

3.5 Vehicle Trip Table

3.5.1 Vehicle Trip Table Preparation and Assignment

This chapter documents the process of taking the various estimates of person trips and vehicle in different formats, creating origin-to-destination vehicle or passenger trip tables, and assigning those tables to highway or transit networks. The generic estimates of trips are:

- DAYSIM person trip segments, which includes person trip segments in origin-to-destination format, with one record per person trip, with mode and time of travel information on each trip record.
- Commercial vehicle trips which are daily, total flow of vehicle trips, split into number-of-axle classifications (2 axle and 3+ axle vehicles). The trips are in origin-to-destination form, with assumed symmetry of flows to and from origins and destinations.
- Airport passenger person trips, which are predicted as “half-round-trips” in production-to-attraction format, with the airport end being the attraction. The half-round-trip, P-to-A matrix is converted to a daily, both direction flow by transposing the P-to-A half-round trips, with symmetry of round trips assumed.
- IX and XI daily person trips, in production-to-attraction format.
- XX vehicle trips, in daily, both-direction, origin-destination format, with three tables: private autos and commercial vehicles (2 axle and 3+ axle combined).

Trip assignment to highway networks is made for nine demand periods using a conventional, TAZ-to-TAZ, origin-destination, static equilibrium assignment using Citilabs® TP+/HWYLOAD software.:

- 7-8 AM,
- 8-9 AM,
- 9-10 AM,
- Midday 10 AM-3 PM,
- 3-4 PM,
- 4-5PM,
- 5-6PM,
- Evening 6-8PM,
- Night Time 8PM-7AM

Transit passenger trips are assigned using Citilabs® Public Transport software, with trips in origin-to-destination format. Five demand periods are assigned:

- Period 1, spanning from 5:00am until 9:00am
- Period 2, from 9:00am until 3:00pm
- Period 3, from 3:00pm until 6:00pm
- Period 4, from 6:00pm until 8:00pm
- Period 5, from 8:00pm until 11:00pm

3.5.2 Trip Table Preparation

This process combines trips from DAYSIM, and the models of external, airport, and commercial vehicle trips into time periods for assignment to highway and transit networks. SACSIM19 is broken into nine time periods, for simplicity, performance, and establish unit-hour period durations for the entire day. Previous version of SACSIM broke out the two peak periods each cover three-hour periods. SACSIM19 separates these out into individual hours for a total of six separate trip tables during the peak periods. The midday period is five hours, Evening is two hours, and Night time (late evening/early morning) period is eleven hours.

Table 3-17 SACSIM Demand Period Definition

Time Period	Begin	End	Hours
7am	7:00	7:59	1
8am	8:00	8:59	1
9am	9:00	9:59	1
Mid-Day	10:00	14:59	5
3pm	15:00	15:59	1
4pm	16:00	16:59	1
5pm	17:00	17:59	1
Evening	18:00	19:59	2
Late Evening / Early Morning	20:00	6:59	3

3.5.2.1 DAYSIM Person Trip Segments

For highway assignable trip tables, DAYSIM auto person-trips are aggregated into TAZ-to-TAZ flows, stratified by mode, 3 person values-of-time (VOT) bins, and time period. This file is generated in O-to-D format, with arrival and departure time on each trip record, so none of the ordinary directionality conversion from P-to-A, or from daily to the demand period, is required.

Auto person-trips are already stratified by occupancy (drive alone, 2 person shared ride, and 3+ person shared ride) and VOT bins (high, medium, low), and each record is converted to a vehicle trip equivalent using the inverse of the average occupancy (i.e. 1.0 for drive alone, 0.5 for 2 person shared ride, and 0.3 for 3+ person shared ride). The values of time bins were updated to reflect latest traveler preference survey in the SACOG region conducted by RSG consultants. More information on actual threshold price points, distribution curves, and data collection can be found in *Appendix B, RSG Travel Demand Model Toll Enhancement Technical Memorandum, September 2018*.

In the DAYSIM trip output file, transit person-trips are distinguished by walk-access and drive-access, and the drive-access trips are distinguished by direction (drive-transit-walk versus walk-transit-drive). The transit drive-access trips from DAYSIM are generated in O-to-D format, without explicit reference to the location of the transition the between transit and auto. The Origin-to-Destination

(O-D) person trips were split and converted to Production-to-Attraction (P-A) format, then split into the two transit service periods.

A simple park-and-ride (also including kiss-and-ride) lot choice model in SACSIM19 splits these trips into separate auto and transit segments. The auto portion of the trip (e.g. from home to the park-and-ride lot, or from the park-and-ride lot home) is included with other vehicle trips in the highway assignment; the transit and walk from the last transit stop to the final destination (e.g. at the work end of a work tour), or the walk from the primary tour destination to the first transit stop on the return half-tour, is assigned as a passenger trip in the transit assignment. This process for transit drive-access trips will be discussed in greater detail below.

