

12 Model Calibration and Validation

12.1 Observed Travel Data

Observed travel data is used for model development (estimation and calibration of statistical submodels) and for reasonableness checking and validation (comparisons of model estimates to observed data in the validation years). This section provides a description of the key observed travel datasets used for SACSIM19.

12.1.1 American Community Survey

Five-year ACS data from the Census Bureau is used as the source of demographic controls for the development of the 2016 representative population file for SACSIM19. In addition to the demographic profiles, the ACS reports commute statistics such as mode of commute. One-year samples average 1.5 percent of all households in the SACOG region. Three-year samples roll up three years of the ACS samples, and control or weight the totals to the end year of the three year sample cycle. SACSIM19 used 2016 five-year ACS data, using sampling from 2012, 2013, 2014, 2015, and 2016.

12.1.2 Household Travel Surveys

Household travel surveys (HTS) record the actual demographics, activity locations, and travel for all members of households for a known, structured sample of households within a region. HTSs are valuable for estimation of statistical models that form the basis of travel demand models like SACSIM19. HTSs are also valuable as sources of data for calibration of key submodels, to ensure that when applied, the submodels are reasonable representations of observed travel behavior. Two HTS's were used for SACSIM19: the 2000 SACOG Household Travel Survey, and the 2018 SACOG Household Travel Survey. Both HTSs were based on a structured sample of households in Sacramento, Sutter, Yolo, and Yuba Counties, and the western portions of El Dorado and Placer Counties.

- 2000 SACOG HTS. SACOG documented the survey and sample design, as well as initial results of the survey in Appendix C, "2000 Sacramento Area Travel Survey Final Report". A more detailed analysis of the 2000 HTS and extensive tabulations, are provided in Appendix H, "Pre-Census Travel Behavior Report: Analysis of the 2000 SACOG Household Travel Survey". The 2000 HTS was used to do the estimation of DAYSIM_1.7, which was later developed into DAYSIM_2.1, the version of DAYSIM used for SACSIM19.
- 2018 SACOG HTS. This was the first HTS implemented in the SACOG region using the smartphone as the primary data capture device for the survey. It was also the first HTS in the SACOG region that collected travel activities for multiple days, including weekend days. Detailed documentation of the survey and sample design, as well as initial results of the survey can be found in <https://www.sacog.org/post/2018-sacog-regional-household-travel-survey>. The 2018 HTS was finalized too late for use in re-estimation of SACSIM19, and its use was focused on calibration targets for selected DAYSIM_2.1 submodels, and reasonableness checking of SACSIM19 household-generated travel results.

12.1.3 Sacramento Regional Transit Airport Passenger Survey

In January and February 2002, a contractor for Sacramento Regional Transit surveyed air passengers at the Sacramento International Airport⁴⁰. The goal of the survey was to elicit sufficient information from passengers to estimate a ground access mode choice model, and to sample enough passengers to enable using the sample database itself to apply the model using a sample enumeration approach. The survey sample included 777 departing passengers, which were pre-screened to include passengers traveling to the airport from somewhere in the Sacramento Regional Transit service area. This constitutes an approximately 1-in-10 sample of all departing passengers from the RT service area. The reasonableness of the survey as a basis for direct use using a sample enumeration approach was verified by comparison of the sample to aggregated totals from other random surveys of passengers taken in 1998 and 1999 with ground access trip origins within Sacramento, El Dorado, and Placer counties, which compares to the origin areas of the 2002 passenger surveys. By several key variables, such as ground access trip origin, whether the point of origin was a private residence, hotel, or business, and trip purpose, the 2002 sample matched very closely the near-universe sample taken in the 1999 passenger intercept survey.

The survey included both revealed and stated preference elements. The first questions related to the mode of travel actually taken to the airport on that day. Because very little transit service was present at the time of the survey, a set of stated-preference questions were asked related to transit service. A third set of questions elicited demographic information on the passenger.

12.1.4 On-Board Transit Surveys

To help validate SACSIM's transit ridership predictions, we referred to SACOG's 2013 Connect Card Survey, which surveyed nearly 17,000 transit riders in April 2013 as part of developing the Connect Card multi-agency fare card currently in use in the SACOG region. The survey gathered a rich set of demographic and travel behavior data from riders using Sacramento Regional Transit, Roseville Transit, Yuba-Sutter Transit, YoloBus, Folsom Stage Line, El Dorado Transit, and E-Tran (City of Elk Grove). Below we summarize some of the key metrics from the survey that we compared against modeled transit data outputs.

