planning Organizations.* p.49

Figure 12-9 Line-Level Transit Boarding Validation



Source: SACOG 2020.

Although slightly outside of CTC's transit assignment validation threshold, SACSIM's boarding estimate is not of significant concern because, as described above, it is calibrated to match transit trip share rather than match boardings at the line level. And an alternative way to determine how reasonably SACSIM assigns transit trips, given that we are confident in its prediction of transit trip share, is to compare SACSIM's rate of boardings per trip to an observed rate of boardings per trip.

As described in the above summary of SACOG's 2013 Connect Card survey, among transit operators included in the survey, there were an average of 1.78 boardings per trip. In comparison, based on dividing SACSIM's modeled boardings by its predicted transit trips, SACSIM estimated approximately 1.46 boardings per transit trip. This difference between SACSIM's and observed rates of boardings per trip may seem significant, but critical to consider is that the survey did not collect responses from Unitrans riders. This matters because (1) Unitrans is the second most-used system in the SACOG region, so its riders' transfer rate (boardings per trip) significantly affects the regional average predicted by SACSIM and; (2) because Unitrans's service is tailored to bringing its users to the UC Davis campus, it likely has a very low transfer rate compared to other systems included in the survey. Combining these two considerations, we believe SACSIM's transfer rate, because it includes Unitrans users, should be lower than that found in the 2013 survey and that its rate of 1.46 boardings per trip is reasonable.