3.5.2.2 External Trips

The external models create partial matrices of daily person-trips between the gateways and the internal zones in P-to-A format. These are converted to vehicle trips split by occupancy and time of day to be included in the vehicle trip assignments. The auto mode split, directionality, and time-of-travel factors were presented earlier. No external transit, walk, or bike trips are predicted.

Conversion of auto person-trips to vehicle trips is made using the same vehicle trip equivalent factors discussed above.

3.5.2.3 Commercial Vehicle Trips

Commercial vehicle, and exogenous through-trip matrices are also split by time of day for the vehicle trip assignments using the time-of-travel factors presented in Section 3.2. Commercial vehicle and through trips do not have any orientation of production and attraction defined, so they are split equally in both directions and split by time of day using the non-directional factors in presented in Section 3.2.

3.5.2.4 Airport Ground-Access Trips

Airport passenger trips are converted to vehicle trips, including the extra “return” trip required for pick-ups and drop-offs, within the airport mode choice computation module, because the traveling party-size is available then as a survey variable. Assumptions used in this process include the following rules:

- *Auto Drop*--One vehicle trip for pick-up or drop-off, plus the vehicle trip of the air traveler. If the air travel party size is 1 or 2, then it is assumed that 80% of such travelers are picked up or dropped off by one person, and 20% are by two persons. For larger air travel party sizes, this changes to 90% by one person, 10% by two. These assumptions are judgments, for lack of survey data. The pick-up or drop-off vehicle trip is stratified by occupancy (number of meeting persons), and the air-travelers’ vehicle trip is stratified by its occupancy (number of meeting persons plus air travel party size).
- *Auto Park*--One vehicle trip per traveler, stratified by party size.

- *Taxi*--One and a half vehicle trips per traveler, one with the traveler, plus a judgmental assumption that half of such trips involve a “deadhead” taxi trip without a passenger. The “deadhead” trip is assumed single-occupant (the driver alone), and the regular trip’s occupancy is the party size plus the driver.
- *Van*--One tenth of a vehicle trip per traveler.
- *Transit Drive and Transit Drop*--The same auto trip making and occupancy assumptions apply as with Auto Park and Auto Drop, including pick-up and drop-off trips. These trips are saved stratified into three matrices of daily auto trips as if to the airport, to be later “relocated” to a park-and-ride lot, and split by time and directionality. The transit part of each trip is also relocated to travel from the park-and-ride lot to the airport.

Time-of-travel factors presented in Section 3.5 were used to split the vehicle trips into the four demand periods for highway assignment. Transit passenger trips were converted to P-to-A format and split into the two transit demand periods (peak and off-peak) for assignment with the other transit passenger trips. Transit-drive access airport passenger trips are split into the drive portion (e.g. from home to park-and-ride, or from park-and-ride to home), and the transit portion in the same manner as non-airport transit-drive access trips, which will be discussed in greater detail below.

3.5.3 Vehicle Trip Assignment

Vehicle trip assignment in this model system uses a standard deterministic user equilibrium algorithm which iterates the Dijkstra tree-building “shortest paths” algorithm and a form of Frank-Wolfe or “conditional gradient” direction step size choice to blend the iteration volumes progressively closer to equilibrium. Ideal equilibrium achieves Wardrop’s criterion, that no traveler can reduce travel time by shifting to another route. Each vehicle trip assignment solves the conditional equilibrium *for the given trips* during any iteration of the SACSIM19 system-equilibrium solution.

This application is a simultaneous multi-class assignment like past versions of SACSIM. However, SACSIM19 differs from past versions by expanding assignment routing classifications by path impedances by vehicle type/occupancy and VOT to determine preferences of path choice by class. A total of 15 combinations of VOT, vehicle type, and vehicle occupancy are grouped into the following 12 classes:

- Class 1: “LOW” VOT Single Occupancy Vehicle (SOV) & “LOW” VOT 2 Axle Commercial Vehicles (CV2)
- Class 2: “LOW” VOT 3+ Axle Commercial Vehicles (CV3+)
- Class 3: “LOW” VOT 2 Passenger Shared Occupancy Vehicle (S2)
- Class 4: “LOW” VOT 3+ Passenger Shared Occupancy Vehicle (S3+)
- Class 5: “MEDIUM” VOT Single Occupancy Vehicle (SOV) & “MEDIUM” VOT 2 Axle Commercial Vehicles (CV2)
- Class 6: “MEDIUM” VOT 3+ Axle Commercial Vehicles (CV3+)
- Class 7: “MEDIUM” VOT 2 Passenger Shared Occupancy Vehicle (S2)
- Class 8: “MEDIUM” VOT 3+ Passenger Shared Occupancy Vehicle (S3+)

- Class 9: “HIGH” VOT Single Occupancy Vehicle (SOV) & “HIGH” VOT 2 Axle Commercial Vehicles (CV2)
- Class 10: “HIGH” VOT 3+ Axle Commercial Vehicles (CV3+)
- Class 11: “HIGH” VOT 2 Passenger Shared Occupancy Vehicle (S2)
- Class 12: “HIGH” VOT 3+ Passenger Shared Occupancy Vehicle (S3+)

Previous SACSIM iterations also included a percentage of “Violators” and exempt SOV vehicles to use HOV lanes and a percentage of HOV prefer general purpose lanes. Since implementing the VOT bins already increases the class, thus significant assignment runtime, and is required for implanting roadway and mileage-based pricing functionality; violator HOV choice classifications were removed from SACSIM19 vehicle path choice.