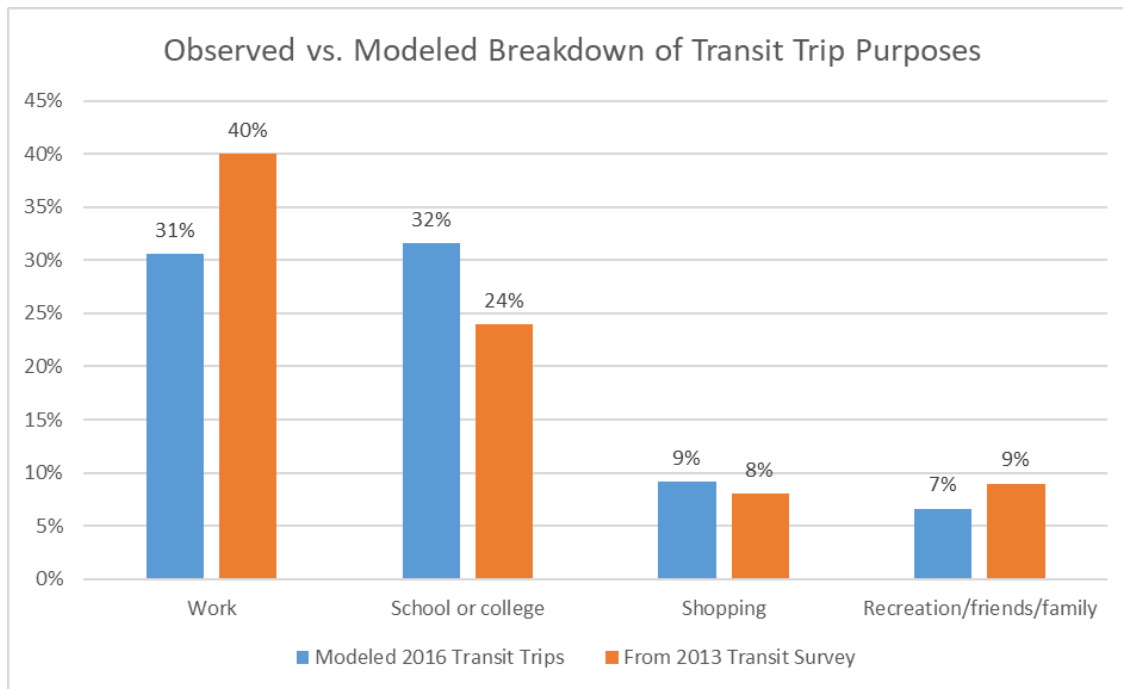
12.1.4.1 Trips by Purpose

Figure 12-1 breaks down transit trips by trip purpose, comparing the trip purpose shares of the model against those found in the 2013 Connect Card Survey. While other trip purposes are captured in the survey and by SACSIM, they are not included in the comparison because they do not have a shared, apples-to-apples definition between the two data sets. E.g., SACSIM has a "meal" trip purpose, but the survey does not. Conversely, the 2013 survey has a "medical appointment" trip purpose, but SACSIM does not.

⁴⁰ Parsons Brinckerhoff Quade & Douglas, DKS Associates, and JD Franz Associates, "Methodology for Conducting the Passenger Survey at Sacramento International Airport in Support of the Downtown/Natomas/Airport Corridor Alternatives Analysis/Draft EIS Project", July 2002.

For purposes that were comparable, shown in Figure 12-1, SACSIM’s modeled share of transit trips dedicated to each purpose is reasonably close to the observed share of trips dedicated to the same purpose. There is some discrepancy, e.g. 40% of observed transit trips were work trips, while only 31% of modeled transit trips were work trips, while for school trips SACSIM predicted that 32% of trips are school trips while observed data only indicated that 24% of trips are school trips. Both discrepancies are likely explained by the absence of Unitrans data in the 2013 Connect Card survey. Unitrans is the second most-used system in the SACOG region, so its riders’ behaviors have a significant effect on regional aggregate numbers on rider behavior, and its riders are overwhelmingly UC Davis students. These two factors likely explain why the model data show both a lower share of work trips and higher share of student trips than the observed data.

Figure 12-1 Year 2013 Transit Trips by Purpose



12.1.4.2 Trips, Boardings, and Transfer Rates

Two distinct terms when measuring transit usage are “boardings” and “linked trips”. A “linked trip” is the journey that a traveler makes from the trip origin to the trip destination, while a “boarding” occurs each time the traveler gets on a transit vehicle. E.g., if during a linked trip a traveler makes one transfer, that traveler made one linked trip but two boardings.

Table 12-1 below breaks down transfer habits for each transit agency, including how many transfers passengers made and the average boardings per trip. Considering all systems studied in the 2013 survey, the average passenger completed 1.78 boardings for every linked trip. This transfer rate is significantly higher than observed in prior on-board surveys, which ranged from 1.4 to 1.5. Important to note, and discussed in more detail in Section 12.3.4, is the absence of Unitrans data from the 2013 survey. Unitrans is the second busiest transit system in the SACOG region, and its

users are less likely to transfer because the system is oriented toward giving students a “one-seat” ride to the UC Davis campus. Therefore, the transfer rate from the 2013 survey is likely somewhat higher than the regional average after accounting for Unitrans riders.

Table 12-1 Year 2013 Transfer Rates by Service Type

Operator	Transit vehicles used to make trip					Boardings/Trip
	1	2	3	4	5	
RT	31%	61%	7%	2%	0%	1.80
Elk Grove	56%	30%	12%	2%	0%	1.60
El Dorado	89%	9%	2%	0%	0%	1.13
Folsom Stage Line	28%	48%	22%	2%	0%	1.98
Roseville	51%	37%	9%	2%	1%	1.65
Yolobus	42%	46%	10%	2%	0%	1.72
Yuba-Sutter	38%	51%	8%	3%	1%	1.79
<i>All Systems</i>	<i>33%</i>	<i>58%</i>	<i>7%</i>	<i>2%</i>	<i>0%</i>	<i>1.78</i>

12.1.5 Transit Boarding Counts

Year 2016 weekday passenger boardings by line were assembled for use in validation of the transit assignment,

12.1.6 Traffic Counts

Traffic counts are used for validation and reasonableness checking of the SACSIM19 highway vehicle assignments for the MTP/SCS base scenario year 2016. Historical count data for 2005, 2008, and 2012 from past model generations are also used for reasonableness checking and backcast validating. Year 2016 is the base year for SACSIM19 and for analysis of the 2020 Metropolitan Transportation Plan. SACSIM uses multiple sources for the traffic counts:

- Caltrans Performance Measurement System (PeMS): Average Spring or Fall, Tuesday – Thursday Daily average counts are used where sensors have been deemed healthy by PeMS sensor health monitor, observed percentage, and staff review.
- Caltrans Traffic Census Program including Traffic Columns: Annual Daily Traffic (AADT) and Truck Traffic: Annual Average Daily Truck Traffic. Reports provide average annual daily volumes and not typical weekday volumes, where provided “Peak Month” volumes were used.

