3.3 External Travel

DAYSIM simulates the activities of households located within the Sacramento region, for their travel ***within the region***. The activities simulated must also be located within the region, since the simulation uses employment and travel data available only within the region. The submodels and processes described here predict the trips entering and exiting the region, which must be included for complete traffic prediction. DAYSIM also uses the predicted external trips to adjust its own predictions to account for external travel, including regional residents who may work or do other activities outside the region, as well as the effect of outside residents who take jobs within the region. These submodels and processes are based on customary aggregate trip generation and distribution models, producing person- and vehicle-trip matrices, at a traffic analysis zone (TAZ) level, not parcel.

Some definitions of common terms from traditional aggregate modeling applicable to these external models include:

- *Gateways*--TAZ's representing the areas outside of the SACOG region, connected to highways exiting or entering the region are called "gateways". Typically, each exiting highway is represented as a gateway TAZ, but some groups of highways that converge to practically the same external place share a single TAZ. Table 3-5 lists the SACSIM gateways. Important to note, SACSIM gateways representing roadways outside the region.
- *Gateway Production*--Source of travel demand located outside the SACOG region, but with travel taking it into the region. A household located outside the region, but with household members traveling to the SACOG region to work, shop, etc., would generate some number of gateway productions, which would be located at the gateway zone through which they entered or exited the region.
- *Gateway Attraction*—A location outside the SACOG region, but visited by a SACOG resident for work, shop, etc. would generate some number of gateway attractions, which would be located at the gateway through which the resident exited and re-entered the region.
- *Internal-Internal (I-I)Trips*--Describes trips which have both origin and destination within the region. All household based I-I trips are modeled by DAYSIM (for most normal household activities), and the internal passenger portion of the airport passenger ground access submodel. The commercial vehicle submodel includes the I-I truck trips.
- *Internal-External (I-X) Trips*--Describes a trip which is produced within the region, and attracted to a location outside the region, regardless of the actual direction of travel. A tour (round trip) of an area resident to San Francisco and back is considered two I-X trips. Full understanding of this concept of directionality of trip requires understanding of the difference between a "production" end of a trip, and the "attraction" end of the trip:
    - For all home-based trips, the production end of the trip is the home end. E.g., for a commute trip, the worker's home is the production end.
    - For all home-based trips, the attraction end of the trip is the non-home end. E.g., for a commute trip, the worker's place of work is the attraction end.
    - For non-home-based trips, the difference between production and attraction is somewhat arbitrary, and is assigned by convention. E.g., for work-based trips, the work end of the trip is designated the production, and the other end is the attraction.

- *External-Internal (X-I) Trips--D*escribes a trip produced outside the SACOG region, and attracted within the region, regardless of the actual direction of travel.
- *Through (X-X)Trips*--A trip entering the region through one gateway, passing through the region without stopping, and exiting through another gateway is an X-X trip.
- *Trip Purposes***--**External trips are processed in five trip purposes, corresponding to the activities judged most productive of external travel: Work (or worker-flow), personal business, shopping, social-recreational, and airport passenger ground access. Other trip purposes used in DAYSIM (school, escort, and meal activities) are omitted.

All external travel is exogenous (i.e. determined outside the context of the model, and manually set by SACOG as a fixed scenario variable for both the base year and the forecast years) to some degree. I-X and X-I travel is "semi-exogenous", in that the external gateway levels of activity are exogenously set, but the internal levels and locations of activity are modeled to some degree along with other internal activities. X-X travel is exogenous, outside of vehicle trip assignment, where the impact of through trips on capacity affect the level-of-service for internally modeled trips, and I-X and X-I trips.