Controls for the equilibrium assignment are set to and increasing number of maximum assignment iterations, and a decreasing relative gap. The “maximum assignment iterations” are a limit placed on the vehicle/highway assignment process for each time period assignment. “Relative gap” is a measure of the degree of closure or the decreasing difference in target measures for additional assignment iterations. In combination, maximum assignment iterations and relative gap function as an “either/or” criteria for ending a given time period assignment. The assignment ends if either the relative gap closure criteria is met (i.e. if the difference between the current assignment iteration and the last iteration is less than the relative gap criteria), or if the number of iterations reaches the maximum. “System iterations” are iterations of the entire model system, also known as “feedback loops”—system iteration and convergence is discussed in the following chapter. The settings for the equilibrium assignment criteria are shown in Table 3-18

Table 3-18 Equilibrium Assignment Closure Criteria

System Iteration	Maximum Assignment Iterations	Relative Gap
1	300	0.0006
2	300	0.0003
3	300	0.0002

Source: SACOG 2020.

3.5.3.1 Congestion Delay Functions

3.5.3.1.1 Conical Delay

SACSIM19 uses computed speed-flow curves, which are based on the conical delay function. Conical delay function has the form:

$$f(x) = E - A(1-VC) + (A(1-VC)^2 + B^2)^{0.5}$$

Where:

- VC = V/C ratio on a link;
- A = a user-specified coefficient; and
- B = $(2A - 1)/(2A - 2)$
- E = 2 - B

The attributes of this function which make it desirable for applications in travel demand model assignments are:

- $f(x)$ is strictly increasing. This is necessary for convergence to a unique solution;
- $f(0) = 1$ and $f(1) = 2$. This ensures that free-flow travel times are uncongested, and congestion at capacity (i.e. V/C ratio = 1) doubles travel time for the link.
- The function does not require exponentiation, which results in computation time savings.

A modified form of the conical delay function was used for SACSIM:

$$T_C = T_0 * \min\{E - A(1-Lx) + (A^2(1-Lx)^2 + B^2)^{0.5}, \max(T_C)\}$$

The variables are the same as for the basic conical delay function, except:

- T_C = congested travel time
- T_0 = "free flow" travel time
- L = VC ratio factor, adjusted so that $T_C = +/- 1.5$ when $VC = 1.0$
- $\text{Max}(T_C) = M + N(VC)$

3.5.3.1.2 Passenger Car Equivalents Conversion

Commercial vehicles are converted into passenger equivalent vehicles by for the delay function to more accurately reflect vehicle size impacts on congestion and delay estimations. Vehicles are used for the to calculate volume to capacity ration by:

- Passenger vehicles = 1

- Smaller commercial vehicles = 1.5
- Larger or 3+ axle commercial vehicles = 2.0

For this reason, V_1 or V_1T are considered passenger equivalent total volume and not recommend to be used to report total vehicle volumes. The subtotals volume classes after the assignment has been completed should be used to report to total vehicle volumes totals.

3.5.3.1.3 SACSIM Delay Formula Variables

Table 3-19 reports the variable values utilized for SACSIM. The A and B values were calibrated to allow for “softening” of the basic form. As mentioned above, the function itself was created to return a congestion factor of 2 when VC ratios equal 1. In test assignments, this resulted in erratic assignments with high link error. The optimal results were achieved when congestion factors were about 1.5 when VC ratios equal 1. A “soft ceiling” maximum was included in the function, to reasonably constrain the time factors, while still providing some positive slope to the curve. Table 3-20 provides a comparison of the current speed-flow functions

Table 3-19 Congestion Factor Variables and Values

Class of Roadway	Variable					
	A	B	E	L	M	N
	User Specified Conical Delay Coeff.	User Specified Conical Delay Coeff.	User Specified Conical Delay Coeff.	VC factor	Maximum constant at 2.2 V/C	Maximum coeff.
Freeway	6	1.1	0.9	0.88	9.1	0.5
Highway	5	1.125	0.875	0.86	8.3	0.0002
Arterial	4	1.167	0.833	0.83	6.4	0.0002