- Processed counts provided by local agency staff in various forms, but generally as paper counts.
- Processed counts provided by a local traffic sensors, provided by local city traffic monitoring systems and readily available traffic count databases.
- Processed counts provided by a local traffic count vendor, with the permission of the clients that paid for the counts.
- Historic count data from permanent electronic count stations on the State Highway system, which were provided to SACOG in raw form by the Teal Data Center.
- Counts taken by count contractor for SACOG in Fall 2008.

In general, counts were used which met the following criteria:

- Counts were daily volumes broken down by direction of travel, or daily volumes broken down by direction of travel and hour.
- Counts were taken in Spring months (March, April, or May) or early Autumn months (September or October) of calendar year.
- Counts were taken during the mid-week weekdays (Tuesday, Wednesday or Thursday).

In some cases, counts were utilized by SACOG which did not meet these two criteria. The most common exceptions were non-directional daily counts, which were split 50/50 to get to direction of travel, or counts taken outside the desired seasonal windows and year, if there was some level of confidence that the count was a reasonably good representation of weekday volumes.

No peak hour counts were processed or utilized for SACSIM. The reasons for this have to do with the limitations of static or aggregate assignment of vehicle trips onto a regional network the size and extent of SACSIM. Table 12-2 provides a tabulation of the traffic counts assembled by county of the count location by year.

Table 12-2 Traffic Counts Collected by Year

	Year			
	2005	2008	2012	2016
Functional Class				
Freeway/HOV	189	241	191	371
Arterial/Expressway/Rural Highway	556	702	481	1,065
Other Surface Streets & Ramps	520	820	368	760
Total	1,265	1,763	1,040	2,196

Source: SACOG 2020.

12.1.7 Vehicle Miles Traveled

Estimates of VMT were extracted from the annual Highway Performance Monitory System data from the California Public Road Data⁴¹ report, and adjusted for comparison to the SACSIM19 estimates VMT. Adjustments of the CPRD VMT estimates are needed for two reasons.

First, reported VMT is based on average annual daily traffic volumes (AADT) in the CPRD, while the SACSIM19 VMT estimates are typical weekday. The technical definition for “annual average” is the sum of daily volumes on a roadway for every day of the year, divided by the number of days in the year (365 or 366 for leap years). In practice, AADT volumes are rarely computed in this way, though—they are estimated from a limited number of counts, and adjusted for presumed seasonal variation, and for weekday/weekend variations. Spot comparisons of typical weekday volumes to AADT volumes show that on average, typical weekday volumes are about 5 percent higher than AADT volumes. In comparison, SACSIM “typical weekday” (discussed in greater detail in the “Introduction” of this report) is defined as mid-weekday (Tuesday through Thursday) in spring or fall months. In general, typical weekday is more focused on “workday” travel conditions. Since annual average includes weekends, holidays, and all seasons, the volumes tend to be lower on average than typical weekday. A global adjustment factor of 1.05 (i.e. a five percent increase) is used to convert from annual average to typical weekday and regional level.

Second, the CPRD reports provide printed tables which do not allow for tabulation of geography consistent with the SACSIM model area, which is all of Sacramento, Sutter, Yolo and Yuba Counties, and the non-Tahoe-Basin portions of El Dorado and Placer Counties. SACOG assumed the non-Tahoe-Basin portions of CPRD-reported VMT are 90 percent and 95 percent for El Dorado and Placer Counties, respectively.

⁴¹ California Department of Transportation, *California Public Road Data*, published annually, <http://www.dot.ca.gov/hq/tsip/hpms/datalibrary.php>

12.1.8 Other Data Sources

For reasonableness checking and manual adjustments of free-flow speeds, available estimates of vehicle speed were utilized. For 2012 speeds, SACOG used INRIX average speed estimates by time of day and direction, average for the months of September and October. For 2016 speeds, SACOG used speed data provided through the Federal Highway Administration (FHWA) “National Performance Management Research Dataset” (NPMRDS). NPMRDS data are provided at 15-minute increments for all time periods and days; however, if raw data do not meet the reporting standards of the contractor to FHWA, data are not provided. In general, NPMRDS data coverage is very good for higher volume roadways, and very poor for lower volume roadways. SACOG processes the raw data for use in regional monitoring functions and the Congestion Management Program. The processed speeds are used for reasonableness checking of individual roadway segments and manual adjustments to free-flow speeds in the SACSIM19 highway network.

12.2 Model Calibration

12.2.1 DAYSIM Model Calibration

As described in Chapter 3, DAYSIM is the core of SACSIM and is consisted of two modules: long term and short term choices. Both modules are consisted of a series of nested choice models. In operation, given the households' residence, DAYSIM runs long term module first and simulates people's long term choices such as usual work and school locations, and auto ownership, and then run short term choice module such as day pattern, main destination, tour mode, trip mode etc. With this hierarchical or nested choice structure, the lower level choices were affected or constrained by upper choices. For example:

- Choices of usual locations for work and school affect the choices of work and tour destinations, since the usual locations are the most likely destinations.
- Auto ownership affects both day pattern and tour (and trip) mode choice, by generating auto ownership market segments used in the model.

In SACSIM19, all DAYSIM choice models were re-estimated using the 2008 parcel level landuse data, skim data and the expanded 2000 survey in 2008 travel conditions. All initial re-estimated coefficients and standard error are listed in Appendix A-DAYSIM User Reference Guide. Table 12-3 lists the choice models and variables calibrated based on 2016 landuse/demographics and travel conditions with ACS 2012-2016 5 year data and 2018 Household Travel Survey:

Table 12-3 DAYSIM Choice Model Coefficients

1. WorkLocation - WorkLocationCoefficients_SACOG-v1.5			
Item#	Name	Description	Ratio variable Description
6	Beta00006	workAwayFromHomeFlag * IsFulltimeWorkerFlag * [One-way drive dist--0-3.5 mi (10s of mi)]	% of full time workers with to usual-work-place distance < 3.5 mile
7	Beta00007	workAwayFromHomeFlag * IsFulltimeWorkerFlag * [One-way drive dist--3.5-10 mi (10s of mi)]	% of full time workers with to usual-work-place distance >=3.5 and <= 10 mile
8	Beta00008	workAwayFromHomeFlag * IsFulltimeWorkerFlag * [One-way drive dist--10+ mi (10s of mi)]	% of full time workers with to usual-work-place distance >= 10 mile
41	Beta00041	workAtHomeFlag	% of workers working at home
2. SchoolLocation - SchoolLocationCoefficients_SACOG-v1.8			
Item#	Name	Description	Ratio variable Description
7	Beta00007	schoolAwayFromHomeFlag * IsChildUnder5Flag * [One-way drive dist--0-1 mi (10s of mi)]	% of under 5 year old kids with to usual-school- place distance < 1 mile
8	Beta00008	schoolAwayFromHomeFlag * IsChildUnder5Flag * [One-way drive dist- -1-5 mi (10s of mi)]	% of under 5 year old kids with to usual-school- place distance >= 1 and < 5 mile
9	Beta00009	schoolAwayFromHomeFlag * IsChildUnder5Flag * [One-way drive dist- -5+ mi (10s of mi)]	% of under 5 year old kids with to usual-school- place distance >= 5 mile
10	Beta00010	schoolAwayFromHomeFlag * IsChildAge5Through15Flag * [One-way drive dist--0-1 mi (10s of mi)]	% of 5-15 year old kids with to usual-school- place distance < 1 mile
11	Beta00011	schoolAwayFromHomeFlag * IsChildAge5Through15Flag * [One-way drive dist--1-5 mi (10s of mi)]	% of 5-15 year old kids with to usual-school- place distance >= 1 and < 5 mile
12	Beta00012	schoolAwayFromHomeFlag * IsChildAge5Through15Flag * [One-way drive dist--5+ mi (10s of mi)]	% of 5-15 year old kids with to usual-school- place distance >= 5 mile
3.AutoOwnerShip - AutoOwnershipCoefficients_SACOG-v1.5			

Item#	Name	Description	Ratio variable Description
1	1 Beta00001	0 autos--household.Has1Driver.ToFlag();	% of households has 1 driver with 0 auto
2	2 Beta00002	2 autos--household.Has1Driver.ToFlag();	% of households has 1 driver with 2 auto
3	3 Beta00003	3 autos--household.Has1Driver.ToFlag();	% of households has 1 driver with 3 auto
4	4 Beta00004	4+ autos--household.Has1Driver.ToFlag();	% of households has 1 driver with 4+ auto
5	5 Beta00005	0 autos--household.Has2Drivers.ToFlag();	% of households has 2 driver with 0 auto
6	6 Beta00006	1 auto--household.Has2Drivers.ToFlag();	% of households has 2 driver with 1 auto
7	7 Beta00007	3 autos--household.Has2Drivers.ToFlag();	% of households has 2 driver with 3 auto
8	8 Beta00008	4+ autos--household.Has2Drivers.ToFlag();	% of households has 2 driver with 4+ auto
9	9 Beta00009	0 autos--household.Has3Drivers.ToFlag();	% of households has 3 driver with 0 auto
10	10 Beta00010	1 auto--household.Has3Drivers.ToFlag();	% of households has 3 driver with 1 auto
11	11 Beta00011	2 autos--household.Has3Drivers.ToFlag();	% of households has 3 driver with 2 auto
12	12 Beta00012	4+ autos--household.Has3Drivers.ToFlag();	% of households has 3 driver with 4+ auto
13	13 Beta00013	0 autos--household.Has4OrMoreDrivers.ToFlag();	% of households has 4+ driver with 0 auto
14	14 Beta00014	1 auto--household.Has4OrMoreDrivers.ToFlag();	% of households has 4+ driver with 1 auto
15	15 Beta00015	2 autos--household.Has4OrMoreDrivers.ToFlag();	% of households has 4+ driver with 2 auto
16	16 Beta00016	3 autos--household.Has4OrMoreDrivers.ToFlag();	% of households has 4+ driver with 3+ auto
18	18 Beta00018	0-4+--household has at least as many cars as workers	% of households has at least as many cars as workers

4. IndividualPersonDayPattern - IndividualPersonDayPatternCoefficients_SACOG-v1.8

Item#	Name	Description	Ratio variable Description
work			
100	W-TASC	tour constant(FTW)	% of full time workers taking 1+ work tours
101	W-SASC	stop constant	% of work tours with 1+ stops
102	W-PTW	PartTimeWorker	% of part time workers taking 1+ tours
school			
200	S-TASC	tour constant	% of people taking 1+ school tours
201	S-SASC	stop constant	% of school tours with 1+ stops
205	S-UNI	UniversityStudent	% of university students taking 1+ school tours
206	S-DAS	DriveAgeKid	% of driving school kids taking 1+ school tours

207	S-PAS	5-15 kids	% of 5 to 15 year old kids taking 1+ school tours
208	S-CU5	under 5	% of 5 to 5 year old kids taking 1+ school tours
Escort			
300	E-TASC	tour constant	% of people taking 1+ escort tours
301	E-SASC	stop constant	% of escort tours with 1+ stops
Personal Bus			
400	P-TASC	tour constant	% of people taking 1+ personal bus tours
401	P-SASC	stop constant	% of personal bus tours with 1+ stops
shop			
500	H-TASC	tour constant	% of people taking 1+ shopping tours
501	H-SASC	stop constant	% of shopping tours with 1+ stops
meal			
600	M-TASC	tour constant	% of people taking 1+ meal tours
601	M-SASC	stop constant	% of meal tours with 1+ stops
Social			
700	D-TASC	tour constant	% of people taking 1+ social tours
701	D-SASC	stop constant	% of social tours with 1+ stops
TourStopCombo			
1311	NT/NS-1/1	1 tour/1 stop	% of people taking 1 tour with 1 stop
1312	NT/NS-1/2	1 tour/2 stop	% of people taking 1 tour with 2 stop
1313	NT/NS-1/3	1 tour/3+ stop	% of people taking 1 tour with 3+ stop
1321	NT/NS-2/1	2 tour/1 stop	% of people taking 2 tour with 1 stop
1322	NT/NS-2/2	2 tour/2 stop	% of people taking 2 tour with 2 stop
1323	NT/NS-2/3	2 tour/3+ stop	% of people taking 2 tour with 3+ stop
1331	NT/NS-3/1	3 tour/1 stop	% of people taking 3 tour with 1 stop
1332	NT/NS-3/2	3 tour/2 stop	% of people taking 3 tour with 2 stop