Table 3-5 SACSIM Gateways

TAZ[1] No.	Gateway Roadway	Segment	Gateway Representation
1	SR-99 N	Sutter-Butte CL	Chico/Butte Co., via SR 99
2	SR-70 N	Yuba-Butte CL	Chico/Butte Co., via SR 70
3	E20/Marysville Rd NE	W. of SR 49/Yuba-Nevada CL	Nevada Co., via Marysville Rd.
4	SR-20 NE	Yuba-Nevada CL	Nevada Co., via SR 20 (from Yuba Co.)
5	SR-49 NE	Placer-Nevada CL	Nevada Co., via SR 49 (from Placer Co.)
6	I-80 NE	E. of Yuba Gap	North Lake Tahoe Basin to east of region, via I-80
7	SR 174 NE	Placer-Nevada CL	Nevada Co., via SR 174 (from Colfax)
8	SR 20 NE	Placer-Nevada CL	Nevada Co., via SR 20 (from Placer Co.)
9	Omo Ranch Road E	N. of SR-88	Amador Co., via Omo Ranch Rd (from S. Central El Dorado Co.)
10	US-50 E	Btwn. Ice House Rd & Echo Lake	South Lake Tahoe Basin, via US50
13	SR 16, 49 East	Sacramento-Amador CL	Amador Co., via SR 16 and 49
15	SR-99 S	Sacramento-San Joaquin CL	San Joaquin Co. and Central Valley, via SR 99
16	Lincoln Road S	Sacramento-San Joaquin CL	San Joaquin Co., via Lincoln Rd.
17	Franklin Road S	Sacramento-San Joaquin CL	San Joaquin Co., via Franklin Rd.
18	I-5 S	Sacramento-San Joaquin CL	San Joaquin Co. and Central Valley, via I-5
19	SR-160 S	S. of SR-12	E.Solano Co., N.Contra Costa Co., N.San Joaquin Co.
20	CR-95A	Yolo-Solano CL	N.Solano Co.
21	CR-104/Mace Blvd. SW	S. of CR-32D/Montgomery	N.Solano Co.
22	I-80 W./I-505 S.	W. of I-505	Solano Co. and Greater SF Bay Area
23	SR-128 W	Yolo-Solano CL	Solano and Napa Counties
24	Putah Creek Rd. W	W. of Winters Rd. Bridge	N.Solano Co.
25	SR-12 SE	E. of SR-160	NW.San Joaquin Co.
26	SR-12 SW	W. of SR-160	E.Solano Co.
27	SR 16	Yolo-Colusa CL	Colusa and Lake Co.
28	I-5 N	Yolo-Colusa CL	Colusa Co. and N.Sacramento Valley, Redding etc. via I-5
29	SR 45	Sutter-Colusa CL	Colusa Co.
30	SR-20 NW	Sutter-Colusa CL	Colusa Co. and N.Sacramento Valley, Redding etc., via SR 20

1. TAZs 11,12,14 are currently left blank and not used.

Source: SACOG 2020.

Trip Generation for I-X and X-I Travel

Trip generation of the gateway TAZs is an exogenous input consisting of person trips for gateway productions (i.e. trips produced outside the region, but traveling to attractions within the region) and for gateway attractions (i.e. trips produced within the region, but attracted to locations outside the region, as represented by the gateway zones). External trip purposes are:

- Work
- Personal Business
- Shopping
- Social-Recreational
- Commercial Vehicle (2 Axle)
- Commercial Vehicle (3+ Axle)
- Airport Passenger

Table 3-6 and Table 3-7 provide the exogenously set worker flow, home-based non-work and commercial vehicle trip ends. The worker flows, home-based non-work and commercial vehicle trips were based off previous version of SACSIM. The file was originated by using Census Journey-to-Work statistics (to set worker flows at each gateway), Caltrans truck volume counts (to set commercial vehicle volumes), with the other trip purposes set as "residuals" which made up the difference between the observed vehicle volumes at each gateway and that portion of the vehicle volume accounted for by worker flows and commercial vehicles. Home-based school trips, escort and meal trips are such a small part of gateway travel that they are omitted in SACSIM.

Table 3-6 SACSIM19 Year 2016 External Gateway Demand (Part 1 of 2)

