

## 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**

<b>Mode</b>	<b>Description</b>
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**

<b>Operator / Fare Group Number</b>	<b>Description</b>
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 maximum 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  $k$ :

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

Where:

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