5. PersonExactNumberOfTours - PersonExactNumberOfToursCoefficients_SACOG-v1.5

Item#	Name	Description	Ratio variable Description
work tours			
	0&1 Tours		
152	WC-2Tours		% of people take 2 work tours
153	WC-3Tours		% of people take 3 work tours
school tours			
	0&1 Tours		
252	SC-2Tours		% of people take 2 school tours
253	SC-3Tours		% of people take 3 school tours
escort			

	0&1 Tours	
352	EC-2Tours	% of people take 2 escort tours
353	EC-3Tours	% of people take 3 escort tours
person business		
	0&1 Tours	
452	PC-2Tours	% of people take 2 Personal Business tours
453	PC-3Tours	% of people take 3 personal business tours
shopping		
	0&1 Tours	
552	HC-2Tours	% of people take 2 shopping tours
553	HC-3Tours	% of people take 3 shopping tours
meal		
	0&1 Tours	
652	MC-2Tours	% of people take 2 meal tours
653	MC-3Tours	% of people take 3 meal tours
social/Rec		
	0&1 Tours	
752	RC-2Tours	% of people take 2 social/Rec tours
753	RC-3Tours	% of people take 3 social/Rec tours

6. WorkBasedSubTourGeneration - WorkbasedSubtourGenerationCoefficients_SACOG-v1.5

Item#	Name	Description	Ratio variable Description
1	Beta00001	work stop	% of work based tours with work purpose stop
3	Beta00003	school stop	% of work based tours with school purpose stop
4	Beta00004	escort stop	% of work based tours with escort purpose stop
6	Beta00006	personal business stop	% of work based tours with personal business purpose stop
8	Beta00008	shopping stop	% of work based tours with shopping purpose stop
10	Beta00010	meal stop	% of work based tours with meal purpose stop
13	Beta00013	social/rec stop	% of work based tours with social/rec purpose stop

7. WorkTourMode - WorkTourModeCoefficients_SACOG-v1.5 - Copy.F12

Item#	Name	Description	Ratio variable Description
10	dt-const	Drive to Transit Constant	Drive to Transit Tours
20	wt-const	Walk to Transit	Walk to Transit Tours
30	s3-const	Shared Drive 3 Constant	Shared Drive 3+ Tours

40	s2-const	Shared Drive 2 Constant	Shared Drive 2 tours
50	da-const	Drive Alone Constant	Drive Alone Tours

8. Other home based tour mode - OtherHomeBasedTourModeCoefficients_SACOG-v1.5.F12

Item#	Name	Description	Ratio variable Description
20	wt-const	Walk to Transit Constant	Walk to Transit Tours
30	s3-const	Shared Drive 3 Constant	Shared Drive 3+ Tours
40	s2-const	Shared Drive 2 Constant	Shared Drive 2 tours
50	da-const	Drive Alone Constant	Drive Alone Tours
60	bi-const	Bike Constant	Bike tours

9. TripMode - TripModeCoefficients_SACOG-v1.5.F12

Item#	Name	Description	Ratio variable Description
20	wt-const	Walk to Transit Constant	Walk to Transit Trips
30	s3-const	Shared Drive 3 Constant	Shared Drive 3+ Trips
40	s2-const	Shared Drive 2 Constant	Shared Drive 2 Trips
50	da-const	Drive Alone Constant	Drive Alone Trips
60	bi-const	Bike Constant	Bike Trips

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).

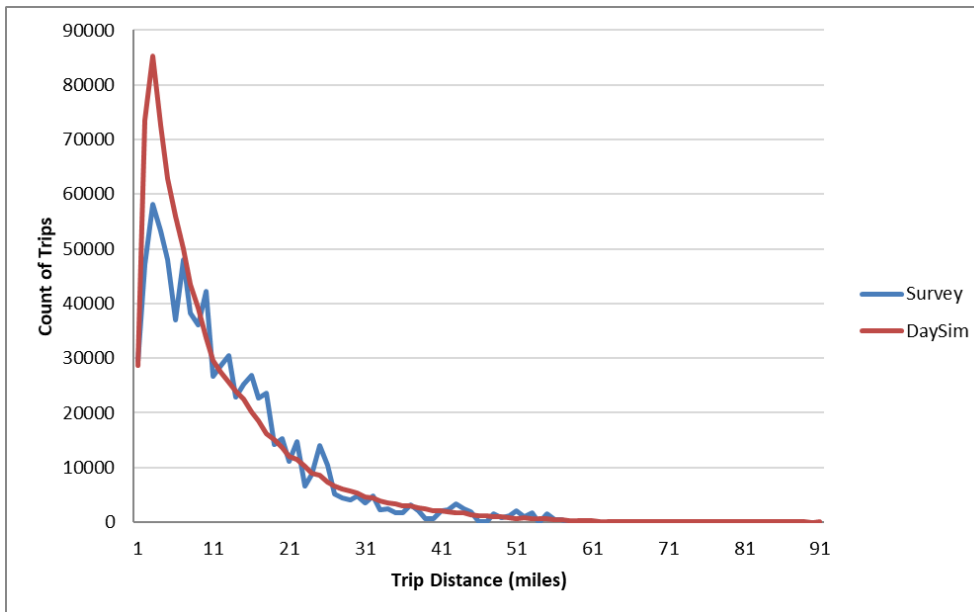
The total work location choices are constrained to TAZ-level total jobs by a shadow price process. Figure 12-3 demonstrates a good fit between the number of jobs in each TAZ and how many workers’ usual work locations are in that TAZ.