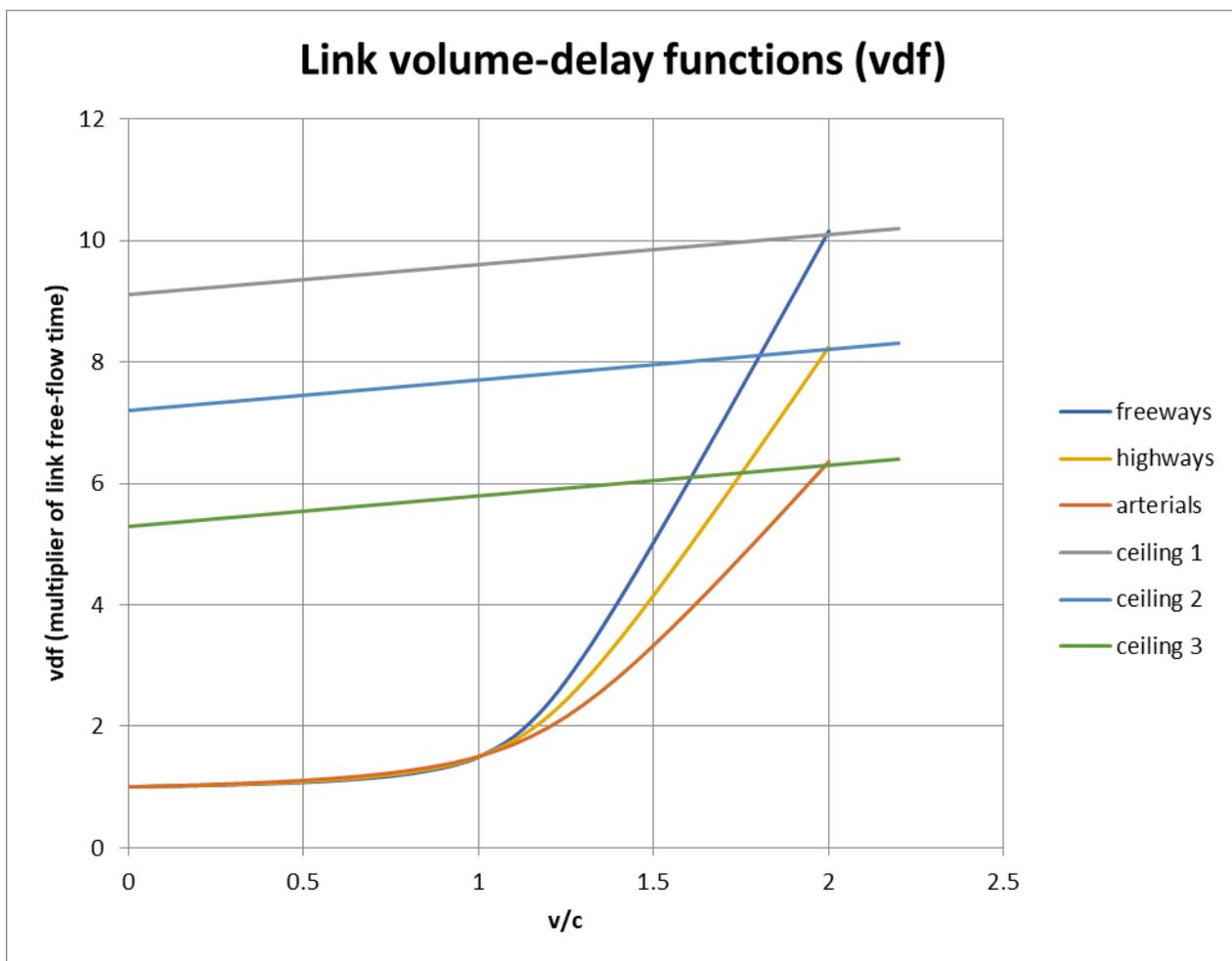
Source: SACOG 2020.

Table 3-20 Range of Congestion Factor Calculations

Class of Roadway	Congestion Factor at VC =...					Max. @ VC=...
	0.00	0.80	1.00	2.00	Max TF	
Freeway	1.00	1.21	1.49	10.15	11+	2.20
Highway	1.00	1.24	1.50	8.25	11+	2.20
Arterial	1.00	1.27	1.50	6.36	7+	2.20

Source: SACOG 2020.

Figure 3-9 SACSIM19 Link volume delay function



Source: SACOG 2020.

3.5.3.2 Traffic Flow Intensity Factors

The time periods of traffic assignment depend on vehicle trip tables factored by the directional time-of-day factors. Also needed is a factor, for each assignment period, relating the volume of traffic in that period, to the average flow rate in vehicles per hour. The "time-mean" definition of such an average is simply one divided by the number of hours. Instead of that, however, an average was preferred that represents the average intensity of traffic as experienced by the drivers, what may be termed a "vehicle-mean." Vehicle-mean traffic intensity rates were calculated using a summary, from the household travel survey, of vehicle-miles traveled grouped by 15-minute increments of the whole day. This formula estimated the "vehicle-mean" traffic intensity for AM and PM 3-hour periods and the off-peak period, summing for all 15-minute periods within the 3-hour periods:

$$\frac{\sum_1^n VMT^2}{(\sum_1^n VMT)^2}$$

Where n is the number of 15-minute periods within the multi-hour AM/PM peaks.