Gate-way No.	Gateway Desc.	Worker Flows		Pers.Bus. Trip Ends		Shop Trip Ends		Soc./Rec. Trip Ends	
		X-I (P's)	I-X (A's)	X-I (P's)	I-X (A's)	X-I (P's)	I-X (A's)	X-I (P's)	I-X (A's)
1	SR-99 N	1,792	2,422	2,005	1,337	2,415	1,610	2,415	1,610
2	SR-70 N	1,467	1981	1,632	1,632	1,010	1515	2,070	1,380
3	E20/Marysville Rd NE	0	0	125	125	125	125	125	125
4	SR-20 NE	0	0	1027	1,027	303	708	1,172	502
5	SR-49 NE	4,345	5,992	3,116	3,116	3,116	3,116	3,116	3,116
6	I-80 NE	1380	1,902	1,862	1,862	3,944	1,690	1,602	3,738
7	SR 174 NE	483	666	615	615	615	615	615	615
8	SR 20 NE	0	0	431	431	374	374	492	738
9	Omo Ranch Road E	0	0	255	255	255	255	255	255
10	US-50 E	690	951	1128	1,128	588	1,371	967	2,256
13	SR 16, 49 East	622	1,380	1,262	1,262	1,619	1,619	1,574	1,574
15	SR-99 S	7,200	6,986	5,242	5,242	6,889	10,334	6,028	11,195
16	Lincoln Road S	720	699	677	677	677	677	677	677
17	Franklin Road S	0	0	167	167	167	167	167	167
18	I-5 S	5,039	4,890	5,289	3,526	9,437	4,044	3,526	5,289
19	SR-160 S	1,440	1,397	985	985	985	985	985	985
20	CR-95A	0	0	76	76	58	134	78	78
21	CR-104/Mace Bl. SW	0	0	246	246	246	246	246	246
22	I-80 W	37,649	22,837	12,783	12,783	18,609	18,609	17,152	17,152
23	SR-128 W	0	0	268	268	430	107	368	859
24	Putah Creek Rd. W	0	0	28	28	28	28	43	43
25	SR-12 SE	0	0	313	580	395	734	461	461
26	SR-12 SW	768	466	1271	1271	1230	1230	1554	1554
27	SR 16	0	0	83	45	110	74	78	116
28	I-5 N	1,219	1,352	2,595	1,730	3,285	1408	1,612	1,612
29	SR 45	0	0	119	119	129	129	89	89
30	SR-20 NW	25	28	976	976	1,059	1059	728	728

Source: SACOG 2020.

Table 3-7 SACSIM19 Year 2016 External Gateway (Part 2 of 2)

RAD	Gateway No. / TAZ	Gateway Desc.	Commercial Vehicle Trip Ends	
			2 Axle	3+ Axle
97	1	SR-99 N	194	472
97	2	SR-70 N	214	382
97	3	E20/Marysville Rd NE	50	25
97	4	SR-20 NE	1260	1030
97	5	SR-49 NE	1370	835
97	6	I-80 NE	2,022	2,286
97	7	SR 174 NE	64	182
97	8	SR 20 NE	160	180
97	9	Omo Ranch Road E	168	284
97	10	US-50 E	420	310
97	13	SR 16, 49 East	438	444
97	15	SR-99 S	684	4667
97	16	Lincoln Road S	0	0
97	17	Franklin Road S	0	0
97	18	I-5 S	460	5,005
97	19	SR-160 S	252	476
97	20	CR-95A	0	0
97	21	CR-104/Mace Blvd. SW	0	0
97	22	I-80 W	3,826	2,538
97	23	SR-128 W	100	50
97	24	Putah Creek Rd. W	0	0
97	25	SR-12 SE	356	528
97	26	SR-12 SW	456	478
97	27	SR 16	24	62
97	28	I-5 N	2,688	3,419
97	29	SR 45	26	113
97	30	SR-20 NW	622	311

Source: SACOG 2020.

3.3.1 Internal Trip Generation for External Work Travel Model

The internal productions are employed residents who work outside the region. These are computed from the household marginals database, counting 1 employed resident per 1-worker household, 2 per 2-worker household, and 3.5 per household with 3 or more workers. The internal attractions are jobs held by workers residing outside the region, aggregated into zones (TAZs) from the parcel database. Both internal productions and attractions are scaled in total to balance to the external productions and attractions in the gateway file described above and shown in Table 3-8 and Table 3-9.

3.3.2 Internal Trip Generation for External Non-Work Travel Model

As discussed below, the non-work external trip distribution model only distributes I-X and X-I trips; only the gateways have "trip generation" in the customary sense. But the probability that a gateway trip is distributed to a particular internal zone is based on both its proximity to the gateway, and to a composite measure of the zone's "size". This composite measure of size is the exponentiated "size variables" coefficients, times the size function scale. Since the composite size function is not used as a number of trips or other constraint, its scale is arbitrary. The actual number of external trips distributed to any given zone is not known until external distribution, since that would depend on proximity to gateways.