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

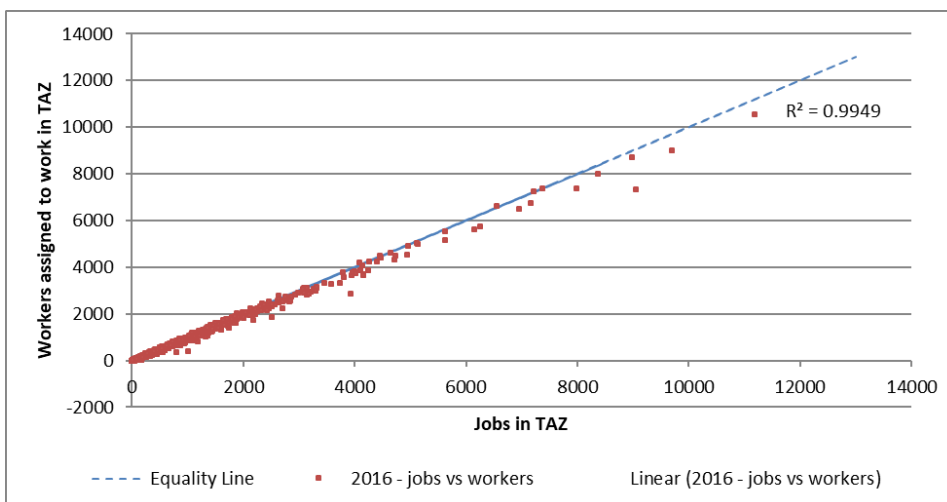
Source: SACOG 2020.

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

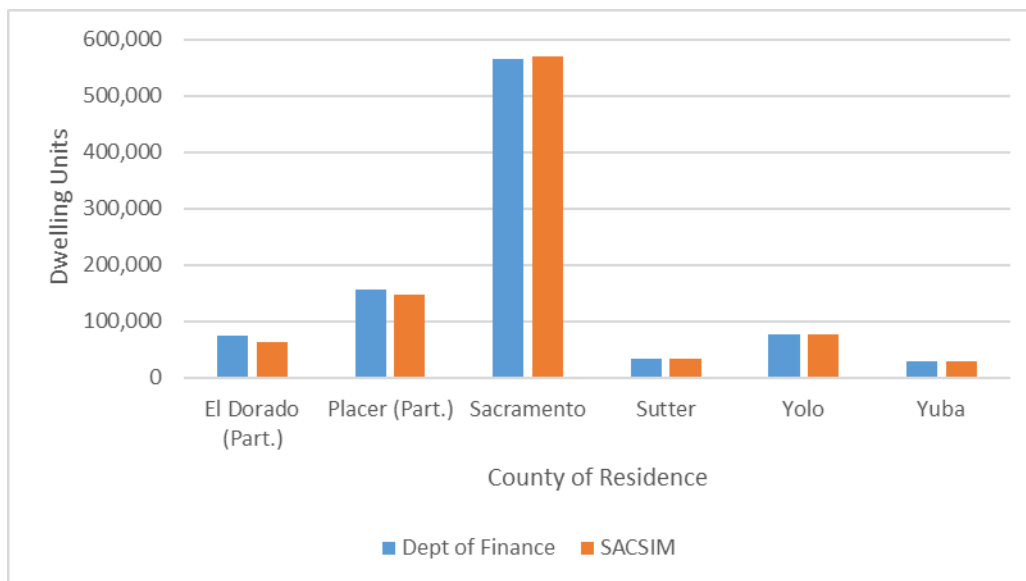
Variable	Observed Data	SACSIM19 Estimate	Validation Ratio
Dwelling Units ¹	932,289	921,123	0.99
Households ¹	849,779	872,699	1.03
Population ¹	2,401,837	2,412,755	1.00
Jobs ²	1,071,199	1,060,751	0.99

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		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

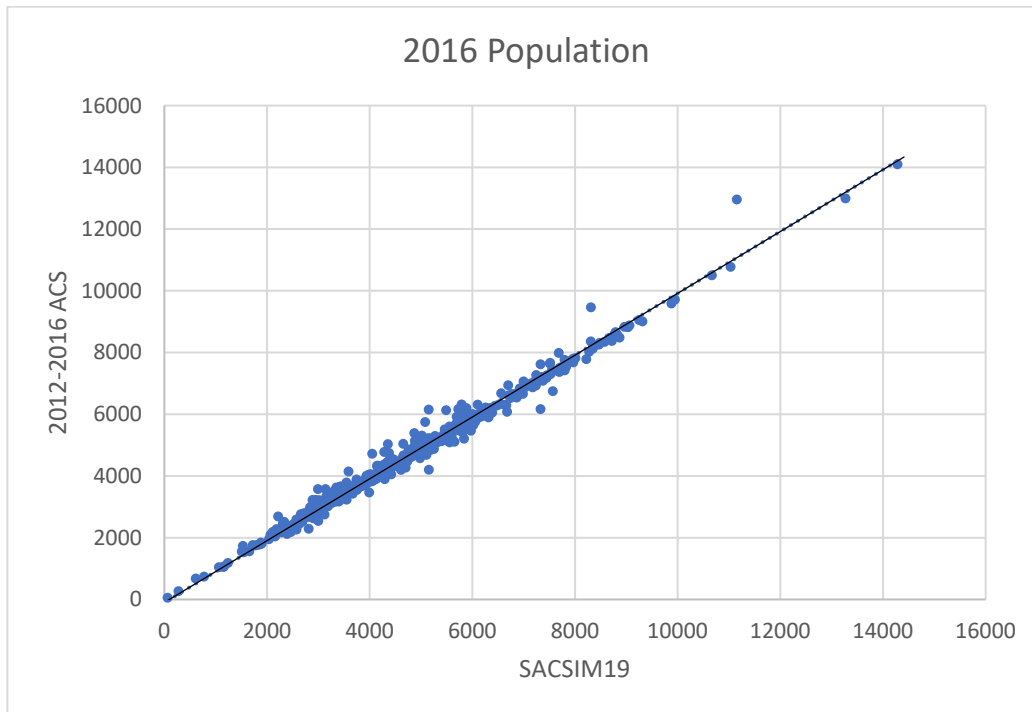
Source: SACOG 2020.