3.5.3.3 Metered On-Ramps

Migrating the traffic assignments to TP+ required a new way to operationalize HOV lanes and metered on-ramps. In the highway network, DELCURV identifies on-ramp links that restrict or "meter" flow entering a freeway at certain times of the day using special traffic signal systems at the on-ramp. Values of this code are:

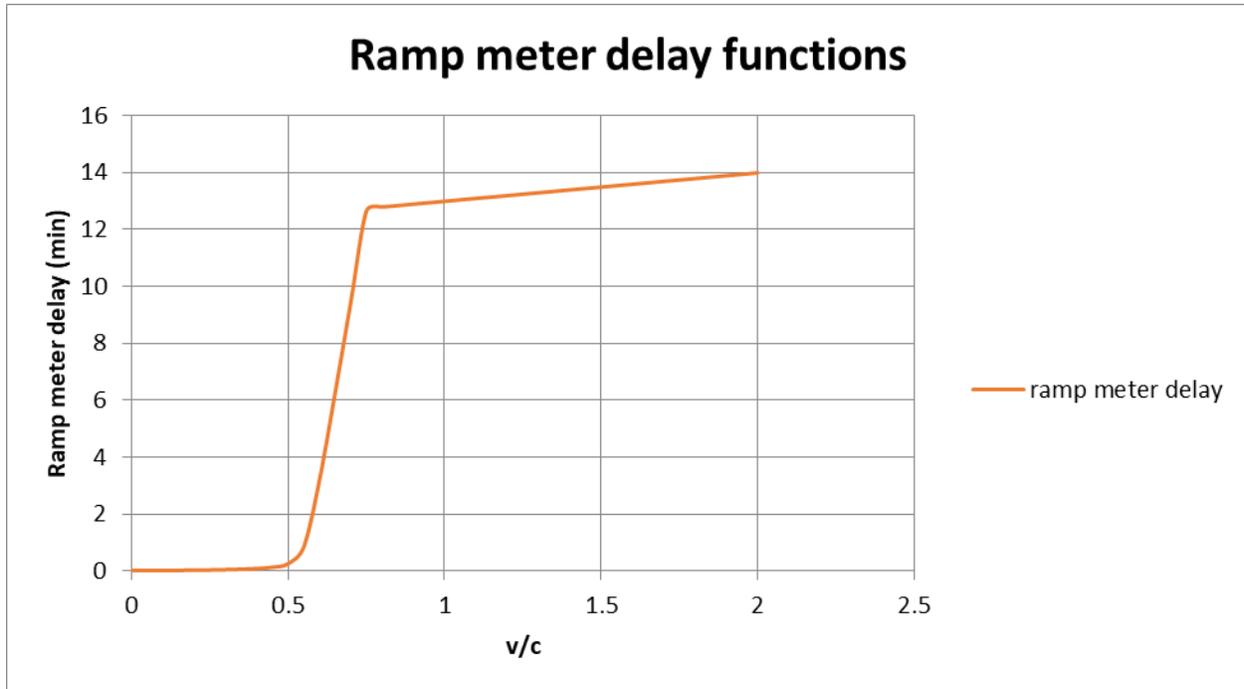
- 0 = not a metered on-ramp (most links in the network)
- 1 = metered in the AM peak period (3 hours)
- 2 = metered in the PM peak period (3 hours)
- 3 = metered in both AM and PM peak period (6 hours)
- 4 = metered in AM, Mid-Day, PM
- 5 = metered all 24 hours

The presence of ramp metering on freeway entrance ramps can significantly add to vehicular travel time for trips which utilize metered ramps, particularly when demand is near or exceeds ramp capacity. Therefore, a delay function was developed which estimates vehicular delay at metered ramps as a function of the volume-to-capacity (v/c) ratio.

The two key input factors are the distribution of demand over time and the vehicle discharge rate. For the assignment periods during the three hour peak AM and PM periods modeled, the relative distribution of demand was initially derived from the Caltrans/SACOG household travel surveys and travel time testing. The vehicle discharge rate was assumed to be 900 vehicles per lane per hour. By proportionally changing the three-hour demand, total delay over a three hour period was calculated as a function of three-hour v/c ratio. The delay curve was represented as a piecewise linear

equation. Overriding this derived curve was a “soft ceiling” delay of 15 minutes, and a constantly increasing delay with respect to v/c ratio. Figure 3-10 shows the meter delay curve.