3.3.3 Internal Trip Generation for Commercial and Airport Passenger Trips

Commercial vehicle trip generation (and distribution) is fundamentally different than home-based travel in SACSIM, since the submodel is entirely independent of DAYSIM. Exogenous gateway trips are appended to the internally generated trip ends, as described in the previous chapter. Airport passenger trips from the external gateways do not require internal attractions, since the airport is the sole generator of the trips.

Table 3-8 Relative Attraction Rates for External Trip Distribution

Size Variable	Measure	Personal Business	Shopping	Social-Recreational
Educational	employment	0.260	0	0.213
Restaurant	employment	0.107	0.136	0.351
Government	employment	0.286	0	0.112
Office	employment	0.324	0.022	0.146
Other	employment	0	0	0.095
Retail	employment	0.244	1.000	0.142
Service	employment	0.538	0.088	1.000
Medical	employment	1.000	0	0.467
Industrial	employment	0.063	0	0
Households	households	0.035	0	0.092
University	enrollment	0	0	0.266
K-12 School	enrollment	0.113	0	0.173

Source: Bowman and Bradley, SACSIM Technical Memo 8, Usual Location and Tour Destination Models, 2005

3.3.4 Trip Distribution for I-X and X-I Travel

SACSIM calculates a doubly-constrained zone-to-zone gravity model of worker flows, including I-I, I-X, and X-I trips (but not through trips). The I-I trips are then disregarded, and the I-X and X-I trips retained. Additionally, the I-X and X-I worker flows deduct from the parcel files (for internal attractions—jobs) and from the representative population file (for internal productions—workers).

Since DAYSIM's non-work destination choice models do not constrain the numbers of trips attracted to activities, a singly-constrained distribution model is applicable for external trips. For I-X trips, the gateway attractions are constrained, since they are derived from gateway traffic counts or forecasts and any available interregional travel surveys. There is no constraint on the amount or percentage of trips produced by internal zones to go to external attractions. For X-I trips, the gateway productions are constrained, and there is no constraint on the internal zones' trips that go external. For each trip purpose, I-X and X-I trips are distributed separately. Attraction rates for this process are shown in Table 3-8.

3.3.5 Friction Factors and Deterrence for Work Trips

The deterrence function for worker flows was estimated by iteratively fitting trip length frequency of observed home-based work trips in the 2000 household survey. After applying the gravity model with a previous estimate of the deterrence function, a new one is first numerically estimated by multiplying values at each trip length increment by the ratio of observed to modeled trip frequency. Then the parameters of a rational function (quotient of two polynomials) are estimated to best fit the numerical function to a log-likelihood objective (analogous to that used to fit logit choice models). After iterating this fitting procedure until reasonable convergence, this function is obtained:

$$f(t) = \exp\left(\frac{-0.00421t^3 - 0.106t^2 + 0.201t}{1 + 0.0425t^2}\right)$$

This function is applied as a lookup table in file "sacfftpp.txt," rather than coded algebraically.

3.3.6 Friction Factors and Deterrence for Non-Work Purposes

The deterrence function for non-work trips is a composite from parameters in the tour-destination and mode choice models, as listed below in Table 3-9 and Table 3-10.

The deterrence function is the exponential of a parameter times the travel time, in the manner of a logit choice model. The composite parameters are calculated from the above parameters (and an assumption of 50 mph speed). The deterrence function is shown in Table 3-10.

Table 3-9 DAYSIM Factors Utilized for External Trip Deterrence

Parameter	Personal Business	Shop	Social-Recreation
Non-Work Non-School Tour Destination			
Mode Choice Logsum	1	1	1
1-way drive distance, 10+ miles (10s of mi)	-0.7635	-0.8238	-0.4468
Aggregate mode-dest. LogSum at dest.	0.0206	0.1892	n/a
Home-Based Other Tour Mode Choice			
In-vehicle time (min)	-0.025	-0.025	-0.025
Mode nesting parameter	0.73	0.73	0.73
Simplified Mode Choice for Calculating Aggregate Logsums			
In-vehicle time (min)	-0.02	-0.025	n/a

Source: SACOG 2020.
Based on Bowman, John L. and Bradley, Mark A. "Technical Memorandum Number 8: Usual Location and Tour Destination Models", October 28, 2005, and on draft documentation provided by DKS Associates.