*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
<i>Route Mileage</i> [†]			
Freeway/Interstate*	319	326	1.02
Surface Street**	3,678	3,668	1.00
Subtotal	3,997	3,994	1.00
<i>Lane Mileage</i> [‡]			
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 analysis⁴².

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 models⁴³.

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.

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

County	2005		2008		2012		2016	
	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 performing well for freeways and major arterials roadway classifications. 2016 does not perform 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 perform slightly better. Further ramp counts and validation have been 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
<i>Daily Volumes</i>						
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
<i>Daily Volumes</i>						
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

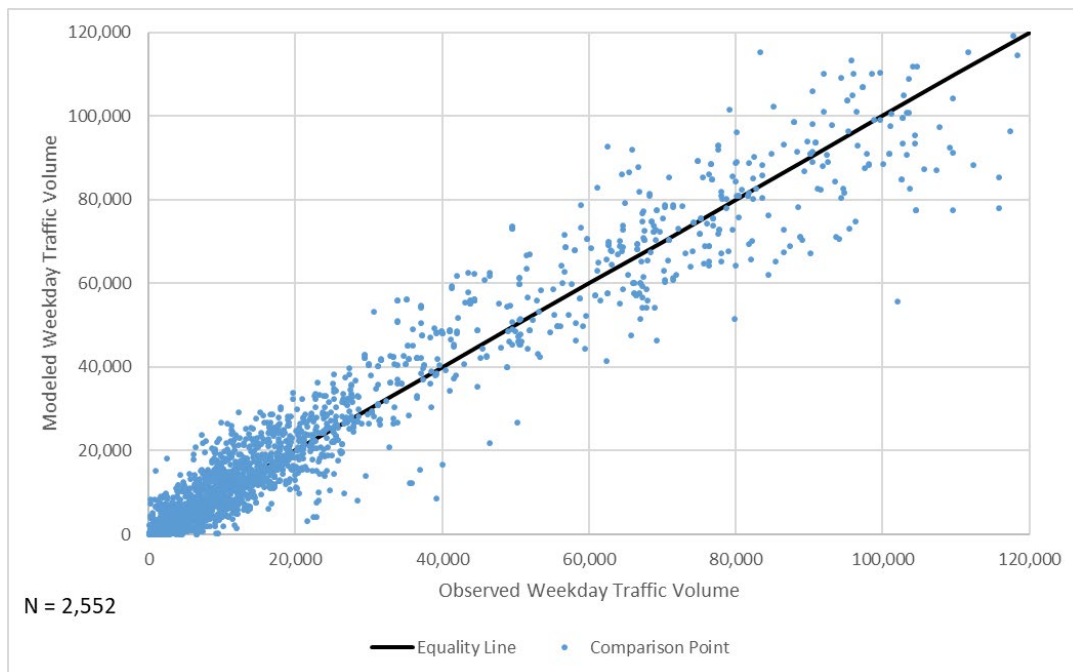
Source: SACOG 2020.

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, .

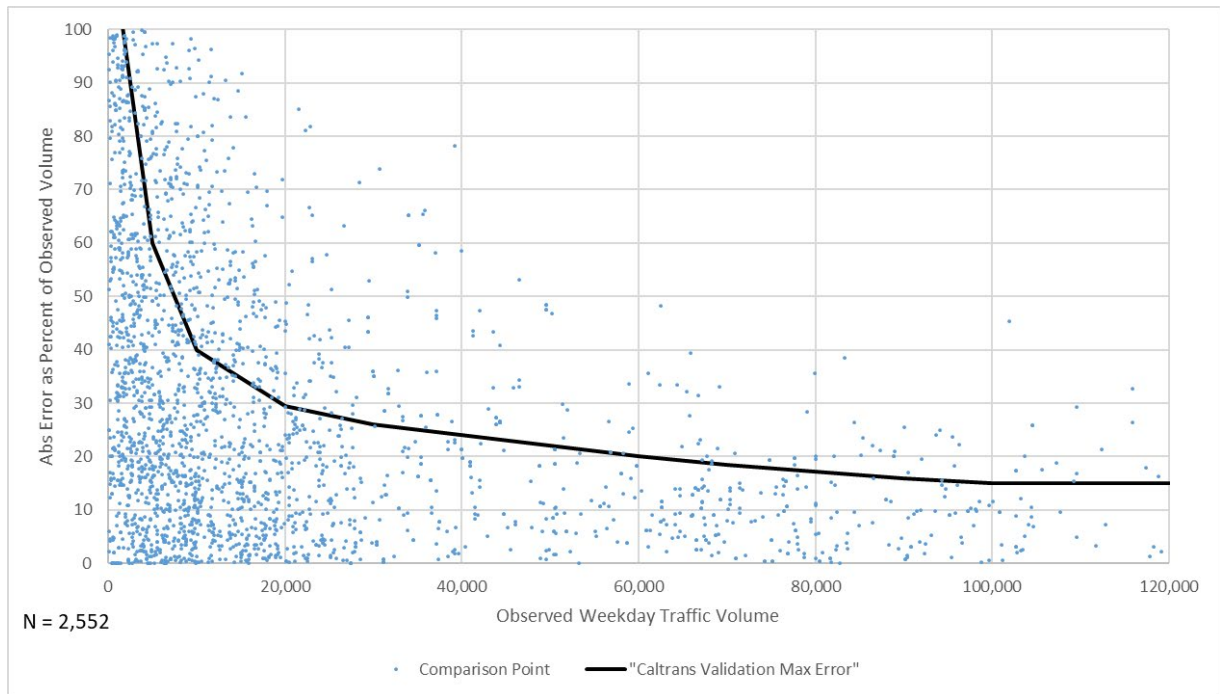
Figure 12-7 scatterplot points show, for each model link with observed count data, the absolute percent difference between the modeled and observed traffic on that link. The black line represents the maximum percentage difference recommended by Caltrans model validation guidelines (e.g. for weekday volumes 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