Figure 3-10 Ramp Meter Delay



3.5.3.4 Bypass Lanes for HOVs at Metered On-Ramps

At some metered on-ramps in the Sacramento region, special lanes for high-occupancy vehicles have been designated. These lanes are not controlled or otherwise delayed by the ramp-meter signal. The model network representation of these lanes consists of longitudinally-connected pairs of links parallel to the metered on-ramp link. (Two links instead of one are required because the network software permits only one link in a direction between the same pair of nodes.) The effect is that HOVs (and any other eligible vehicles) are not delayed by the ramp meter delays. The following codes are required on HOV links that bypass metered on-ramps:

- DELCURV = 0 (0 for all links except metered on-ramps)
- USECLASS 2 or 3 (for ramp meter bypass links, specify minimum occupancy requirement to use bypass)

3.6 Transit Assignment

3.6.1 Transit Path Building and Assignment

Transit path-building and assignment is performed in five time periods:

- Morning peak (start of service to 10:00AM)
- Midday period (10:00AM to 3:00PM)
- Afternoon peak (3:00PM to 6:00PM)
- Early Evening (6:00PM to 8:00PM)
- Night period (8:00PM to end of service)

Additionally, transit path-building and assignment is done in an origin-to-destination, direction format. SACSIM19 accomplishes this O-D assignment format by splitting the drive portion of drive access trips from the transit assignment, and assigning all trips as “walk-transit-walk”. The drive portion of path-building and assignment, between home and the park-and-ride lot, is accomplished through HWYLOAD and matrix processing, outside of PT.

3.6.2 Transit Background Network

The SACSIM19 PT implementation builds routes using transit lines and walk access links connecting them to each other and zone centroids. A background network is created on which transit lines run, and walk access is found. The background network is created from:

- Loaded highway networks corresponding to the five transit service periods, including centroid connectors, minus any dummy placeholder links used in different scenarios. This is the source of walking distance and traffic speeds.
- Reverse directions of one-way links in the highway network, for (1) walk access, and (2) enable two-way transit lines to use one-way streets without run failure.
- Exclusive transit links, given in a file manually prepared transit links file (“transit_links.csv”), for light rail and other transit-only links.
- Walk access links connecting the highway network to light rail stops (and other services on exclusive ROW), given in in a manually-prepared station links file (“station_links.csv”).
- A manually prepared park-and-ride file (“_pnr.dbf”) with lot sizes and connections to transit stops from, to provide a shorter walk distance from park-and-ride zone than the centroid connector.

Before PT builds complete routes via transit, it prepares walk access links using the shortest path between nodes on the compiled background network. In output files, however, these links appear as direct connections between nodes, skipping the intermediate nodes.

3.6.3 Transit System Coding Structure

The SACSIM19 PT implementation uses three “system” files:

- A fare file (“PTfare.txt”) which specifies initial boarding fares, and operator-to-operator transfer fares.
- A system file (“PTsystem.txt”) which specifies transit modes, operators, and various wait time curves.
- A factor file (“PTfactor.txt”) which specifies parameters affecting path-building.

The PT system file declares the coding conventions for transit lines, transit access links, and operators. It also declares a set of wait curves (discussed later). Each transit line has a mode and an operator. PT generates additional links for access, egress, and transfer, with their own modes. Modes are shown in Table 3-21. Operators and fare groups area shown in Table 3-22.

Table 3-21 SACSIM19 Transit Modes

Mode	Description
1	Light rail (and other local guideway)
2	Commuter bus and rail
3	Local bus
12	Transfer links generated by PT
13	Access and egress links generated by PT
14 (not used)	(reserved for separate egress links, if needed)
15 (not used)	(reserved for separate park-and-ride access links, if needed)

Source: SACOG 2020.

Table 3-22 SACSIM19 Transit Operators

Operator / Fare Group Number	Description
1	RT light rail lines
2	RT fixed-route bus lines
3	Yolobus commuter/express lines
4	Yolobus local fixed route bus lines
5	Roseville commuter bus lines
6	Roseville local fixed route bus lines
7	Yuba-Sutter Transit commuter lines
8	Yuba-Sutter local fixed route bus lines
9	El Dorado Transit commuter bus lines
10	El Dorado Transit local fixed route bus lines
11	Placer County Transit commuter lines
12	Placer County Transit local fixed route bus lines
13	Unitrans local fixed route bus lines; CSUS Hornet shuttle lines
14	Heavy rail (currently Sacramento region stops for Capitol Corridor)
15	South County Transit (SCT Link)
16	E-Tran commuter lines
17	E-Tran local bus lines
18	Future Neighborhood Shuttle
19	Future Streetcar
20	Folsom Stage Line

Source: SACOG 2020.

The PT factors file declares:

- Parameters for path building
 - Maxima on numbers of boardings, etc.
 - Relative weights for costs and out-of-vehicle times compared to in-vehicle, in determining generalized cost of paths
 - Multi-path choice parameters
- Additional coding convention information
- Associates fare-systems with operators
- Time-transfer nodes declaring special wait curves for particular nodes.