Table 3-10 Computation of External Deterrence Factors

Personal Business: -0.0823 = -0.025*0.73 + -0.7635/10mi * 50mi/60min + -0.020*0.0206
Shop -0.0916 = -0.025*0.73 + -0.8238/10mi * 50mi/60min + -0.025*0.1892
Social-Recreational -0.0555 = -0.025*0.73 + -0.4468/10mi * 50mi/60min
Source: SACOG 2020. Based on draft documentation provided by DKS Associates.

3.3.7 Trip Distribution for I-X and X-I Commercial Vehicle and Airport Trips

Commercial vehicle trips are generated and distributed independent of DAYSIM. Trip distribution for all trips is treated through a gravity model as described in the previous chapter. Airport trip distribution is trivial, because of all external airport passenger trips that are to or from the airport.

3.3.8 Mode Split and Time-of-Travel for I-X and X-I Travel

External trips are allocated to vehicle trip modes using flat person-to-vehicle trip factors. The factors are shown in Table 3-11.

Time-of-travel for I-X and X-I trips were also allocated to the nice time periods using fixed factors. Table 3-12 shows the factors used.

Table 3-11 Mode Split Factors for I-X and X-I Travel

Purpose	Mode			
Household-Generated Travel[1]				
	Drive Alone	2 Person Carpool	3+ Person Carpool	Total
Work	89.0%	8.5%	2.5%	100.0%
Personal Business	54.0%	29.0%	17.0%	100.0%
Shop	45.0%	40.0%	15.0%	100.0%
Social Recreational	29.0%	31.0%	40.0%	100.0%
Airport Passenger Ground Access[2]				
	Drive/Park	Drop Off	Van/Shuttle	Total
Airport	50.3%	43.9%	5.8%	100.0%

Source: SACOG 2020.

[1] Based on 2000 SACOG Household Survey data, adapted to SACSIM11 external trip purposed by DKS Associates.

[2] Based on 2002 airport passenger survey, adapted to external passengers by SACOG.

Table 3-12 Time-of-Travel for I-X and X-I Travel

	Purpose									
	Production > Attraction					Attraction > Production				
Demand Time Period	Pers. Bus.	Shopping	Soc./ Rec.	Work	Airport	Pers. Bus.	Shopping	Soc./ Rec.	Work	Airport
AM 7-8	4.2%	2.0%	2.8%	13.8%	3.0%	0.2%	0.1%	0.2%	0.2%	0.3%
AM 8-9	6.6%	2.0%	3.3%	7.8%	2.7%	0.1%	0.3%	0.1%	0.3%	2.0%
AM 9-10	7.8%	4.0%	2.5%	2.9%	4.7%	0.7%	0.3%	0.6%	0.3%	3.0%
MD 10-15	24.6%	19.5%	14.0%	3.7%	15.6%	12.9%	12.4%	6.1%	2.8%	16.1%
PM 15-16	2.3%	3.7%	2.9%	0.4%	2.7%	3.5%	7.9%	2.2%	3.3%	2.7%
PM 16-17	2.3%	3.6%	3.0%	0.5%	3.0%	5.0%	7.2%	3.7%	5.9%	2.7%
PM 17-18	2.7%	3.6%	5.4%	0.5%	2.4%	5.5%	8.2%	4.2%	12.9%	3.4%
EV 18-20	2.0%	2.0%	10.3%	0.4%	5.1%	7.8%	12.5%	7.8%	19.4%	6.0%
NI 20-6	3.9%	2.6%	5.4%	18.3%	10.9%	7.9%	8.0%	25.6%	6.5%	14.0%

Source: SACOG 2020.

3.3.9 Through Trips for X-X Travel

Through trips are a completely exogenous model input, which are read in directly from a prepared through trips file. A portion of gateway trips are assigned to though travel, meaning vehicles that start from and end outside of the SACOG region (XX). Caltrans 2016 3+ Axle and 2+ Axle truck volumes, total vehicle traffic counts at each gateway, and CTPP county to county worker flows are all used to estimate both the passenger vehicle and commercial vehicle through travel model input file.