Functional Class	Year							
	2005		2008		2012		2016	
	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 validation⁴⁴. 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, it's 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, it's 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
<i>Annual Average Growth Rates</i>	'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

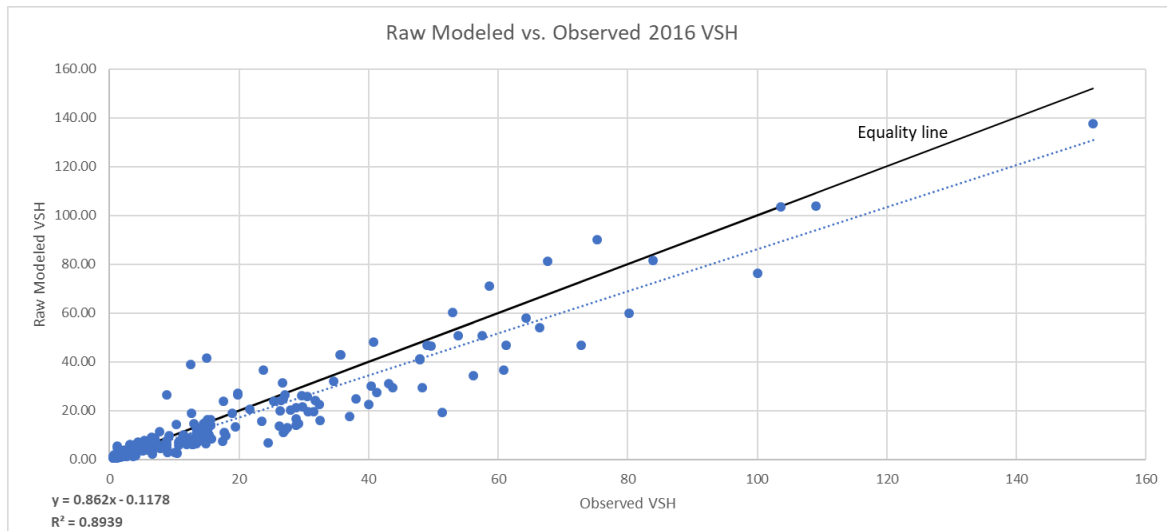
As with highway networks, direct, independent checks of modeled transit networks against actual transit networks are difficult to perform. But as a generic check we compared vehicle service hours estimated in the model against observed vehicle service hours provided by transit operators.

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

Variable	Regression Statistics	
	$(\beta * \text{Model VSH} = \text{Actual VSH})$	
	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

Service Type	Weekday Vehicle Service Hours		
	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 boardings⁴⁵.

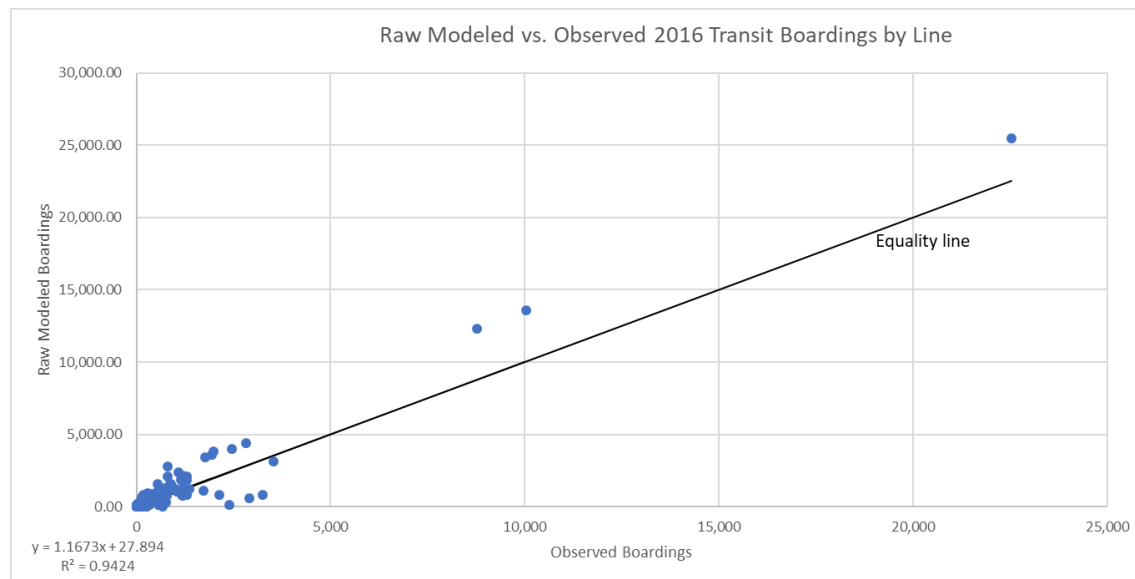
Table 12-29 Weekday Transit Passenger Boardings by Service Type: Comparison of Model to Counts

Service Type	Weekday Boardings			Boardings per Trip	
	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 Commission, 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.