3.6.4 Transit network

Details of transit network coding are provided in Chapter 7. For purposes of path building and assignment, travel speeds of buses on highway links are related to the background traffic speeds in the respective period of the day, multiplied by a time factor that represents delays from stopping, loading and unloading, acceleration and deceleration. Time factors are specified for each line but can vary along different segments of the same line. Each operator has an initial boarding fare, and transfer fares from an operator-to-operator matrix. There are no zone- or distance-based fares in the model.

Timed-transfer stations are coded with alternatives to the global or default maxima on wait time specified in the PT factors file. These alternatives are specified by station or stop node. Each refers to an “xwaitcurve” code which must be present in PT system file. Code 105 represents a 5-minute maximum wait (or “pulse” period), 107 is a 7-minute maximum wait, and 110 a 10-minute maximum wait.

3.6.5 Routing

For drive-access transit travel, the PT application processes only the walk-transit-walk portion. Park-and-ride lot choice is a separate model applied outside of PT, using auto and transit skims, and the auto and transit trip-legs separated for assignment. The auto portion uses the highway network to or from any zone having capacity in the “_pnr.dbf” file, and the transit portion uses the transit network to or from the respective park-and-ride zone.

Generalized time (or “perceived time” used to evaluate routes) derives from times, distances, and costs according to parameters specified in the PT factors file. Perception of first-wait time is a piecewise-linear function fitted to the logarithm of randomly-distributed exponentiated utility, coded as the “wait curve” in the Factors file. This gives a high sensitivity to short headways, and a lesser sensitivity to long headways (infrequent service) without the total loss of sensitivity that a truncation would impose.

PT applies a multi-path routing model. Waiting at a stop, travelers are routed among all acceptable lines with probability proportional to frequency, from the premise that a traveler will board whichever service arrives there first among those that efficiently reach his/her destination. PT also provides a multinomial logit choice at decision points to wait at one node or another. Its parameters are the “spread” parameters in the “PTfactors.txt” file, specified close to the program defaults.

3.6.5.1 Skimming

DAYSIM uses TAZ-to-TAZ skim components rather than total perceived time. DAYSIM does not use the skimmed walk time, but instead estimates it parcel-to-parcel. (Composite time among walk branches is available but not used, although multiple used lines picking up at a node get the combined frequencies. For future improvement, consider adding “value of choice” to utility)

3.6.6 Transit Assignment

Transit assignment is performed at the end of the model, since it is not needed in feedback. It uses the same routing criteria as skimming.

Within SACSIM19, DAYSIM uses 5 discrete period skims, but outputs trips in continuous time, therefore it is not always certain by which skim period SACSIM19 created a transit trip prior to settling the person’s full itinerary. As a result, some trips are placed into a period having no transit service, so they are unassignable. Many of the unassignable trips occur in the evening period. To minimize unassignable trips, special rules are applied for transit trips in their placement into periods of the day for assignment.

- All trips earlier than the normal AM 4-hour period are placed in AM,
- If a trip begins in one period and ends in another, but one of these periods lacks transit service (as evident from lacking a transit skim), it is placed into the period that has service,
- If a trip occurs in the evening period, but has no service, it is placed into the PM period if it has service.

3.6.7 Drive Access to Transit

Park-and-ride travel is modeled in much the same way as described in *Sacramento Activity-Based Travel Simulation Model (SACSIM11): Model Reference Report* (SACOG, Feb 2012). For each individual park-and-ride trip pair (drive-transit-walk and walk-transit-drive), the park-and-ride lot of minimum generalized time is chosen, among those not already full at the time of the trip’s outbound departure (beginning of the drive-transit-walk leg). Skims are a probability-weighted average across the period, of the time-dependent best choice.

To provide a more realistically short walk access between the park-and-ride zone and light rail stops, the model script was changed so the short link between them connects directly to the light rail stop, instead of a nearby node on the highway network.

PT, and this model’s park-and-ride model, allow but do not require the “funnel link” system at light rail stops as in the SACSIM11/TRNBUILD model. It is sufficient to provide one link (or a few as needed) connecting an adjacent node in the highway network to each light-rail stop node. Conversion to PT retained all the funnel links from the SACSIM11/TRNBUILD model, in the interest of preserving access that was provided before, and to expedite conversion.

3.6.8 Park-and-Ride Lot Assignment

Some park-and-ride lot choice approaches were proposed for use in this model system that take advantage of TP+'s capabilities. These models include:

- Multinomial logit with shadow cost solution;
- All-or-nothing choice of the least generalized cost;
- All-or-nothing least generalized cost choice, but with maximum drive times solved for each full lot so that demand does not exceed capacity. (A maximum drive time can be considered a catchment area radius, but with catchment areas of different lots freely overlapping; and
- Simulate filling of parking lots over time, making each lot that fills up unavailable to later trips.

The first approach, (multi-nomial logit + shadow cost) was not explored due to lack of data, and budget and time constraints. The second approach (AON assignment based on generalized least cost) was rejected, simply because it lacked any capacity constraint. The third approach (varying drive-to-park-and-ride-lot sheds to match observed loadings) was rejected, because any correlation between drive shed size and lot capacity was weak, and lacked any behavioral relationship. The fourth approach (simulated lot filling, based on generalized least cost), which simulated lot choice, was tested and implemented.

The selected approach has appeal as a simple simulation of a familiar process of parking lots available to those who arrive before they fill up and closed to those who come late. Such a mechanism is reasonable since transit park-and-ride lots mostly serve commuters to work in the morning, and most vehicles stay parked through the day until the evening commute period. Its run-time is quite fast when applied to disaggregate trips such as from DAYSIM.

3.6.8.1 Implementation

There are two interrelated parts to the implementation of the park-and-ride lot choice model: the actual parking lot choice for each trip, and level of service (skim) measurement of the auto-access transit mode for each origin-destination pair.

The park-and-ride lot choice model is applied to each disaggregate trip record predicted by DAYSIM with the auto-transit-walk mode (mode 1). For each, this model selects one zone for this trip to park. Only zones having available parking capacity are allowed. With this selection, the trip is split into an auto trip from the origin to the parking zone, and a transit trip from the parking zone to the destination.

Each trip is linked to the same person's return trip (mode 2), and the return trip is split into a transit and an auto trip through the same parking zone. (The return trip may have a different origin than the original d-t-w trip's destination, and/or a different destination than the original trip's origin.)

The resulting auto and transit trips are then aggregated into trip matrices by time period for inclusion in the auto and transit assignments. This trip processing model is applied after DAYSIM (since DAYSIM trip predictions are input), and before auto assignment (since the auto portions of trips are included in the assignments).

The parking lot choice model makes a single choice for each d-t-w trip of the parking zone, among those available for parking and not filled up, having the least generalized cost combined from the auto and transit portions of travel parking at that zone. The generalized costs are as follows, for origin zone i and parking zone k :

$$GC(\text{auto})_{ik} = \{3 * \text{Auto Time}_{ik} + 2 * (\text{TermTime}_i + \text{TermTime}_k) + 2 * (\text{AutoDist}_{ik} * 12 \text{ cents/mile} + \text{ParkCost}_k / 2) * 0.0558 \text{ minutes equivalent/cent} \} / 1.28 \text{ persons per vehicle}$$

Where:

- $GC(\text{auto})$ = generalized cost for auto portion of transit-drive access trip, per person trip
- Auto Time_{ik} = auto travel time from i -zone to park-and-ride lot k -zone (minutes)
- TermTime = terminal travel time at i -zone and k -zone (minutes)
- AutoDist = i -to- k zone auto driving distance (miles)

$$GC(\text{transit})_{kj} = \text{InVehTime} + 2 * \text{WalkTime} + 1.5 * \text{InitWaitTime} + 2 * \text{TransfTime} + (2 * \text{Fare} * 0.0558 \text{ minutes equivalent/cent})$$

Costs are in year 2000 cents, consistent with SACSIM. The factors on costs are taken from the SACSIM model's middle stratum of cost factors for work trips. Parking cost is specific to park-and-ride activity, being taken from the park-and-ride capacity database file, not the zonal land use or parcel data.

Ideally, the park-and-ride zones would be special zones coded at the actual locations of the parking lots. However, presently they are in ordinary zones, and some of their centroids are some distance away from the parking and the transit station. The ordinary walk-access transit skims would include walk time from the parking zone centroid to the transit stops, which is excessive in some zones. TP+ is not able to isolate or exclude walk time from the origin to the first boarding, which would solve this problem. The current solution to transit skimming for park-and-ride is to actually run customary drive-to-transit skimming, with the requirement that all park-and-ride zones be coded in their own catchment areas. This approach does not appear to introduce conflicts, because the parking lot choice calculations ignore all the transit skims except those beginning at the parking lot zones (i.e. the zones with parking capacities).

This model processes AM trips in chronological order, according to the predicted time-of-day of each trip. Because the trip start-times from DAYSIM occur at a limited number of unique times, a random number breaks ties to settle the order in which trips are processed and given priority at parking lots. One parking zone is chosen for each DAYSIM drive-transit trip, which has the least total generalized cost from its auto and transit legs. The remaining capacity of the chosen zone is decreased by 1 vehicle; if that was the zone's last available parking space, then the zone is unavailable to all later trips.

In addition to the trip pairs labeled with the parking lot choice, the AM drive-transit trip processor also outputs the schedule of when each parking zone fills up, expressed as a fractional number from 0 to 1, representing the cumulative fraction of AM period trips that have been processed.

For the midday period, all lots that fill up in the AM period are unavailable. For PM and evening, all lots are available for drive-to-transit trips. Airport transit-drive trips are not disaggregate and are few in number, so all parking lots are considered available to them.